TEST Engineering & Management

July-August 2020
ISSN: 0193-4120 Page No. 1413- 1426

DSGE Analysis of Knowledge-Intensive Industry and South Korea's Economic Growth

Shuqiang Liu[a, 1, 3, *], Dawei Zhao[b, 1], Zhaohua Jiang[c, 2]

[1] School of Economics and Management, Harbin University of Science and Technology, Harbin 150080, China

[2] Faculty of Humanities and Social Sciences, Dalian University of Technology, Dalian 116000, China

[3] School of Economics and Management, Heilongjiang Institute of Technology, Harbin 150050, China

[a]hgclsq@126. com; [b]37980627@qq. com; [c] 57996924@qq. com

Article Info
Volume 83
Page Number: 1413- 1426
Publication Issue:
July-August 2020

Abstract

Based on the synergy theory of economic growth and the theory of supply-side structural reform, this paper establishes a dynamic stochastic general equilibrium model group of economic growth in South Korea, does the in-depth research on urbanization, industrialization, informatization, agricultural modernization, foreign debt, population, assets-liability ratio, industrial capacity utilization ratio, financial expenditure, mid-to-high end industry, research and development personnel of university, funds from abroad, basic research funds, research and development personnel of private enterprise, technology trade, export, FDI, environmental protection funds/GDP, environment-related taxes, the proportion of high energy-consuming industries, fixed capital stock and so on, which affect economic growth, fiscal revenue, interest rate, exchange rate, non-performing loan, employment, fixed assets investment, human capital, science and technology, energy consumption, carbon emission, pollutant emissions, etc. , and establishes the relation models among them, constructs the DSGE equation group. MATLAB software is used to solve the models and simulate the simulation. Thus, it provides the experiences for the high quality of mid-to-high growth of China under the new normal condition.

Article History
Article Received: *06 June 2020*
Revised: *29 June 2020*
Accepted: *14 July 2020*
Publication: *25 July 2020*

Keywords: *South Korea, Mid-to-high economic growth, Innovation-driven, Knowledge-intensive industry, Dynamic stochastic general equilibrium model*

1. Introduction

With the development of China's economic growth rate from rapid growth stage of 10% to the medium-high growth stage of 7%, the driving force structure of economic growth needs to be adjusted and changed, so that achieve the goal of medium-high rate of growth in the new normal economy. It is increasingly focused on and studied by economists that whether we can realize the rapid growth of economy under the new driving force structure of innovation-driven as the first driving force. South Korea grew at a high rate with growth rate of more than 8% from 1960 to 1985, while achieved the medium-high growth (not the same as Japan), with an average growth rate of 7% from 1986 to 2002. Therefore, this paper uses DSGE method to study the relationship between development of knowledge-intensive industry, innovation-driven and med-to-high growth of economy in South Korea during the period of 1986 to 2002. As an outcome of the Henan provincial department of transportation's "Research on the Reform of the Transportation Supply-side Structure of Henan Province" (2017G3), which provides experiences for China.

2.THE MODEL GROUP OF SOUTH KOREAN ECONOMIC GROWTH

The DSGE model has gradually received more and more attention in the economic field [1]-[5]. The South Korean DSGE model group is composed of several departments, such as resident department, enterprise department, science and technology department, foreign trade department, monetary department, finance department, environment department and so on.

2.1 The model of resident department

According to the theory of supply-side structure reform, promoting urbanization, informatization, industrialization and agricultural modernization are the important themes of the reform of regional economic structure, and these structural changes have promoted the structure of human capital and labor force provided by families, promoted the high quality growth of human capital and employment, and thus promoted the rapid economic growth.

The model of resident department includes information model, the relation models of urbanization, informatization, industrialization, agricultural modernization, and fixed assets investment, science and technology, years of per capita education, employment, unemployment and so on.

2.1.1 The model of informatization

For South Korea, by the available data, the model of informatization is

$$INF_{t-2} = a_1 TE_{t-2} + a_2 EL_{t-2} + a_3 ICT_{t-2}$$

INF_{t-2} , TE_{t-2} , EL_{t-2} , ICT_{t-2} respectively mean, the informatization index, internet users, communication and computer service accounts for the proportion of service export, added value of electronic information industry accounts for industrial added value, ICT investment. a1, a2 and a3 represent the contribution of three indicators to information, that is, weight coefficient. The principal component analysis method is used to solve the coefficients.

