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**Article**

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# RE-INNOVATION FROM FAILURE, INSTITUTIONAL ENVIRONMENTAL DIFFERENCES, AND FIRM PERFORMANCE: EVIDENCE FROM CHINA

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**Abstract**

Due to an anti-failure bias, theoretical and practical studies have not focused much on the problem of innovation failure. The literature does not include studies on how the effect of re-innovation input on firm performance can still be explained by existing theories, especially in the case of previous innovation failures. To explore the intrinsic relationship between the re-innovation from failure and firm performance, as well as the influencing mechanism of the institutional environment differences on a firm's re-innovation activities, using the data of the Listed Companies in China's pharmaceutical manufacturing industry from 2008 to 2014 and a multiple regression model, the relationships between the re-innovation from failure, institutional environment differences, and firm performance were analyzed from 3 aspects: government intervention, financial development, and legal environment. The results show that the re-innovation input from failure has a significant positive impact on firm performance. The level of government intervention and the level of financial development play significant negative and positive moderating roles in the relationship between the re-innovation input and firm performance, respectively, and the above-mentioned effects are more prominent in eastern China. Moreover, with the improvement of the marketization of the financial industry, the beneficial effect of the re-innovation input from failure on firm performance in state-owned firms will be further strengthened. However, the moderating effect of the legal environment is not obvious.

**Keywords:** re-innovation from failure, institutional environment, firm performance, moderating effect

**JEL Classification:** M13, O32, O33, O38

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## Introduction

China's technological innovation level has significantly improved in recent years under the guidance of an innovation-driven development strategy, and China's economic development has grown steadily. Data from the 13th Five-year Plan on Science, Technology, and Innovation indicated that in 2015, China ranked 18th in the world in terms of comprehensive innovation ability, and its contribution rate of scientific and technological progress increased from 50.9% in 2010 to 55.3% in 2015 (Central People's Government of the People's Republic of China, 2016). The uncertainty of innovation, as well as the increase of market competition and innovation difficulty (Morcillo-Bellido and Prida-Romero, 2018; Gutierrez-Garcia, 2019), aggravates the high risk of innovation, and so innovation failures should be approached objectively by firms. According to Schumpeter's definition of innovation, the core criterion for judging failed innovation lies in whether the expected goal of the innovation was achieved, that is, in the innovation process, the achievements were terminated or canceled because of the influence of technological resources, market, organization, capability, or other obstacles to innovation (Li et al., 2016). Some research showed that at Advanced Micro Devices, Inc. and other companies in the US, the commercial success rate of innovation projects is only 30% (Klink and Athaide, 2014). A survey of innovation projects carried out by 2,130 firms in 6 major industries in China showed that the innovation activities of 1,884 firms were suspended or failed, accounting for 88.45% of the total (Wang, 2016). However, due to an anti-failure bias (Fujiwara, 2018), failed innovation studies are not common in innovation research and practice. A failed innovation result in significant losses to firms, and it is highly likely to affect the initiative of firms to innovate, restricting their subsequent innovative behavior and affecting performance (Xiong et al., 2019). Therefore, the methods for examining the reasons for innovation failure and improving the success rate of innovation have become important research topics in the field of innovation management.

Theoretical and practical studies showed that failed innovation is influenced by both technological barriers and external environmental factors, that is, the technological barriers formed by the insufficient innovation ability of firms to garner knowledge resources and technological capabilities (Van Lancker et al., 2019), and the passive innovation interruption caused by the insufficient support of firms in environmental relations (Liu et al., 2019), external resources (D'Este et al., 2016), and market incentives (Mao and Yang, 2006). Some studies showed that firms that experienced failed innovation tended to perform better in identifying and utilizing opportunities (Stokes and Blackburn, 2008), learned from their failure experiences (Wang et al., 2018), better allocated failure resources (Ye and Wang, 2008), and improved their willingness for re-innovation after a failure (McGrath, 2001). However, the current literature neglects the relationship between re-innovation from failure and firm performance. A firm's innovation input has a significant positive impact on its production efficiency, asset return, and profit (Albert and Deng, 2019); however, no study has examined whether the effect of the re-innovation input on firm performance can still be explained by the existing theories. In addition, the impact of the institutional environment on a firm's performance and investment returns has attracted increasing attention from academia. There has been uneven development of the market economy in different regions, especially in the process of China's economic restructuring; the property rights system is not adequate, and the legal system is defective. There are obvious differences in the institutional environments in the different regions in China (Bao et al., 2018). Such institutional environmental differences may also have contingent effects

on the relationship between the re-innovation from failure and firm performance. When firms make re-innovation decisions from failure, does their re-innovation input really improve firm performance? As an external environmental factor closely related to business activities, does the institutional environment also play a contingent role in this influencing process? To answer the above questions, we explored the relationship between the re-innovation from failure, institutional environment differences, and firm performance by using the data of the listed pharmaceutical manufacturing companies in China to reveal the role of the institutional environment in the firm's re-innovation activities from failure and further enrich the literature of the relationship between innovation failure and subsequent innovation behavior.

The remainder of this study is organized as follows. Section 1 provides a literature review and research hypothesis. Section 2 introduces the research method, including the construction of the research model, data sources, and specifications of the variables. Section 3 describes the analysis results and discussion. Section 4 concludes the study with closing remarks and implications.

## 1 Literature review and research hypothesis

### 1.1. Re-innovation from failure and firm performance

The innovation input intensity is an important indicator for measuring a firm's innovation capability (Hu, 2015). Researchers have obtained results on the relationship between the innovation input and firm performance, but there are different opinions on the specific performance of the relationship between them. Most scholars generally believe that the increase of the innovation input promotes the improvement of firm performance, and the innovation input has a significant positive impact on firm performance. Wakelin (1997) found that the innovation input intensity had a significant positive impact on a firm's productivity in an empirical test of British firm data from 1988 to 1996. Liang and Zhang (2006) investigated China's high-tech firms and found that a firm's R&D input had a strong correlation with the main business's profit margins and had a significant effect on improving the firm's profitability and innovation ability. Connolly and Hirschey (2010) studied American firms and found that there was a significant positive correlation between the R&D intensity and Tobin's Q value. Falk (2012) tracked Australian firms and found that the R&D input had a significant positive impact on sales growth in the lag period, and this lagging effect was also obvious at Chinese firms. Zhao and Xu (2013) further confirmed that the R&D input had a lagging positive impact on the operating profit margin. Some scholars thought that the relationship between the innovation input and firm performance was negative or unrelated. Guo (2006) found that the higher the intensity of the R&D input, the lower the profit margin and output rate, but the proportion of R&D personnel had a significant positive impact on the profit margin and output rate. Through an empirical analysis using patent and financial data of 258 American firms, Lin et al. (2006) found that the relationship between the innovation input and firm performance was not significant.

