

# Study on Economy Growth and Employment of R&D Based on Empirical Analysis with VAR

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**Abstract:** With slow growth and quality priority as the main characters of “New Normal” in economy, R&D is one of the main methods for improving quality and efficiency of economy and industrial transformation and upgrading. VAR model was constructed to analyze the impacts of R&D to economy growth and employment based on data of R&D, GDP and employment among 1996 and 2015. It shows that R&D brings obviously promotion to economy growth and significantly related to employment. However, Continuous reinforcement of R&D input is required because of high attenuation of impacts, and well education system and enough reserve of talents are needed because of employment fluctuation due to R&D, according to impulse analysis.

## 1. Introduction

The development of economy will shift from high growth to lower growth for the great effects of the Three Period Superimposed still working, as well as disappearance of demographic dividend, resource rent, and weakness of international trade. That is New Normal of China’s economy development. In order to stabilize growth of the economy, it is innovation that should be the main driving force, not the factors nor the investment. Chairman Xi proposed in the 18th CPC National Congress that the scientific and technological innovation is the strategy support of improving social production and national strength, which should be placed at the core of the overall national development strategies. It is called the strategy of innovation-driven development. The road of China to strong industry, strong economy and strong country driven by strong talents and strong science and technology was clearly proposed in the 19th CPC National Congress, which means the important role of innovation, experts and science and technology to economy development <sup>[1]</sup>. The strategy of innovation-driven development is the common choice of developed countries and also the important choice of China <sup>[2]</sup>, as the engine and source to out of economic growth slowdown. R&D is an important factor of innovation as a pillar, which has been a hotspot of research while more and more attention has been paid on innovation. Though R&D in 2015 was 2.07% to GDP as a new height, it still much lower than 2.38% of OECD countries <sup>[3]</sup>. R&D is both sides to employment. It may improve the productivity with fewer employees (productivity-side), and also may enlarge the enterprise scale with more employees (scale-side). R&D impacts not only technology progress but also employment and economy development. Therefore, the relationships among R&D, GDP, and employment were focused in this paper to analyze the impact extent of R&D to economy development and employment.

## 2. R&D and Endogenous Economic Growth

Studies of Solow, Denison and some others concluded the economy development of America to technical progress. In 1980s, the theory of endogenous economic growth proposed by Romer, Grossman, Helpman etc. regarded R&D as an input factor of “Knowledge Production”<sup>[4]</sup>, which taking the progress of science and technology as the main factor of economic development. Domestic scholars also agree with this argument of positive role according to their studies on view of macro, medium, and micro. In macro view, the level of productivity, represented by the total factor

productivity (TFP) usually, is proved to be related to R&D inputs in Cobb-Douglas production function [5; 6]. It is well known that R&D will promote GDP growth a lot. However, there is no evidence that the progress of economy will promote R&D inputs remarkably [7; 8]. The investment intensity of R&D has not been optimized in China with a big margin, and the rate of return on investment (ROI) of R&D is better than that of capital, compared to developed countries.

Literatures on the relationship between R&D and employment are a little bit less relatively, which was mainly focus on the amount and structure of employment related to technical progress and innovation. R&D may promote employment by technical progress and economy growth. Abroad and domestic researches show the relationship of technical progress and total employment is an interactive and complicated relationship. There is a view that technical progress is a “double-edged sword” to employment with both promotion and depression effect. Therefore, the impact of innovation and technical progress cannot be generalized, which should be analyzed according to corresponding industry, labor, technology and other factors. Factually, different types of technical progress may get different effects according to different types of industry, structure and labor talents.

Therefore, a VAR model was constructed to show the lagging effects of R&D investments to economy growth and employment, as well as their dynamic relationship through associated variables in this paper.

### 3. VAR Model Construction and Empirical Analysis

#### 3.1 VAR Model Construction

Instability and heteroscedasticity be tested and avoided so as to ensure the evaluation results more stable and effective, and no fake regression model will be constructed. ADF test to every variable is the common method of stability test. The ADF test results were listed in the following table after logarithmic transformation to each variable.

Table 1. ADF Test Results

Variable	Lagging	ADF Value	1% Threshold	5% Threshold	10% Threshold	Results
LNRD	2	-6.267	-3.887	-3.052	-2.667	Stable(*)
LNEMPLOYMENT	2	-3.816	-3.887	-3.052	-2.667	Stable(**)
LNPER_GDP	1	-3.064	-3.857	-3.040	-2.661	Stable(**)

According to the rule of AIC and SC to avoid multiple collinear problems, VAR(2) model with 2 lags was constructed as the follows.

$$\begin{aligned}
 & \begin{bmatrix} \text{LNRD} \\ \text{LNEMPLOYMENT} \\ \text{LNPER\_GDP} \end{bmatrix} \\
 &= \begin{bmatrix} -0.006767 \\ 0.001110 \\ 0.002654 \end{bmatrix} \\
 &+ \begin{bmatrix} -0.343183 & -0.328704 & -0.033394 \\ 0.033827 & -0.031471 & -0.037593 \\ 0.220026 & 1.113669 & -0.702953 \end{bmatrix} \begin{bmatrix} \text{LNRD}_{t-1} \\ \text{LNEMPLOYMENT}_{t-1} \\ \text{LNPER\_GDP}_{t-1} \end{bmatrix} \\
 &+ \begin{bmatrix} -0.305405 & -0.451194 & -0.134980 \\ 0.008553 & 0.041188 & -0.053515 \\ 0.120579 & 0.403288 & -0.756815 \end{bmatrix} \begin{bmatrix} \text{LNRD}_{t-2} \\ \text{LNEMPLOYMENT}_{t-2} \\ \text{LNPER\_GDP}_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}
 \end{aligned}$$

As table 2 shows, most T statistical value of VAR regression are remarkable under 10% confidential level of 10%. The model with 2 lags is regarded as acceptable though there are still a few T statistical values unremarkable for heteroscedasticity caused by lags. And the stability of VAR model should be paid more attention, not remarkable of coefficients relatively.