2.1.2 The model of urbanization, informatization and years of per capita education

According to the theory of agglomeration, cities and towns usually have better cultural and health conditions and better educational conditions, which make the level of urban citizens' education generally higher than that in rural areas[8], so the model of urbanization, informatization and years of per capita education is:

$$E_t = a_4 + a_5 URB_{t-2} + a_6 INF_{t-2}$$

Where E_t represents years of per capita education, URB_{t-2} represents urbanization.

2.1.3 The model of urbanization etc. and employment

Urbanization, industrialization, informatization, and agricultural modernization promote employment, and the number of jobs depends mainly on the size of the urban population at the same time.

Suppose the South Korean model of four modernizations and employment:

$$L_t = a_7 + a_8 \left[URB_{t-2} * \mathrm{IND}_{t-2} * \left(1 + INF_{t-2}\right) * AGR_{t-2} \right] + a_9 PO_t$$

In the above model, L_t represents the number of employed persons, PO_t represents population, IND_{t-2} represents industrialization (tertiary industry as the proportion of GDP), AGR_{t-2} represents agricultural modernization (agricultural productivity).

2.1.4 Employment rate Model

When the economic operation efficiency and the productive capacity utilization rate are high, namely when the economy is in the rising period of economic cycle, the employment rate is high, conversely the employment is low, thus the employment rate model is

$$EE_t = a_{10} + a_{11} EFF_t + a_{12} CU_t$$

Where EE_t represents employment rate, EFF_t represents economic operational efficiency (resource allocation efficiency), CU_t represents capacity utilization.

ISSN: 0193-4120 Page No. 1413- 1426

2.2 The model of science and technology department

2.2.1 The model of international papers

$$GP_t = a_{13} + a_{14}N_t + a_{15}YJ_t + a_{16}FC_t$$

Where GP_t represents S&T articles in all fields combined, N_t represents researchers in universities, YJ_t represents foreign research and development expenditure, FC_t represents basic research funding. [10]

2.2.2 The model of the patents granted in the United States patent office and PCT patent

$$USP_t = a_{17} + a_{18}(\mathrm{GP}_t + PN_t) + a_{19}TR_t$$

USP_t represents the patents granted in the United States patent office and PCT patent, PN_t represents researchers of private enterprises[11], TR_t represents the scale of technique trade[12].

2.2.3 The model of informatization etc. and science and technology input

According to the theory of agglomeration, as the center of knowledge, information and skills, cities constantly gather scientific and technological strength, thus the level of science and technology constantly improves[6] [7].

$$S_{t-2} = a_{20} + a_{21}INF_{t-2} * HI_{t-2} + a_{22}URB_{t-2}$$

Where S_{t-2} means technology input.

2.3 The model of enterprise department

2.3.1 Economic growth model

LIU (2006) and others[9] pointed out that the added value (national income) included the property income brought by investment as well as the mixed income of operation income derived from operating and managing these investments. The rapid increase in such mixed income has increased the total amount of capital on the one hand and provided the impetus to China's economic growth on the other. It was an important reason for the expansion of Chinese residents (mainly urban residents) income distribution gap after the reform and opening up. In accordance with this logic, the national income can be decomposed as the following:

GDP= laborers' income +investments' income + mixed income

It is shown that establishing the universal economic growth model which includes the factors of science and technology input and institutional innovation and so on should embark from some kind of basic economic principles.

The synergy theory of economic growth is to decompose the gross domestic product into compensation of employees, investors' interests and synergy benefits, and use the method of income value decomposition to study economic growth. This can be expressed as:

GDP= compensation of employees + investors' interests + synergy benefits

The "synergy benefits" is similar to the "Provident Fund" in the stock company's account, which is "the third" independent of the compensation of employees and investors' interests, and is the source of expanding reproduction and improving innovation ability. The mutual benefit is to some extent the common and shared interests of the laborer, the investor and other stakeholders, but cannot be clearly divided into the interests of either party. Thus, according to the synergy theory, economic growth model of South Korea for the 1990 to 2013 period is:

$$Y_t = (E_t * L_t * L_t)^{a_{23}} (S_{t-2} * D_t / L_t)^{a_{24}} + a_{25}K_{t-1} + a_{26}S_{t-2}D_tE_tL_t / {K_{t-1}}^2$$