Based on the existing research on the relationship between innovation input and firm performance, we argue that the re-innovation input from failure is a follow-up innovation input based on the previously failed innovation. Therefore, the relationship between the re-innovation input from failure and firm performance has its own characteristics. Re-

innovation input from failure will affect a firm's performance and competitive advantage to a large extent. First, the previously failed innovation result in a significant cost of failure for firms, but the existing literature indicates that innovation failure is not useless. The failure results often contained "positive" resources. The integration and absorption of these failed resources can improve firms' follow-up innovation activities (Mueller and Shepherd, 2016). Increasing re-innovation input can enhance the resource integration and knowledge absorption ability of failed firms. The accumulation of failure knowledge and experience can help firms enhance their own knowledge and technology capital in the follow-up innovation activities. The stock of knowledge and technology of firms gradually increases, and the innovation ability of the firms is enhanced. Second, the innovative advantages brought by the accumulation of failure knowledge and experience can promote the steady improvement of the efficiency of failed firms in the follow-up innovation and reduce the failure probability of the firms' re-innovation, which also provides conditions for firms to realize large-scale production. The production process generated by large-scale production is highly integrated, which improves firm performance. Based on the above analysis, we proposed the following hypothesis:

- Hypothesis H1: There is a positive impact from the re-innovation input on firm performance in firms with failed innovation and increasing re-innovation input will promote firm performance.

### 1.2 Moderating effect of institutional environment

In view of the positive impact of the innovation input on firm performance, existing research indicated that the prerequisite for the establishment of the impact relationship is the need for institutional environmental protection. That is to say, a firm's innovation input cannot naturally promote the improvement of the firm's performance, especially in the absence of an effective legal system and incomplete regulatory mechanism. The efficiency of a firm's innovation input is likely to be greatly reduced or innovation achievement is decreased, thus weakening the improvement effect of the innovation input on the value and competitive advantage of firms (Hong and Shi, 2017). Jensen and Meckling (1979) pointed out that the determinants of the firm's production process included not only capital, labor, raw materials, knowledge, and technology, but also the rights structure and contractual arrangements of the external environment. To a certain extent, the rights structure and contract rules determine the cost and benefit arrangement of firms in the competitive environment. This change of the firms' profits will affect the decision-making behavior of the firms and then affect the firms' performance. Therefore, the impact of a firm's innovation input on the firm's performance not only is determined by its own internal control but also depends on the external institutional environment. Institutional environmental factors may also have contingent effects on the positive relationship between the re-innovation input and firm performance.

Forty years of reform and opening-up have brought about the rapid development of China's economy. However, due to the large differences in resource endowments among the different regions, there is a significant imbalance in the level of economic development among the different regions in China, which also leads to obvious regional differences in the degree of marketization among the these regions. The institutional environment is vastly different. First, because China is in the process of transition from a planned economy to a market economy, the government's intervention in economic development is

unavoidable, but excessive government intervention in the business process of firms will affect fairness in the competitive market. Reducing government intervention is conducive to creating a fairer business environment for firms, helping firms to establish their own competitive advantages more quickly and effectively, and thus stimulating the innovative spirit of entrepreneurs. In the face of innovation failure results, firms can better allocate failure resources, and so the enthusiasm for re-innovation is higher. Therefore, the improvement derived from the re-innovation initiative of firms with failed innovation leads to a further increase of the re-innovation input. The reduction of government intervention not only improves the success rate and efficiency of re-innovation with failed firms but also increases the output of firms' re-innovation. Accordingly, the following hypothesis was proposed:

- Hypothesis H2: The level of government intervention has a negative moderating effect on the positive impact of the re-innovation input on firm performance: the lower the level of government intervention, the stronger the promotion effect of the re-innovation input on firm performance.

Second, the financing constraint is a problem that restricts the innovation activities of Chinese firms at current stage (Chen, 2017). The higher the marketization degree of the financial industry, the more effective it is in alleviating the financing difficulties of firms in the innovation process. This is especially true for small and medium-sized firms, since the large cost caused by failed innovation makes it difficult to make re-innovation input decisions. A high marketization degree of the financial industry can provide more financing channels for firms with failed innovation, greatly reducing the difficulty of financing, thus providing more capital input for re-innovation activities. The increase of re-innovation input makes it possible to improve firm performance. Accordingly, the following hypothesis was proposed.

- Hypothesis H3: The level of financial development has a positive moderating effect on the positive impact of the re-innovation input on firm performance: the higher the marketization degree of the financial industry, the stronger the promotion effect of the re-innovation input on firm performance.

Finally, it is important to improve the legal system for firms' innovation activities, which can guarantee the profits generated by firms' exclusive innovation activities. The monopoly of innovation profit is the power source of a firm's innovation input, and a suitable legal system and supervision system form an important institutional guarantee to protect innovators' achievements from being encroached upon and imitated. The value of failed innovation projects is often neglected, which further increases the risk of undertaking technological innovation. In the absence of a stronger legal system, the exclusive cost of firms to protect their intellectual property rights will be greatly increased. Therefore, a stronger local legal environment will result in better legal protections of the intellectual property rights of firms and their innovative achievements. Based on the above analysis, the following hypothesis was proposed:

- Hypothesis H4: The strength of the legal environment has a positive moderating effect on the positive impact of the innovation input on firm performance: The better the regional legal environment, the stronger the role of re-innovation input in promoting firm performance.

## 2. Methodology

### 2.1. Variable definition

**Firm performance.** Most studies mainly used 3 proxy variables to measure firm performance: return on assets, profit margin on sales, and return on equity (Zhong et al., 2018). Because the return on equity is affected by the mixed proportion of equity and debt of the firm itself, the resulting comparison among different firms lacks the ability to be convincing (Song, et al., 2017). Therefore, we followed the path used by most of the studies and used the return on assets (*roa*) and profit margin on sales (*ros*) as the proxy variables of the firm performance measurement. The return on assets (*roa*) was used to test the basic hypothesis, and the profit margin on sales (*ros*) was used to test the robustness of the empirical results.

