



A Study on the Misallocation Effect of Capital Combination on China's High-tech Industry

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This paper aims to investigate the misallocation effect of different capital combinations accumulated from R&D and non-R&D activity in China's high-tech industry. Using a conceptual model, the study first establishes an equilibrium combination derived from the firm's behavior, and then analyzes the misallocation situation in China's high-tech industry from 2003–2016. The findings indicate that the misallocation effect becomes clearer in the Chinese high-tech industry as input increases, and increased non-R&D activity worsens the misallocation.

Keywords: Capital combination, R&D expenditure, Non-R&D activity, Misallocation Effect

Introduction

Many countries have attempted to develop a high-tech industry by augmenting capital, as is the case with China. Statistical data show that from January to May 2019, investment in the Chinese high-tech industry grew by 11.9% as compared to the previous year. Despite the ubiquity of such investments, their effects are double-edged. On the one hand, significant investment may bring substantial growth for the high-tech industry and make it a genuine new engine for economic growth.^{1,2} On the other hand, enormous investment may reduce the production efficiency of the high-tech industry by decreasing total factor productivity (TFP) due to resource misallocation. Thus, this paper aims to investigate the relationship between various capital combinations accumulated from different activities and production efficiency loss. In other words, it determines if there is a misallocation effect in the Chinese high-tech industry and the degree of misallocation, if so.

A Conceptual Model

In general, misallocation effects on TFP are diagnosed in framework that detects how resource misallocation between firms can affect the TFP of an economy. A typical research, called the OP covariance analysis, was conducted in 1996 by Olley & Pakes.³

The OP covariance analysis establishes an elegant analysis framework and computable measure for resource misallocation effect. But it cannot be used to inquire misallocation effect of capital combination because capital is a proxy for productivity in that framework. In this situation, capital is looked as a whole, thus cannot be divided into different types to explore misallocation effect.⁴

To measure efficiency loss caused by different capital combinations, we follow three steps to establish a new analysis framework: a) provide certain propositions derived from stylized facts in China's high-tech industry; b) build a behavior model to obtain the equilibrium combination of capital accumulated from R&D and non-R&D activities on the basis of analyzing the representative firm's behavior; c) establish a computable measure to measure misallocation of capital combination, as OP covariance analysis framework did.

Step 1: Provide propositions

As a preliminary component of the behavior model, three key propositions are provided to define key characteristics related to our research issues in the investment situation of the Chinese high-tech industry.

Proposition 1: It is necessary to probe misallocation effects of capital more carefully, for example, by deconstructing capital into different sources instead of considering it as a whole (as was done by OP covariance analysis).

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Proposition 2: Compared to investment on non-R&D activities, R&D investment is of vital importance for Chinese high-tech firms. R&D investment brings not only short-run profit but also long-run competitiveness.⁵

Proposition 3: Certificate of High and New Technology Enterprise policy plays a decisive role in the firm's investment choice in Chinese high-tech industry. Racing for certificates of high and new technology enterprise may induce excessive R&D investment, which can cause misallocation of capital combination.⁶

Step 2: Build model

Our economy is composed of two typical firms—firms with a Certificate of High and New Technology Enterprise and firms without this Certificate, dominated by F_H and F_N . Both firms are price-takers in input markets and output markets. So price of capital and labor are supposed to be given, denoted by r and w . Let $\pi_{F_H}, P_C, Y_{F_N}, K_{F_N}, L_{F_N}$ be F_N 's profit, price for output, output, capital usage, labor usage, and $\pi_{F_H}, Y_{F_H}, K_{F_H}, L_{F_H}$ be F_H 's profit, price for output, output, capital usage, and labor usage.

Labor in each firm can be divided into two types: workers who are engaged in non-R&D activity, whose output and efficiency are mainly determined by operational investment, such as fixed asset; and personnel who are engaged in non-R&D activity, whose output and efficiency are mainly determined by R&D expenditure. Based on cost and efficiency, a firm's rational choice will cause a functional relationship between capital and labor, which we define as $L_w = \phi(K_{non-R\&D})$.

For this reason, $L_w = \psi(K_{R\&D})$, where $K_{non-R\&D}$ and $K_{R\&D}$ represent investment on R&D and non-R&D activities, respectively. For simplicity and without loss of generality, we define $L_w = \phi(K_{non-R\&D}) = \alpha K_{non-R\&D}$, whereas $L_p = \psi(K_{R\&D}) = b K_{R\&D}$. Meanwhile, we assume the aforementioned product function takes a Cobb-Douglas functional form: $F(K_{R\&D}, K_{non-R\&D}) = K_{R\&D}^\alpha K_{non-R\&D}^{1-\alpha}$. To solve $\max \pi_{F_N} = P_C F(K_{R\&D}, K_{non-R\&D}) - r[K_{R\&D} + K_{non-R\&D}] - w[\alpha K_{non-R\&D} + b K_{R\&D}]$. We can get: $MRPK_{non-R\&D} = \frac{r+wa}{P_C}$; $MRPK_{R\&D} = \frac{r+wb}{P_C}$.