Where Y_t represents GDP, L_t represents labor, K_{t-1} represent fixed capital stock in the previous period (in the case of annual data, the fixed capital stock at the end of the year), D_t represent fixed assets investment, S_{t-2} represents technology investment(ahead of two phases), E_t represents years of per capita education. $(E_t * L_t * L_t)^{a_{23}} (S_{t-2} * D_t / L_t)^{a_{24}}$ represents compensation of employees, $a_{25}K_{t-1}$ represents investors' interests, $a_{26}S_{t-2}D_tE_tL_t / {K_{t-1}}^2$ represents synergy benefits.

July-August 2020
ISSN: 0193-4120 Page No. 1413- 1426

2.3.2 Efficiency decomposition model

Suppose that efficiency decomposition model:

$$EFF_t = a_{27} + a_{28} INF_{t-2} * CU_t + a_{29} DRT_t * CH_t / (IND_{t-2})$$

In the above model, CU_t means capacity utilization rate, DRT_t means asset-liability ratio, CH_t means exchange rate.

2.3.3 The model of real estate and fixed assets investment

According to the leading role of real estate and knowledge-intensive industries, the following model is established.

$$D_t = a_{30} + a_{31} FE_t * HI_{t-2} / ES_t + a_{32} ES_t$$

In the above model, ES_t represents numbers of new houses.

2.3.4 The model of urbanization and fixed assets investment

Urbanization has improved the investment demand of urban infrastructure and housing, and every link of urbanization has stimulated the development of related industries and increased investment demand. Suppose the South Korean model of urbanization and fixed assets investment :

$$D_t = a_{33} + a_{34} URB_{t-2} + a_{35} HI_{t-2}$$

D_t represents fixed assets investment, HI_{t-2} represents the value-added of the knowledge-intensive industry.

2.4 The export model of foreign trade department

The export model is :

$$Y_t - C_t = a_{36} + a_{37} D_t + a_{38} EX_t$$

Where C_t means consumption, EX_t represents amounts of exports.

2.5 The model of monetary department

2.5.1 M2 model

$$M2_t = a_{39}((E_t * L_t * L_t)^{a_{40}} (S_{t-2} * D_t / L_t)^{a_{41}} + a_{42} K_{t-1} - C_t) + a_{43} ED_t$$

ED_t represents external debt.

2.5.2 The model of non-performing loans:

$$NPL_t = a_{44} + a_{45} DRT_t * (1 - EE_t) * CH_t$$

The formula of NPL_t (called weighted non-performing loans increment) is

$$NPL_t = NP_t - 0.52 NP_{t-1}$$

Where NPL_t means non-performing loans, DRT_t means asset-liability ratio, EE_t means employment rate, CH_t means Korean Won against the U.S.dollar[13].

2.5.3 The model of exchange rate model

According to the exchange rate formation mechanism, the model of exchange rate is

$$CH_t = a_{46} + a_{47} ED_t / Y_t + a_{48} FDI_t / Y_t$$

Where CH_t represents exchange rate, ED_t represents foreign debt[14] [15].

2.5.4 The model of interest rate

According to the adjustment rules of interest rate, the model of interest rate is

$$R_t * 100 = a_{49} Y_t * P_t / YP + a_{50} M2_t / M2$$

R_t represents interest rate, Y_t represents gross domestic product, Y represents the trend value of gross domestic product, P_t represents price, P represents the trend value of the price, $M2$ represents the trend value of $M2_t$.

2.5.5 The model of loans

$$LO_t = a_{51} HI_t / R_t + a_{52} R_t^2 + a_{53} FE_t$$

FE_t represents fiscal expenditure.

2.6 The model of financial sector

$$FB_t = a_{54} + a_{55}FE_t + a_{56}ED_t * (1 - EE_t)$$

In the model, FB_t means financial revenue, FE_t means fiscal expenditure, ED_t means external debt.

2.7 The model group of environment department

2.7.1 Energy consumption model

$$EC_t = a_{57} + a_{58}INF_{t-2} * HI_{t-2} + a_{59}\, IND_{t-2} * S_{t-2} / (Y_t * EDI_t)$$

EC_t represents energy consumption, EDI_t represents the added value of energy-intensive industry as a proportion of GDP[16].