**Re-innovation from failure** (*reinnov*). We used Maslach (2016)'s method of dealing with variables on failed innovation; Maslach defined the individual with adverse drug reactions (ADRs) in the late clinical use of pharmaceutical products in pharmaceutical manufacturing firms as an indication of a failed innovation. The main reasons for adopting this method are as follows:

First, the core of the criteria for judging failed innovation lies in whether the innovation achievements have reached the expected goals. Specifically, according to the characteristics of an innovative product or service, the appropriate criteria for examining innovation failure should be determined from various dimensions, such as the social, economic, and ecological benefits. For innovative pharmaceutical products, the expected goal is to alleviate or eliminate the symptoms of patients through drug use. ADRs are the undesirable adverse reactions of qualified drugs, which have nothing to do with the purpose of drug use in the application of the normal dosage of drugs. Although pharmaceutical products need to undergo rigorous clinical trials before they can be put on the market, the emergence of adverse reactions is precisely due to the limitations of pre-market drug research, which reflects that the pharmaceutical products have not reached the expected goal of alleviating or eliminating patients' diseases. As such, they fail to meet the core criteria of innovation.

Second, due to the negative attributes of innovation failure, China's firms have an insufficient subjective willingness to disclose information about failed innovation. Thus, the possibility of obtaining data through a questionnaire is relatively low. For pharmaceutical products, China's government has formed a useful ADR monitoring system to control drug risks in a timely and effective way to ensure public safety. As such, a relatively complete ADR report is available that can provide the relevant data.

The ratio of R&D expenditure to the main business income in the year of innovation failure was used to measure the intensity of re-innovation input.

**Institutional environment**. We used the widely-studied method of measuring the institutional environment (Song and Liu, 2015; Lu et al., 2019). The China Marketization Index compiled by Fan et al. (2011) was used as the proxy variable of the institutional environment. The sub-index of "the relationship between government and market" in the China Marketization Index was selected to measure the level of government intervention (*gover*). The sub-index of "marketization of financial industry" was selected to measure the level of financial development (*finance*). The sub-index of "the development of market

intermediary organizations and the environment of legal system" measures the level of legal environment (*law*).

**Control variable.** The nature of firm ownership (*state*) was set as a virtual variable when the sample firm is a state-owned firm: virtual variable *state* = 1, otherwise *state* = 0. The firm size (*size*) was measured by the natural logarithm of the total assets of the sample firm: The larger the value, the larger the firm's size. Firm growth (*growth*), measured by the growth rate index of the main business income, reflects the investment ability of firms. Firm age (*age*) was measured by the difference between the time of establishment of the firm and the year of the sample data. Financial leverage (*leverage*) reflects the debt situation of firms, while debt pressure will restrict firms' innovation input. The year dummy variable *Year* was set to control the fixed effect.

The definitions and explanations of the main variables in this study are shown in table no. 1.

**Table no. 1: Definition of variables**

| Variable Type | Variable Name | Symbol | Definition |
|---|---|---|---|
| Dependent Variable | Firm performance | *roa* | Return on assets |
| | | *ros* | Profit margin on sales |
| Independent Variable | Re-innovation from failure | *reinnov* | In the case of failed innovation, the ratio of the R&D expenditure to the main business income in the year of the innovation failure |
| Moderating Variable | Government intervention | *gover* | The sub-index of "the relationship between government and market": The greater the index value, the lower the level of government intervention. |
| | Financial development | *finance* | The sub-index of "marketization of financial industry": the greater the index value, the higher the level of financial development. |
| | Legal environment | *law* | The sub-index of "the development of market intermediary organizations and the environment of legal system": the greater the index value, the stronger the legal environment. |
| Control Variable | Nature of firm ownership | *state* | Virtual variable, *state* = 1 for state–owned firm, *state* = 0 for a non-state-owned firm. |
| | Firm size | *size* | The larger the natural logarithm of the total assets of a firm, the larger the firm's size. |
| | Firm growth | *growth* | The growth rate of the main business income, (main business income of this year – main business income at the beginning of this year) / main business income at the beginning of this year. |
| | Firm age | *age* | The difference between the time of establishment of the firm and the year of the sample data. |
| | Financial leverage | *leverage* | (Net profit + income tax expenses+ financial expenses) / (net profit + income tax expenses). |

### 2.2. Data

Using the *Guidelines for the Classification of Listed Companies (Revised in 2012)* issued by China's Securities Regulatory Commission, we chose listed pharmaceutical manufacturing firms in China's A-share market from 2008 to 2014 as samples. The Chinese government implemented the Accounting Standards for Business Enterprises in 2007, which has an impact on the accounting policies of the listed companies. Therefore, the sample interval began in 2008 to ensure that the sample data were generated under the same accounting standards. The sample data were obtained and screened as follows:

First, excluding veterinary and agricultural drugs in the range of non-ADR monitoring, drug manufacturers were matched manually by using the information disclosed on the official websites of the listed companies and their annual reports. A total of 408 subsidiary drug manufacturers, included from the listed pharmaceutical manufacturing firms, were obtained. We used the information retrieval of the national ADR monitoring system; the ADRs produced by a listed company's subsidiary firms in a certain year were manually evaluated, and the firms with the ADRs were taken as research samples.

Second, we used the definition of the major variables and the time interval (2008–2014) of the sample to eliminate listed companies that did not meet the criteria; companies that had missing data of the relevant indicators were also excluded.

Third, the institutional environment variables were derived from the newly published *NERI INDEX of Marketization of China's Provinces 2016 Report* in 2017 (Wang et al., 2017). The sample data of government intervention, financial development, and the legal environment were matched using the registered location of the listed companies.

Fourth, the data of the listed companies in the pharmaceutical industry were from the China Stock Market and Accounting Research (CSMAR) database. We obtained 288 valid samples.

### 2.3. Modeling

Regression models (Model (1)) and (Model (2)) were constructed to test *Hypotheses H1*, *H2*, *H3*, and *H4*. Due to the obvious lag of the impact of innovation input on firm performance, the dependent variable *roa* was processed with 1 lead period, that is, the regression analysis of *roa* in the t+1 phase and other variables in the t-phase was performed to effectively reduce the interference of endogenous problems on the empirical results:

$$roa_{i,t+1} = \beta_1 reinnov_{i,t} + \lambda \sum Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$\begin{aligned} roa_{i,t+1} = {} & \beta_1 reinnov_{i,t} + \beta_2 gover_{i,t} + \beta_3 gover_{i,t} \times reinnov_{i,t} + \beta_4 finance_{i,t} \\ & + \beta_5 finance_{i,t} \times reinnov_{i,t} + \beta_6 law_{i,t} + \beta_7 law_{i,t} \times reinnov_{i,t} \\ & + \lambda \sum Control_{i,t} + \varepsilon_{i,t.} \end{aligned} \quad (2)$$

Where:

$roa_{i,t+1}$ – the firm performance in the t+1 phase of the *i*-th firm with failed innovation.
$reinnov_{i,t}$ – the re-innovation input in the t-phase of the *i*-th firm with failed innovation.