By virtue of the Cobb-Douglas production function, marginal revenue products can be also proportional to their average revenue product

counterparts: $ARPK_{R\&D} = \frac{1}{\alpha} MRPK_{R\&D} = \frac{r+wb}{\alpha P_C}$; $ARPK_{non-R\&D} = \frac{1}{1-\alpha} MRPK_{non-R\&D} = \frac{r+wa}{(1-\alpha)P_C}$; Then, the equilibrium combination of capital from R&D activity and non-R&D activity for F_N measured by one unit $K_{R\&D}$ is $\left[1, \frac{\alpha(r+wa)}{(1-\alpha)(r+wb)}\right]$

Because of the requirement (proportion of R&D investment to sales revenue at the same time), capital from R&D activity in F_H is more than that in F_N . We assume it to be $\theta K_{R\&D}$. We also define $L_w = \phi(K_{non-R\&D}) = c K_{R\&D}$, and $L_p = \psi(K_{R\&D}) = d K_{non-R\&D}$, the parameter is different from those of F_N .

Following the same way, we can get the equilibrium combination of capital from R&D activity and non-R&D activity for F_H measured by one unit $K_{R\&D}$ is $\left\{1, \frac{\alpha(r+wd)}{(1-\alpha)[r(1+\theta)+wc]}\right\}$.

Suppose $\sum_{i=1}^n K_{Ni} = A$ and $\sum_{j=1}^m K_{Hj} = B$, which indicate total capital input in the sum of firms with and without certificate of high and new technology enterprise, we can calculate the equilibrium combination of capital from R&D and non-R&D activities for the high-tech industry is as follows:

$$\begin{aligned} & \left[\frac{(1-\alpha)(r+wb)}{r+wb-w\alpha(b-a)} A \right. \\ & \left. + \frac{(1-\alpha)[r(1+\theta)+wc]}{r(1+\theta)+wc(1-\alpha)-\alpha(r\theta-wd)} B, \right. \\ & \left. \frac{\alpha(r+wa)}{r+wb-w\alpha(b-a)} A \right. \\ & \left. + \frac{\alpha(r+wd)}{r(1+\theta)+wc(1-\alpha)-\alpha(r\theta-wd)} B \right] \end{aligned}$$

Step 3: Establish measures

Now, we define the aforementioned equilibrium combination as $(K_{R\&D}^*, K_{non-R\&D}^*)$ and the actual combination as $(K_{R\&D}, K_{non-R\&D})$. $\sqrt{(K_{R\&D} - K_{R\&D}^*)^2 + (K_{non-R\&D} - K_{non-R\&D}^*)^2}$ can be used to measure the degree of misallocation effect. The larger the value of the equation, the worse the degree of misallocation effect.

Estimation and Quantitative Analysis

To make the measurement of misallocation more feasible, we first describe estimation procedures for parameters of our model. (1) Equilibrium combination is supposed to be the combination that achieves the

highest production efficiency. DEA is used to get the targeting equilibrium combination.^{7,8} (2) Non-dimensionalize the targeting equilibrium combination to get the comparable measuring standard between different combination so as to get an observable proxy for misallocation effect.

Data and DEA result

Using data from the China Statistic Yearbook on High-Tech Industry (2003–2016), DEA results are

presented in Table 1, and the degree of misallocation in different years is described in Table 2.

Findings

Results in Table 2 confirm misallocations in China's high-tech industry from 2003–2016. As inputs from both R&D and non-R&D activities increase, the degree of misallocation worsens. When the capital accumulated from R&D activities and capital from non-R&D activities are somewhat equal, the degree of

Table 1 — DEA results for Equilibrium Combination

Output orientated DEA

Scale assumption: VRS

Single-stage DEA - residual slacks presented

EFFICIENCY SUMMARY:

	Crste	Vrste	Scale
2003	0.493	1.000	0.493
2004	0.957	1.000	0.957
2005	0.928	0.948	0.979
2006	0.893	0.896	0.996
2007	1.000	1.000	1.000
2008	0.657	0.823	0.798
2009	0.804	1.000	0.804
2010	0.679	0.969	0.701
2011	0.573	0.935	0.613
2012	0.519	0.946	0.549
2013	0.497	0.950	0.523
2014	0.458	0.914	0.501
2015	0.053	0.947	0.056
2016	0.488	1.000	0.488

Table 2 — The degree of misallocation in different year

	Standardized actual combination	Equilibrium combination	Degree of misallocation
2003	(0.46, 0.44)	(1,1)	0.78
2004	(0.57, 0.56)	(1,1)	0.62
2005	(0.72, 0.68)	(1,1)	0.43
2006	(0.94, 0.79)	(1,1)	0.22
2007	(1.00, 1.00)	(1,1)	0.00
2008	(1.65, 1.14)	(1,1)	0.66
2009	(1.62, 1.27)	(1,1)	0.68
2010	(2.15, 1.50)	(1,1)	1.26
2011	(2.99, 1.98)	(1,1)	2.22
2012	(4.16, 2.38)	(1,1)	3.45
2013	(4.94, 2.74)	(1,1)	4.30
2014	(5.88, 3.01)	(1,1)	5.28
2015	(7.31, 3.37)	(1,1)	6.74
2016	(6.63, 3.85)	(1,1)	6.31

misallocation will be less. If capital from non-R&D activities is more than the capital from non-R&D activities proportionally, the situation of misallocation will have a clear trend of remarkable deterioration.

Conclusions

Input (investment) is necessary for China's high-tech industry. However, the proportion of inputs on R&D and non-R&D activities is more important, because inappropriate proportions may cause misallocation. This research will contribute towards a behavior model to investigate the situation of misallocation in China's high-tech industry. As a result, we provide a computable measurement of misallocation. We find that if capital accumulated from non-R&D activities, it is dominantly more than capital accumulated from R&D activities, the misallocation is worsening. Our findings suggest that input on R&D activities is a suitable method to propel China's high-tech industry development as excess inputs on non-R&D activities have a significant likelihood of triggering misallocation. The estimation of parameters in our model is a major area for future research.

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