2.7.2 Carbon emission model

$$CE_t = a_{60} + a_{61}EC_t + a_{62}\left[IND_{t-2} * \left(1 + INF_{t-2}\right) * S_{t-2}\right] / (Y_t * EDI_t)$$

CE_t represents carbon emission.

2.7.3 Pollutant emission model

$$PE_t = a_{63} + a_{64}EF_t + a_{65}EC_t \,/\, (\mathrm{ER}_t * \mathrm{IND}_{t-2} * INF_{t-2} * S_{t-2} * HI_{t-2} / Y_t)$$

PE_t represents pollutant emission, EF_t represents ratio of environmental expenditure to GDP, EC_t represents energy consumption, ER_t represents environmentally related tax revenue, HI_t represents the added value of mid-to-high end industry.

2.8 Objective function

The objective function of the entire economic system is shown in the formula below.

$$E_0\left[\sum_{t=0}^{\infty} \beta^t U(C_t, M_{2t} / P_t, L_t)\right]$$

U means utility function, which E means expectation, β^t means discount factor.

These models above constitute the basic framework of the DSGE model of the South Korean economic system. P_t is state variable, [NPL_t , EFF_t , R_t , $M2_t$, Y_t , INF_{t-2} , D_t , S_{t-2} , L_t , E_t , ES_t , EC_t , CE_t , PE_t , GP_t , USP_t , EE_t, C_t, CH_t, GR_t LO_t] are control variables, and [ED_t , EL_{t-2} , ICT_{t-2} , TE_{t-2} , URB_{t-2} , IND_{t-2} , AGR_{t-2} , PO_t , DRT_t , CU_t , FE_t , HI_{t-2} , EF_t , ER_t , EDI_t , FDI_t , YJ_t , N_t , FC_t, PN_t, TR_t, EX_t , K_{t-1}] are random variables.

3. LOGARITHMIC LINEARIZATION AND PARAMETRIC SOLUTION OF THE MODEL

In order to transform the non-linear model into a good enough linear model, a relatively simple logarithmic linearization method is proposed by Harald Uhlig. Consider general variable X_t, define $X_t = X(1 + x_t)$,where the capital X without the subscript is the trend value of X_t , x_t denotes the deviation of the volatility components of a variable from the trend value X . Because x_t is close to 0, thus $e^{x_t} = 1 + x_t$. Based on the South Korean's data from the period of 1990 to 2013, Bayesian estimation and econometric methods are used to estimate parameters, and all of the above models can be linearized into the following model systems:

（1） $0 = c_t + p_t - 7.5E_t p_{t+1} - 0.3m_t$

（2） $0 = -eff_t + 0.066\inf_{t-2} - 0.001dr_t - 0.001ch_t + 0.001ind_{t-2} + 0.067cu_t$

（3） $0 = -npl_t + 0.1dr_t + 0.03ee_t + 0.094ch_t - 0.037lo_t$

（4） $0 = -r_t + 10.1y_t - 0.16p_t + 2.4m2_t$

（5） $0 = -m2_t + 0.9d_t - 0.45c_t + 0.586ed_t$

（6） $0 = -y_t + 0.6842e_t + 0.45215l_t + 0.22d_t + 0.20286k_{t-1} + 0.22s_{t-2}$

（7） $0 = -\inf_{t-2} + 0.4012te_{t-2} + 0.2854el_{t-2} + 0.3149ict_{t-2}$

（8） $0=-d_t+0.6urb_{t-2}+0.4hi_{t-2}$

（9） $0=-l_t+0.18urb_{t-2}+0.18ind_{t-2}+0.07\inf_{t-2}+0.18agr_{t-2}+0.62po_t$

（10） $0=-s_{t-2}+0.6\inf_{t-2}+0.47urb_{t-2}+0.6hi_{t-2}$

（11） $0=-e_t+2.11urb_{t-2}+0.22\inf_{t-2}$

（12） $0=-es_t+4.1d_t-1.14fe_t-1.14hi_{t-2}-agr_{t-2}$

（13） $0=-pe_t-0.831ef_t+0.084ec_t-0.084er_t-0.084ind_{t-2}-0.084\inf_{t-2}-0.084s_{t-2}+0.084y_t-0.084hi_{t-2}$