$gover_{i,\,t}$, $finance_{i,\,t}$, and $law_{i,\,t}$ – indicate the level of government intervention, financial development, and legal environment, respectively.

$gover_{i,\,t}$*$reinnov_{i,\,t}$, $finance_{i,\,t}$*$reinnov_{i,\,t}$, and $law_{i,\,t}$*$reinnov_{i,\,t}$ – the interaction items of the re-innovation input of the firm with failed innovation and government intervention, financial development, and legal environment, respectively.

$\sum Control_{i,\,t}$ – a set of control variables, including the firm ownership (*state*), firm size (*size*), firm age (*age*), firm growth (*growth*), and financial leverage (*leverage*). $\varepsilon$ is a random perturbation term.

In Model (1), when the regression coefficient $\beta_1$ is significant and positive, it shows that the re-innovation input has a positive impact on the firm's performance, and Hypothesis H1 can be verified. In Model (2), when the regression coefficients $\beta_3$, $\beta_5$, and $\beta_7$ are significantly positive, it shows that the institutional environment has a positive moderating effect on the relationship between the re-innovation input and firm performance. When the regression coefficients $\beta_3$, $\beta_5$, and $\beta_7$ are significantly negative, it shows that the institutional environment has a negative moderating effect on the relationship between the re-innovation input and firm performance. To avoid the multiple-collinearity problem in the model, the interaction terms were centralized in the regression analysis process.

## 3. Results and discussion

### 3.1. Descriptive statistics analysis

Table no. 2 shows the descriptive statistical results of the main variables. The mean value of the re-innovation input intensity (*reinnov*) of the firm with failed innovation is 0.02. This is compared with the average ratio of the R&D input to the main income of China's firms measured by Ye and Zhao (2017), which was 3.1%. Our result is slightly lower than that value, but not very different, and it reflects the characteristics of the re-innovation input after the failed innovation. That is, since they are affected by the previous innovation failure, firms will bear the cost of failure, and the painful experience of failure will affect the firms' willingness and enthusiasm for re-innovation. Thus, to a certain extent, the sample data of the re-innovation input intensity (*reinnov*) for firms with failed innovation are reliable. For the firm's performance, the average value of the return on assets (*roa*) and profit margin on sales (*ros*) are 0.09 and 0.15, respectively, and the minimum value is negative, which indicates that the firm's performance will be poor over time, and this outcome is in accord with the actual business situation of firms. The average value of a firm's ownership (*state*) is 0.49, which indicates that the number of state-owned firms and non-state-owned firms in the sample is roughly the same. The standard deviations of a firm's age (*age*), size (*size*), growth (*growth*), and financial leverage (*leverage*) are all greater than 0.5, which indicates that the sample data have great differences in the above variables. The standard deviation of the government intervention level (*gover*), financial development level (*finance*), and legal environment level (*law*) are also greater than 1.0, which indicates that there are great differences in the institutional environments in the various regions.

**Table no. 2: Descriptive statistical analysis results**

| Variables | Sample size | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| *reinnov* | 288 | 0.02 | 0.03 | 0.00 | 0.15 |
| *roa* | 288 | 0.09 | 0.08 | –0.27 | 0.50 |
| *ros* | 288 | 0.15 | 0.21 | –0.79 | 2.15 |
| *gover* | 288 | 7.36 | 1.24 | 3.45 | 9.65 |
| *finance* | 288 | 5.69 | 2.12 | 2.05 | 12.23 |
| *law* | 288 | 6.85 | 3.97 | 0.52 | 16.19 |
| *state* | 288 | 0.49 | 0.50 | 0.00 | 1.00 |
| *age* | 288 | 14.76 | 4.54 | 2.00 | 29.00 |
| *size* | 288 | 21.72 | 0.96 | 19.10 | 24.29 |
| *growth* | 288 | 0.16 | 0.63 | –1.37 | 6.26 |
| *leverage* | 288 | 1.37 | 1.35 | –2.11 | 11.41 |

### 3.2. Correlation analysis

The results of the correlation analysis among the major variables are shown in table no. 3. The Pearson correlation coefficient between the firm performance (*roa*) and re-innovation input (*reinnov*) is 0.095, which is significant at the level of 5%. This indicates that there is a significant positive correlation between the re-innovation input (*reinnov*) and firm performance (*roa*), which provides a basis for verifying *Hypothesis H1*. The correlation coefficient between the firm performance (*roa*), government intervention (*gover*), financial development (*finance*), and legal environment (*law*) is not significant, which indicates that there may be no obvious direct relationship between the institutional environment and firm performance. This outcome also proves the validity of taking the institutional environment as a moderating variable of the relationship between the re-innovation input and firm's performance. In addition, among the measurement variables of the institutional environment, the correlation coefficient among government intervention (*gover*), financial development (*finance*), and legal environment (*law*) is relatively large, mainly because the marketization index involves the index data of regional economic development, and there may be collinearity interference (Liu et al., 2014). Therefore, government intervention (*gover*), financial development (*finance*), and legal environment (*law*) were introduced into the regression model separately.

**Table no. 3: Correlation analysis of main variables**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 *reinnov* | 1 | | | | | | | | |
| 2 *roa* | 0.10** | 1 | | | | | | | |
| 3 *gover* | 0.11** | –0.03 | 1 | | | | | | |
| 4 *finance* | 0.22*** | 0.06 | 0.21*** | 1 | | | | | |
| 5 *law* | 0.30*** | –0.01 | 0.55*** | 0.59*** | 1 | | | | |
| 6 *state* | –0.10** | –0.16*** | 0.07 | 0.14*** | –0.07 | 1 | | | |
| 7 *age* | –0.09** | –0.15*** | –0.14*** | 0.15*** | 0.03 | 0.08* | 1 | | |
| 8 *size* | 0.01 | 0.15*** | –0.02 | 0.26*** | 0.16*** | 0.17*** | 0.22*** | 1 | |
| 9 *growth* | 0.00 | 0.09** | –0.02 | 0.01 | –0.04 | –0.05 | –0.00 | –0.02 | 1 |
| 10 *leverage* | –0.02 | –0.13*** | –0.02 | –0.04 | –0.06 | –0.01 | 0.07* | 0.03 | –0.02 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1% respectively.*

### 3.3. Regression analysis

- ***Basic regression***

The results of the basic regression analysis are shown in table no. 4. Column (1) only adds the control variables. Column (2) adds the independent variable *reinnov* on the basis of Column (1), and its regression coefficient is 0.558, which is significant at the level of 1% and is still significant after adding the adjustment variables. The table shows that the re-innovation input has a significant positive impact on the performance of the firms with failed innovation. The greater the re-innovation input of the firms with failed innovation, the better the performance feedback for the firms with failed innovation. Hypothesis H1 is verified.