Table 2. T Statistical Value of Variables

Variable	LNRD <sub>t-1</sub>	LNEMP <sub>t-1</sub>	LNPER_GDP <sub>t-1</sub>	LNRD <sub>t-2</sub>	LNEMP <sub>t-2</sub>	LNPER_GDP <sub>t-2</sub>	C
LNRD	-0.9074	0.46629	0.54685	-0.96263	0.14055	0.35725	-0.38733
LNEMP	0.46629	-0.09475	-0.59181	0.14055	0.117786	-0.89726	0.33117
LNPER_GDP	0.54685	0.60452	-1.99532	0.35725	0.20807	-2.2879	0.1428

### 3.2 Variance Decomposition Analysis

The impulse response analysis mainly shows the dynamic tendency of observation variable after the shock of the other variable. However, as we all know, observed effect is usually a terminal and compound result from different effects of different variables. Variance decomposition can decompose the variance to every perturbed term in VAR model. Therefore, the method of variance decomposition analysis can analyze the extent of impact to endogenous variables from every perturbed period. Variance of estimation in different period can be decomposed to LNEMP, LNPER\_GDP and LNRD in percentage as table 4 shows.

Table 3. Variance Decomposition Table

Period	S.E.	D(LNEMP,2)	D(LNPER_GDP,2)	D(LNRD,2)
1	0.013237	6.841244	56.73017	36.42859
2	0.013349	8.010603	56.68243	35.30696
3	0.013623	8.747418	57.36234	33.89024
4	0.013885	8.478791	59.46656	32.05465
5	0.013931	8.616700	59.35043	32.03287
6	0.014034	8.433008	60.32631	31.24068
7	0.014077	8.478111	60.44429	31.07760
8	0.014096	8.486101	60.56515	30.94875
9	0.014127	8.462841	60.76585	30.77131
10	0.014132	8.514822	60.71634	30.76884

According to the above table, the shock of LNRD influences itself firstly in a gradually diminishing way. The influence to LNEMPLOYMENT increases in the first three periods and gets stable a little less than period 3 in the following periods. The influence to LNPER\_GDP is totally in an increasing way and the increasing speed gets slow from period 4. The contribution rate of LNRD to LNEMPLOYMENT is at a level of about 10% with little fluctuation. The contribution rate of LNRD to LNPER\_GDP increases from about 55% to 60% in the beginning 4 periods and gets stable at 60% in the subsequent periods. In view of fluctuation cycle, investment of R&D usually gets much higher ROI (Return of Investment) at period 3 or 4. In short, investment of R&D influences the economic growth more obviously, but not so obviously for employment in current development stage of China.

### 4. Conclusions

According to the above empirical analysis, there are mainly three conclusions. Firstly, the growth rate of GDP per capita and employment of the secondary and the tertiary industry are positive correlated to the growth rate of R&D investment. As a granger causer of the GDP per capita, investment of R&D may promote economy. On current slow down time of economy growth, it is the effective way to fulfill economy engine exchange by improving innovation and productivity that drives economy, not by investment. Therefore, it is most important to ensure the R&D investment for economy continuous growth and society development. R&D is also a granger causer of employment to promote employment of the secondary and the tertiary industry. That is to say, scale-side influence is more obviously than productivity-side influence now. Secondly, the influence of R&D to GDP and employment were obvious delay according to the empirical data, with different lagging pattern. In the short term, R&D promotes the GDP and employment directly and obviously, but in the long term, the

influence becomes weaker and weaker. According to the lagging pattern and R&D investment structure of fundamental research, applied research and experimental research, current R&D are mainly focused on short period, fast commercialization for short-term profits, as much coincident to the empirical analysis. Thirdly, according to the variance decomposition analysis, the investment of R&D now promotes economy growth much. But in order to maintain steadily progress under the economy framework of the new normal and supply-side reform, high R&D investment to increase productivity and innovation for industry structure adjusting and upgrading is mostly essential.

Therefore, expand the share of R&D in GDP is recommended firstly because R&D may promote economy growth. Our share of R&D in GDP is much smaller than developed countries. And private R&D also should be encouraged financial organization and private capital to investment R&D as market behaviors to promote the whole economy prosperity. Current governmental R&D investment share is much higher with much more limitation. Secondly, government should pay more attention on fundamental research which may provide more development engine, though it would be more slow and low profits. An evaluation system of R&D investment on government should be constructed to keep R&D structure more reasonable and sustainable. Thirdly and last, education is the key of innovation and progress. New technology needs new and well educated employees. Well educated graduated full of innovation and creativity may promote technical progress. So education and R&D are dual engines of economy progress.

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