（14） $0=-ce_t+1.205ec_t-0.224ind_{t-2}-0.224s_{t-2}+0.224y_t+0.224edi_t-0.09\inf_{t-2}$

（15） $0=-ec_t-0.1323\inf_{t-2}-0.1323hi_{t-2}-0.03ind_{t-2}-0.03s_{t-2}+0.03y_t+0.03edi_t$

（16） $0=-gp_t+1.72n_t+0.21yj_t+0.54fc_t$

（17） $0=-usp_t+0.09gp_t+1.37pn_t+1.23tr_t$

（18） $0=-c_t+y_t-0.91d_t-0.375ex_t$

（19） $0=-ee_t+0.038eff_t+0.064cu_t$

（20） $0=-ch_t+0.235ed_t+0.152fdi_t-0.387y_t$

（21） $0=-lo_t+0.267hi_{t-2}-0.7r_t+0.99fe_t$

（22） $0=-gr_t+1.22fe_t-2.48ed_t-2.4ee_t$

And the random variable models are

（1） $0=ed_t-0.89ed_{t-1}+\varepsilon_{1t}$

（2） $0=te_{t-2}-0.91te_{t-3}+\varepsilon_{2t}$

（3） $0=el_{t-2}-0.82el_{t-3}+\varepsilon_{3t}$

（4） $0=ict_{t-2}-0.95ict_{t-3}+\varepsilon_{4t}$

（5） $0=urb_{t-2}-0.92urb_{t-3}+\varepsilon_{5t}$

（6） $0=ind_{t-2}-0.87ind_{t-3}+\varepsilon_{6t}$

（7） $0=agr_{t-2}-0.76agr_{t-3}+\varepsilon_{6t}$

（8） $0=po_t-0.95po_{t-1}+\varepsilon_{7t}$

（9） $0=drt_t-0.92drt_{t-1}+\varepsilon_{8t}$

（10） $0=cu_t-0.34cu_{t-1}+\varepsilon_{9t}$

（11） $0=fe_t-0.98fe_{t-1}+\varepsilon_{10t}$

（12） $0=hi_{t-2}-0.97hi_{t-3}+\varepsilon_{11t}$

（13） $0=pn_t-0.94pn_{t-1}+\varepsilon_{12t}$

（14） $0=er_t-0.87er_{t-1}+\varepsilon_{13t}$

（15） $0=edi_t-0.55edi_{t-1}+\varepsilon_{14t}$

（16） $0=pn_t-0.98pn_{t-1}+\varepsilon_{15t}$

（17） $0=yj_t-0.49yj_{t-1}+\varepsilon_{16t}$

（18） $0=fc_t-1.02fc_{t-1}+\varepsilon_{17t}$

（19） $0=ef_t-0.94ef_{t-1}+\varepsilon_{18t}$

（20） $0=tr_t-1.03tr_{t-1}+\varepsilon_{19t}$

（21） $0=ex_t-0.89ex_{t-1}+\varepsilon_{20t}$

（22） $0=fdi_t-0.88fdi_{t-1}+\varepsilon_{21t}$

（23） $0=k_{t-1}-0.936k_{t-2}+\varepsilon_{22t}$

4. SIMULATION ANALYSIS

Since the 1990s, the volatility standard deviation of South Korea's GDP was 2.26%, its volatility degree of economic growth was stable. South Korea's urbanization rate reached 73.8% in 1990, and the urbanization rate was as high as 83.7% in 2013. The

July-August 2020
ISSN: 0193-4120 Page No. 1413- 1426

value-added of the knowledge-intensive industry such as the machinery transportation equipment industry, chemical products industry and the communications computer industry was highly volatile among these macroeconomic indicators, and also higher than the volatility of GDP, which indicated that volatility of the value-added of the knowledge-intensive industry had a greater impact on GDP [17], and a reduction of the volatility of the indicator, with a certain effect on the steady growth of economy.