Columns (3)–(5) are based on Column (2) by adding moderating variables government intervention (*gover*), financial development (*finance*), legal environment (*law*), and the interaction terms of 3 variables with the independent variable *reinnov* to further examine the moderating effect of institutional environment on the relationship between the re-innovation input and firm performance. In Column (3), the coefficient of *reinnov*gover* is –0.294, which is significant at the level of 10%, indicating that the government intervention level has a negative moderating effect on the relationship between the re-innovation input and firm performance. The analysis results support *Hypothesis H2*. The improvement of the government intervention level will significantly inhibit the positive impact of the re-innovation input intensity on firm performance. To a certain extent, it reflects that excessive government intervention will squeeze out the re-innovation input of firms with failed innovation. Firms with failed innovation may invest a lot of resources to maintain a good government-firm relationship and obtain government compensation for innovation failure or related subsidies, which results in the insufficient learning from previous failure experience, and an inadequate allocation of failed resources, which reduces the quality control of the re-innovation process, thus affecting the improvement of the firm's performance.

**Table no. 4: Basic regression analysis results**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *reinnov* | | 0.558*** (0.172) | 0.730*** (0.192) | 0.354* (0.181) | 0.612*** (0.181) |
| *gover* | | | –0.005 (0.004) | | |
| *reinnov*gover* | | | –0.294* (0.157) | | |
| *finance* | | | | 0.003 (0.002) | |
| *reinnov*finance* | | | | 0.235*** (0.076) | |
| *law* | | | | | –0.001 (0.001) |
| *reinnov* law* | | | | | –0.016 (0.044) |
| *state* | –0.039*** (0.009) | –0.037*** (0.009) | –0.037*** (0.009) | –0.037*** (0.009) | –0.038*** (0.009) |

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *age* | –0.005*** | –0.005*** | –0.005*** | –0.004*** | –0.005*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| *size* | 0.027*** | 0.027*** | 0.028*** | 0.027*** | 0.027*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| *growth* | 0.005 | 0.007 | 0.007 | 0.006 | 0.007 |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) |
| *leverage* | –0.008** | –0.008** | –0.008** | –0.008** | –0.009** |
| | (0.004) | (0.003) | (0.003) | (0.003) | (0.004) |
| *Year* | Control | Control | Control | Control | Control |
| *_cons* | –0.373*** | –0.389*** | –0.377*** | –0.401*** | –0.394*** |
| | (0.109) | (0.107) | (0.109) | (0.106) | (0.108) |
| N | 261 | 261 | 261 | 261 | 261 |
| F | 6.899 | 7.466 | 6.679 | 7.308 | 6.398 |
| $R^2$ | 0.216 | 0.248 | 0.260 | 0.278 | 0.252 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.*

In Column (4), the interaction term *reinnov*finance* is significant at level of 1% and the regression coefficient is 0.235, which indicates that the financial development level plays a positive moderating role in the relationship between the re-innovation input and firm performance. Hypothesis H3 is verified. The results show that with the continuous improvement of the financial development level, the positive impact of the re-innovation input intensity on the firm performance will be further strengthened. Related research showed that the difficulty of external financing is a key factor restricting the technological innovation of China's firms, especially small and medium-sized firms (Fan and Liu, 2017). A high marketization degree of the regional financial industry results in more diversified financing methods and a wider market operation of credit fund distribution, which makes it easier to obtain external financing and to provide sufficient financial support to re-innovation activities for firms with failed innovation. The smooth development of re-innovation activities further improves the firm's performance. In Column (5), the coefficient of *reinnov*law* is –0.016, but it is not significant. This result shows that the moderating effect of the legal environment level on the relationship between the re-innovation input and firm's performance is not obvious. The empirical results do not support *Hypothesis H4*. By comparing the significance level of the interaction items *reinnov*gover* and *reinnov*finance*, we found that the significance level of the interaction items *reinnov*finance* is higher, which further shows that the level of financial development is more sensitive to the moderating effect of the relationship between the re-innovation input and firm's performance. That is to say, in view of the development of China's firms at this stage, the improvement of the marketization degree of the financial industry is more obvious than that of the increasing the level of government intervention to the performance improvement of re-innovation firms with failed innovation.

In addition, in order to show the moderating role of government intervention (*gover*) and financial development (*finance*) in the relationship between the re-innovation input and firm performance, the interaction effects are shown in figures no. 1 and no. 2.

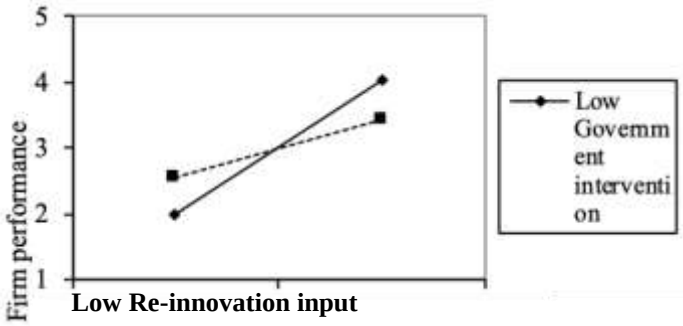


**Figure no. 1: Re-innovation input and firm performance: the moderating effect of government intervention**

Figure no. 1 shows that in the case of a high degree of government intervention, with the increase of the re-innovation input of firms with failed innovation, the growth of the firm performance lags far behind the situation of that with a low degree of government intervention. Under the moderating effect of the financial development level, the low level of financial marketization degree has a very limited effect on the improvement of the firm's performance by the re-innovation input of firms with failed innovation (see Figure no. 2). In contrast, under the influence of a high level of financial marketization, with the increase of re-innovation input, the growth rate of the firm's performance will be greatly enhanced.

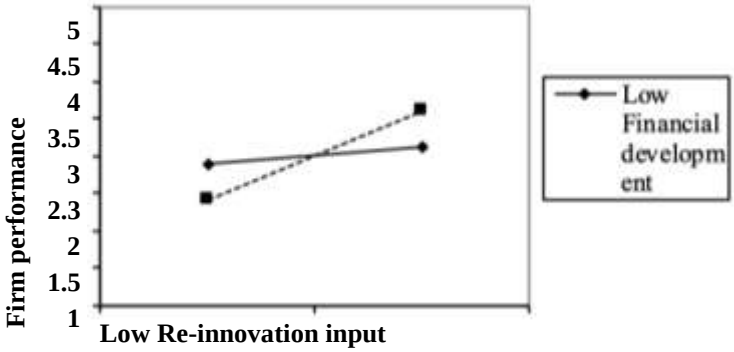


**Figure no. 2: Re-innovation input and firm performance: the moderating effect of financial development**

For the control variables, the coefficient of *state* is negative and significant at the level of 1%, which indicates that the performance of non-state-owned firms is better after the failed innovation. The coefficients of *age* and *leverage* are significantly negative, while the coefficient of *size* is significantly positive. These results show that younger firms with lower debt pressure have a greater performance after a failed innovation. This result also illustrates that after the failed innovation, through the learning of failure experience and the reallocation of failure resources, the implementation of re-innovation activities has a more obvious effect on the improvement of the firm's performance. Moreover, debt pressure is also an important factor that restricts the re-innovation activities of firms with failed innovation. Excessive debt pressure will reduce the firm's performance that results from

re-innovation activities. Larger firm sizes have a greater firm performance with failed innovation after re-innovation activities. The possible reason is that large firms often have a strong control over resources, and the impact of the loss of resources caused by the failed innovation is relatively small. Therefore, they can continue to input sufficient resources in the follow-up innovation activities to ensure the smooth implementation of re-innovation activities and further promote the significant improvement of the firm's performance.

- ***Regional heterogeneity***

Because of the unbalanced level of regional economic development, there are significant differences in the institutional environment among regions. China is divided into 3 regions: eastern China, central China, and western China. Eastern China includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; central China includes Heilongjiang, Jilin, Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; western China includes Sichuan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, and Guangxi. Through the above geographic region classification samples, further analysis of the positive impact of the re-innovation input on firm performance, and the moderating effect of institutional environment may exist in regional heterogeneity.

Tables no. 5, no. 6 and no. 7 show the results of the sub-sample regression according to the regions.

**Table no. 5: The Results of Sub-sample Regression (Eastern China)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *reinnov* | 0.528*** (0.190) | 0.803*** (0.225) | 0.204** (0.206) | 0.521** (0.211) |
| *gover* | | 0.001* (0.007) | | |
| *reinnov*gover* | | –0.423** (0.186) | | |
| *finance* | | | 0.005* (0.003) | |
| *reinnov*finance* | | | 0.280*** (0.082) | |
| *law* | | | | –0.000 (0.002) |
| *reinnov* law* | | | | 0.004 (0.052) |
| *state* | –0.025** (0.011) | –0.025** (0.011) | –0.025** (0.011) | –0.025** (0.012) |
| *age* | –0.004*** (0.001) | –0.004*** (0.001) | –0.003*** (0.001) | –0.004*** (0.001) |
| *size* | 0.022*** (0.006) | 0.024*** (0.006) | 0.021*** (0.006) | 0.022*** (0.006) |
| *growth* | 0.000 (0.008) | –0.000 (0.008) | –0.000 (0.008) | 0.000 (0.009) |

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *leverage* | –0.006*<br>(0.004) | –0.006<br>(0.004) | –0.006*<br>(0.003) | –0.006*<br>(0.004) |
| *Year* | Control | Control | Control | Control |
| *_cons* | –0.315**<br>(0.132) | –0.376**<br>(0.156) | –0.325**<br>(0.127) | –0.312**<br>(0.139) |
| N | 167 | 167 | 167 | 167 |
| F | 3.856 | 3.728 | 4.739 | 3.221 |
| $R^2$ | 0.215 | 0.241 | 0.287 | 0.215 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.*

**Table no. 6: The Results of Sub-sample Regression (Central China)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *reinnov* | 1.928***<br>(0.529) | 2.051***<br>(0.614) | 2.393**<br>(1.029) | 1.490<br>(3.082) |
| *gover* | | 0.025*<br>(0.014) | | |
| *reinnov*gover* | | 0.205<br>(0.605) | | |
| *finance* | | | –0.009<br>(0.017) | |
| *reinnov*finance* | | | 0.291<br>(0.752) | |
| *law* | | | | 0.005<br>(0.016) |
| *reinnov* law* | | | | –0.126<br>(0.766) |
| *state* | –0.039**<br>(0.019) | –0.026<br>(0.020) | –0.036*<br>(0.019) | –0.039**<br>(0.019) |
| *age* | –0.006*<br>(0.003) | –0.008**<br>(0.003) | –0.006*<br>(0.004) | –0.006*<br>(0.003) |
| *size* | 0.024**<br>(0.012) | 0.025**<br>(0.012) | 0.026**<br>(0.012) | 0.024*<br>(0.012) |
| *growth* | 0.034*<br>(0.018) | 0.034*<br>(0.018) | 0.033*<br>(0.018) | 0.035*<br>(0.018) |
| *leverage* | –0.057**<br>(0.023) | –0.067***<br>(0.023) | –0.055**<br>(0.025) | –0.061**<br>(0.024) |
| *Year* | Control | Control | Control | Control |
| *_cons* | –0.246<br>(0.246) | –0.443*<br>(0.262) | –0.279<br>(0.274) | –0.251<br>(0.271) |
| N | 61 | 61 | 61 | 61 |
| F | 6.146 | 5.704 | 5.089 | 5.062 |
| $R^2$ | 0.580 | 0.612 | 0.585 | 0.583 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.*

**Table no. 7: The Results of Sub-sample Regression (Central China)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *reinnov* | –0.204<br>(2.007) | 1.076<br>(3.200) | –0.285<br>(2.550) | –0.819<br>(4.414) |
| *gover* | | 0.011<br>(0.033) | | |
| *reinnov*gover* | | 0.671<br>(1.244) | | |
| *finance* | | | –0.032<br>(0.019) | |
| *reinnov*finance* | | | –0.146<br>(1.063) | |
| *law* | | | | –0.041<br>(0.026) |
| *reinnov* law* | | | | –0.183<br>(1.134) |
| *state* | –0.079**<br>(0.037) | –0.073*<br>(0.040) | –0.057<br>(0.039) | 0.001<br>(0.036) |
| *age* | –0.004<br>(0.004) | –0.004<br>(0.007) | 0.001<br>(0.005) | 0.004<br>(0.004) |
| *size* | 0.027<br>(0.025) | 0.024<br>(0.028) | 0.013<br>(0.025) | –0.004<br>(0.021) |
| *growth* | 0.004<br>(0.019) | 0.007<br>(0.020) | 0.005<br>(0.018) | –0.011<br>(0.015) |
| *leverage* | –0.013<br>(0.017) | –0.013<br>(0.018) | –0.020<br>(0.017) | –0.013<br>(0.013) |
| *Year* | Control | Control | Control | Control |
| *_cons* | –0.389<br>(0.504) | –0.406<br>(0.568) | –0.016<br>(0.516) | 0.289<br>(0.457) |
| N | 33 | 33 | 33 | 33 |
| F | 1.205 | 0.960 | 1.444 | 2.969 |
| $R^2$ | 0.387 | 0.396 | 0.497 | 0.670 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.*