The standard deviation of non-performing loans, technology introduction, FDI, technology trade and so on [18] were relatively large in selected macroeconomic indicators, closely followed in the scale of technology trade, which were 15.05% and 14.34% respectively, and had a significant impact on the fluctuation of GDP, as detailed in Table 1. The standard deviation of DSGE simulation was also given in the table, and the overall accuracy rate of DSGE simulation was over 60%.

4.1 Standard deviation analysis of simulation

Tab.1 Simulated standard deviation and actual standard deviation of each variable

Standard deviation of state variables and control variables			**Standard deviation of random variables**	
State variables and control variables	**Actual standard deviation**	**Simulated standard deviation**	**Random variables**	**Standard deviation**
eff	0.012	0.004	ed	0.257
npl	0.7	0.013	te	0.39
r	0.167	0.35	el	0.107
y	0.023	0.03	Ict	0.125
inf	0.051	0.051	urb	0.0033
d	0.08	0.041	ind	0.036
l	0.0158	0.0158	agr	0.085
s	0.065	0.0684	po	0.002
e	0.005	0.0129	drt	0.058
es	0.17	0.1128	cu	0.034
pe	0.072	0.067	fe	0.059
ce	0.076	0.043	hi	0.113
ec	0.03	0.017	ef	0.086
gp	0.33	0.14	er	0.081
usp	0.13	0.19	edi	0.11
c	0.031	0.04	n	0.052
ee	0.244	0.002	yj	0.51
ch	0.12	0.08	fc	0.083
lo	0.1	0.277	pn	0.083
fb	0.048	0.07	tr	0.143

p	0.012	0.0102	ex	0.176
M2	0.051	0.144	fdi	0.384
			k	0.026

4.2 Variance decomposition analysis

For the model system of estimating the linearity of the parameters, based on the Dynare software of MATLAB to take the variance decomposition, analyze the influence that the fluctuation of the state variable and the control variable by random shocks on the deviation of the trend value, as shown in Table 2 (the variables omit the subscript).

Tab. 2 Variance decomposition (in percent) (HP filter, lambda = 100)

	ed	te	el	ict	urb	ind	agr	po	drt	cu	fe
p	78	0	0	0	0	0	0	0	0	0	0
eff	1	16	21	34	0	0	0	0	0	28	0
npl	33	0	0	0	0	0	0	0	27	0	0
r	74	0	0	0	0	0	0	0	0	0	0
m2	88	0	0	0	0	0	0	0	0	0	0
y	0	7	9	14	3	1	5	0	0	0	0
inf	0	22	30	48	0	0	0	0	0	0	0
d	0	0	0	0	0	0	0	0	0	0	0
l	0	1	2	2	0	14	80	1	0	0	0
s	0	4	6	10	0	0	0	0	0	0	0
e	0	17	22	36	25	0	0	0	0	0	0
es	0	0	0	0	0	0	49	0	0	0	30
pe	0	0	0	0	0	0	0	0	0	0	0
ce	0	4	5	8	0	4	0	0	0	0	0
ec	0	4	6	9	0	0	0	0	0	0	0
gp	0	0	0	0	0	0	0	0	0	0	0
usp	0	0	0	0	0	0	0	0	0	0	0
c	0	2	2	3	0	0	1	0	0	0	0
ee	0	0	0	0	0	0	0	0	0	100	0
ch	51	0	0	0	0	0	0	0	0	0	0
lo	4	0	0	0	0	0	0	0	0	0	0
gr	9	0	0	0	0	0	0	0	0	0	91

Continued tab. 2 Variance decomposition (in percent) (HP filter, lambda = 100)

	hi	ef	er	edi	n	yj	fc	pn	tr	ex	fdi	k
p	19	0	0	2	0	0	0	0	0	1	0	0
eff	0	0	0	0	0	0	0	0	0	0	0	0
npl	16	0	0	0	0	0	0	0	0	0	24	0
r	22	0	0	0	0	0	0	0	0	3	0	0
m2	8	0	0	0	0	0	0	0	0	3	0	0
y	58	0	0	0	0	0	0	0	0	0	0	3
inf	0	0	0	0	0	0	0	0	0	0	0	0
d	100	0	0	0	0	0	0	0	0	0	0	0
l	0	0	0	0	0	0	0	0	0	0	0	0
s	80	0	0	0	0	0	0	0	0	0	0	0
e	0	0	0	0	0	0	0	0	0	0	0	0
es	20	0	0	0	0	0	0	0	0	0	0	0
pe	2	96	1	0	0	0	0	0	0	0	0	0
ce	40	0	0	40	0	0	0	0	0	0	0	0
ec	78	0	0	3	0	0	0	0	0	0	0	0
gp	0	0	0	0	37	53	9	0	0	0	0	0
usp	0	0	0	0	0	0	0	29	70	0	0	0
c	6	0	0	0	0	0	0	0	0	85	0	1
ee	0	0	0	0	0	0	0	0	0	0	0	0
ch	1	0	0	0	0	0	0	0	0	0	47	0
lo	95	0	0	0	0	0	0	0	0	0	0	0
gr	0	0	0	0	0	0	0	0	0	0	0	0