The results show the following:

First, in eastern China, the re-innovation input of firms with failed innovation (*reinnov*) still has a significant positive impact on the firm performance ($\beta$ = 0.528, $p$<0.01). Moreover, the negative moderating effect of the government intervention level (*gover*) on the relationship between the re-innovation input and firm performance ($\beta$ = –0.423, $p$<0.05) and the positive moderating effect of the financial development level (*finance*) on the relationship between the re-innovation input and firm performance ($\beta$ = 0.280, $p$<0.01) still exists. In addition, compared with the regression results of the full sample, the moderating effect of the government intervention level (*gover*) is further enhanced. The coefficients of *reinnov*gover* change from –0.294 to –0.423, and the coefficients of *reinnov*finance* increase from 0.235 to 0.280. These changes show that because of the higher financial

marketization degree in eastern China, its role in promoting the relationship between the re-innovation input and firm performance is more obvious. The relatively high level of economic development also makes the overall market environment better, and improper or excessive government intervention restrains business activities. Therefore, we found that the higher the level of government intervention, the more obvious the inhibition effect on the relationship between the re-innovation input and firm performance.

Second, in central China, the positive impact of the re-innovation input of the firms with failed innovation on firm performance is still significant ($\beta = 1.928$, $p < 0.01$). However, in this situation, the moderating effect of the government intervention level and financial development level on the relationship between the re-innovation input and firm performance is no longer significant. The above results show that compared with the eastern region with its better institutional environment, the institutional environment factors have no significant impact on the relationship between the re-innovation input and firm performance in central China. The performance improvement of firms with failed innovation comes from their own re-innovation input. The firm's re-innovation activities require the investment of its own resources. This outcome also shows that there is room for further improvement in the construction of the institutional environment in central China compared with eastern China.

Third, in western China, the regression results of the sub-samples do not support the hypotheses. A possible reason is that because of the relatively backward level of economic development in western China, the limited production resources restrict the re-innovation input of the firm with failed innovation, making it difficult to carry out effective re-innovation activities, and the poor institutional environment cannot provide sufficient external support to the firms with failed innovation.

- ***Heterogeneity of firm ownership***

In order to further examine the possible heterogeneity of firm ownership in the positive impact of the re-innovation input on firm performance and in the moderating effect of institutional environment, the full samples were divided into state-owned firms and non-state-owned firms. The results of the regression analysis are shown in table no. 8.

**Table no. 8: The results of sub-sample regression according to firm ownership**

| | **State-owned Firms** | | | | **Non-state-owned Firms** | | | |
|---|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** |
| *reinnov* | 0.742*** (0.207) | 0.856*** (0.228) | 0.475** (0.218) | 0.777*** (0.211) | 0.324 (0.301) | 0.537 (0.346) | 0.277 (0.320) | 0.500 (0.364) |
| *gover* | | –0.002 (0.007) | | | | –0.009 (0.006) | | |
| *Reinnov *gover* | | –0.376 (0.259) | | | | –0.118 (0.224) | | |
| *finance* | | | 0.005* (0.003) | | | | –0.003 (0.005) | |
| *Reinnov *finance* | | | 0.296*** (0.100) | | | | 0.219* (0.121) | |
| *law* | | | | 0.001 (0.002) | | | | –0.003 (0.002) |
| *Reinnov *law* | | | | 0.075 (0.076) | | | | 0.014 (0.066) |
| *age* | –0.006*** (0.002) | –0.006*** (0.002) | –0.005** (0.002) | –0.006** (0.002) | –0.004*** (0.001) | –0.004** (0.002) | –0.004*** (0.001) | –0.004** (0.002) |

| | State-owned Firms | | | | Non-state-owned Firms | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *size* | 0.021*** (0.007) | 0.022*** (0.007) | 0.021*** (0.007) | 0.020*** (0.007) | 0.033*** (0.008) | 0.035*** (0.008) | 0.034*** (0.008) | 0.033*** (0.008) |
| *growth* | 0.011 (0.009) | 0.010 (0.009) | 0.010 (0.008) | 0.011 (0.009) | 0.002 (0.011) | 0.003 (0.011) | 0.002 (0.011) | 0.001 (0.011) |
| *leverage* | –0.009** (0.005) | –0.009** (0.005) | –0.010** (0.004) | –0.010** (0.005) | –0.007 (0.005) | –0.006 (0.005) | –0.006 (0.005) | –0.007 (0.005) |
| *Year* | Control | Control | Control | Control | Control | Control | Control | Control |
| *_cons* | –0.291* (0.150) | –0.300* (0.165) | –0.336** (0.146) | –0.291* (0.150) | –0.521*** (0.161) | –0.498*** (0.161) | –0.524*** (0.161) | –0.512*** (0.161) |
| N | 129 | 129 | 129 | 129 | 132 | 132 | 132 | 132 |
| F | 3.946 | 3.507 | 4.347 | 3.339 | 3.911 | 3.497 | 3.571 | 3.473 |
| $R^2$ | 0.251 | 0.266 | 0.310 | 0.257 | 0.244 | 0.261 | 0.265 | 0.259 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.*

Table no. 8 shows that in state-owned firms, the re-innovation input of the firm with failed innovation (*reinnov*) has a significant positive impact on firm performance ($\beta$= 0.742, $p <$ 0.01). In the non-state-owned firms, although the impact is still positive, it is not significant. The findings also conformed to the realistic characteristics of the ownership nature of China's firms at this stage. Generally speaking, state-owned firms have more advantages than non-state-owned firms in terms of firm size and resource acquisition ability, which is more obvious in pharmaceutical manufacturing firms. When a failed innovation occurs, the re-innovation input of state-owned firms will greatly affect the follow-up firm performance. This idea is mainly manifested in 2 aspects. First, compared with non-state-owned firms, state-owned firms are more likely to form a large-scale economy because of their scale advantages, and increase re-innovation input. Due to previous failure experiences, they upgrade production equipment and employ more R&D personnel to remedy the defects of production technology or product services. As a result, a large-scale economy is gradually formed, and the speed of firm re-innovation and the firm performance are improved. Second, because the scale and quality of R&D personnel in state-owned firms are stronger than that in non-state-owned firms, the increase of the re-innovation input will further enhance the accumulation of knowledge and technology capital, especially the absorption ability of failed knowledge, which is more conducive to improving the efficiency of re-innovation input to innovation performance and enhancing firm performance.

The results of the sub-sample regression show that the government intervention level (*gover*), financial development level (*finance*), and legal environment level (*law*) in institutional environment have no significant moderating effects on the relationship between the re-innovation input and firm performance in non-state-owned firms. In the state-owned firms, only the coefficient of *reinnov*finance* ($\beta$= 0.296) is significant at the level of 1%, which indicates that the improvement of the financial development level will enhance the positive impact of the re-innovation input on firm performance. The possible reason for this phenomenon is that the state-owned firms and the government often maintain a good government-firm relationship. Compared with non-state-owned firms, the state-owned firms can get more R&D subsidies, tax incentives, and other types of government compensation in the process of operation. Therefore, when a failed innovation occurs, the sensitivity of the government intervention to the stimulation of re-innovation

activities will be greatly reduced, that is, the driving effect of government intervention on the re-innovation decision-making of firms with failed innovation is not obvious. On the contrary, the increasing marketization of the financial industry will provide more flexible and effective financing methods for innovation firms. Market-oriented financial support reduces the difficulty of financing for firms' re-innovation, and the increase of re-innovation input will also promote the improvement of firm performance.

The above analysis results further show that more attention should be paid to non-state-owned firms to create an innovative environment tolerant of failure. Compared with state-owned firms, due to the relatively limited resource reserve and resource acquisition capacity, the impact of innovation failure on non-state-owned firms is often greater, resulting in the inadequacy of their re-innovation input intensity, which affects the improvement of firm performance by re-innovation activities. That is, the positive impact of the re-innovation input on firm performance is not significant, so the moderating effect of the institutional environment is not obvious.

- ***Robustness test***

In order to verify the robustness of the analysis results, the following tests were carried out in this study.

First, we changed the measurement of the dependent variable. In the process of regression analysis of the above hypothesis test, the proxy variable of firm performance was measured by the return on assets (*roa*). Using Zhong et al. (2018)'s approach, the empirical process was re-examined with the profit margin on sales (*ros*) as the proxy variable of firm performance. The results are shown in table no. 9.

**Table no. 9: Robustness test results of changing the dependent variable measurements**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *reinnov* | | 1.853*** (0.402) | 2.533*** (0.442) | 1.137*** (0.413) | 2.035*** (0.421) |
| *gover* | | | –0.020** (0.009) | | |
| *reinnov*gover* | | | –1.105*** (0.361) | | |
| *finance* | | | | 0.009 (0.006) | |
| *reinnov*finance* | | | | 0.818*** (0.174) | |
| *law* | | | | | –0.005* (0.003) |
| *reinnov* law* | | | | | –0.040 (0.102) |
| *state* | –0.092*** (0.022) | –0.085*** (0.021) | –0.084*** (0.021) | –0.083*** (0.021) | –0.088*** (0.021) |
| *age* | –0.010*** (0.003) | –0.007*** (0.003) | –0.008*** (0.003) | –0.007*** (0.003) | –0.008*** (0.003) |
| *size* | 0.048*** (0.013) | 0.048*** (0.012) | 0.052*** (0.012) | 0.047*** (0.012) | 0.050*** (0.012) |

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *growth* | 0.026 | 0.033** | 0.033** | 0.030* | 0.032** |
| | (0.017) | (0.016) | (0.016) | (0.016) | (0.016) |
| *leverage* | –0.018** | –0.017** | –0.018** | –0.017** | –0.019** |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| *Year* | Control | Control | Control | Control | Control |
| *_cons* | –0.653** | –0.707*** | –0.642** | –0.747*** | –0.721*** |
| | (0.260) | (0.251) | (0.252) | (0.242) | (0.251) |
| N | 261 | 261 | 261 | 261 | 261 |
| F | 5.411 | 7.244 | 7.261 | 8.507 | 6.386 |
| $R^2$ | 0.178 | 0.242 | 0.276 | 0.309 | 0.252 |

*Note: *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.*

The results of table no. 9 show that the effect of the re-innovation input (*reinnov*) on firm performance is still significantly positive ($\beta$= 1.853, $p < 0.01$). The government intervention level still has a significant negative moderating effect on the relationship between the re-innovation input and firm performance. The coefficient of *reinnov*gover* is –1.105, which reaches a significance level at 1%. The level of financial development still has a significant positive moderating effect on the relationship between the re-innovation input and firm performance. The coefficient of *reinnov*finance* is 0.818, which is significant at the level of 1%. The above analysis results are consistent with the results of the basic regression, which shows that the research results are robust.

Second, to solve the endogenous problem of reverse causality that may exist in the process of analysis, the firm performance of the dependent variable was set to lag for a period while multiple control variables were added to control the impact of firm heterogeneity. The reason for this is that the current performance of firms with failed innovation generally does not affect the previous re-innovation input. Thus, the endogenous problem was reduced to a certain extent, and the interference of endogenous errors on the regression results was avoided.

Third, the sub-sample tests of regional heterogeneity and firm ownership heterogeneity were carried out. The results of tables no. 5, no. 6 and no. 7 show that the results of the sub-sample test in eastern China are consistent with the results of basic regression. Table no. 8 shows the sub-sample test results of state-owned firms are generally consistent with the results of basic regression. Although the coefficient of *reinnov*gover* is not significant, its symbol is still negative, indicating that the research results are still robust.

## Conclusions

A multiple regression model was constructed to empirically test the mechanism of the institutional environment in the relationship between the re-innovation input and firm performance using 3 aspects (the level of government intervention, the level of financial development, and the level of legal environment) to explore the possible moderating effect of institutional environment factors on the relationship between the re-innovation input of a firm with failed innovation and firm performance. The following conclusions were drawn:

- The re-innovation input of a firm with failed innovation has a significant positive impact on the firm performance, and the increase of the re-innovation input intensity leads to the improvement of the firm performance.

- The level of government intervention and the level of financial development play a significant negative role and positive moderating role, respectively, in the relationship between the re-innovation input and firm performance, and the moderating effect of the legal environment is not obvious.

- In the sub-sample test of regional and firm ownership heterogeneity, we found that the relationship between the re-innovation input and firm performance is more prominent in eastern China than in other regions. The promotion of the financial marketization degree will further enhance the promotion effect of the re-innovation input of state-owned firms on firm performance.

This study has the following limitations:

- Although the China Marketization Index is widely used as a proxy variable to measure the institutional environment, it focuses on measuring the regional formal institutional environment but does not reflect regional differences in the informal institutional environment. Further research needs to consider both the formal and informal institutional environments.

- Due to the difficulty in obtaining the sample data of innovation failure, the sample data in this study consisted only of listed pharmaceutical manufacturing companies in China. It is necessary to further verify the robustness of the conclusions when other relevant sample data are available.

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