Based on the research, instrumentation industry, computer and electronic products and equipment manufacturing, medical equipment and supplies (including pharmaceuticals), chemical industry, machinery manufacturing, electrical equipment, transport equipment manufacturing, equipment and components manufacturing, E-commerce, real estate and leasing, finance, professional services, science and technology services, information service industry and education culture industry and so on all belonged to mid-to-high end industries, these industries were more innovative, better economic returns, density of scientific and technological personnel, density of research and development, and high patent intensity. The evolution of the proportion of the value-added of the main knowledge-intensive industry to the value-added of industrial increase as shown in Figure 1, the proportion of knowledge-intensive industries was gradually increasing. As can be seen from Table 3, the random impact of the value-added of the knowledge-intensive industry (HI represents the random variable of the study) had an important effect on the variance decomposition of state variables and most control variables. For example, the impact on GDP was 58%, the impact on fixed asset investment was 100%, the impact on loans was 95%, and the impact on technology investment was 80%.

To classify and analyze the value-added of the computer industry, the electronic information industry, the machinery transportation equipment industry and the chemical products industry in the knowledge-intensive industry of South Korea in Table 3. The total value-added of four industries accounted for more than half of South Korea's industrial value-added, which was the main leading force for South Korea's economic growth since 1990.

Tab.3 The technology investment of South Korea's knowledge-intensive industry

Year	Chemical products (million Korean Won)	Computer industry (million Korean Won)	Machinery transportation equipment industry (million Korean Won)	Electronic information industry(million Korean Won)	Proportion of total scientific and technological input
2009	1376218.797	13885549.6	14698.1	1285551.104	44%
2010	1668544.609	17221061.4	64520.47	1590572.39	47%
2013	2544165.734	23251176.1	48989.29	1869517.584	47%

The scientific and technological input of these four industries achieved a total of 47% of scientific and technological input, played an important pulling role in innovation, but also made the Korean research and development investment over more than 3.5% of GDP.

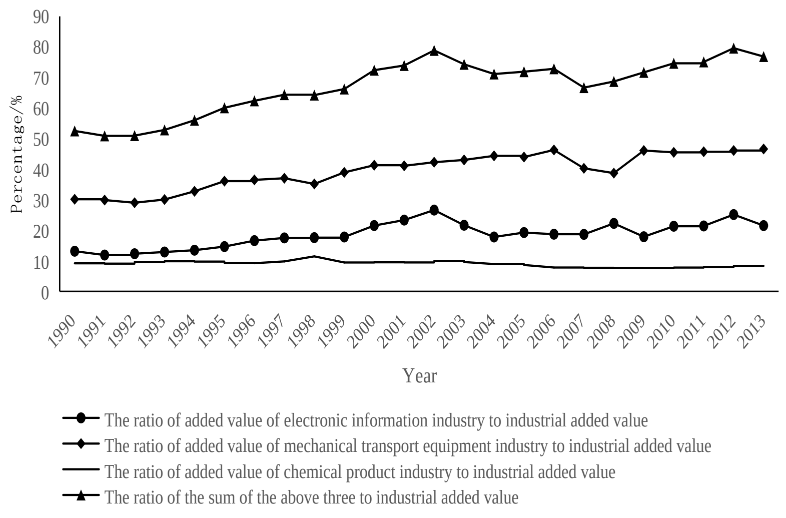

Fig.1 South Korean knowledge-intensive industry accounted for industry

4.3 Combined impact analysis of random variables

In the actual economic growth of a country, the fluctuation of GDP, the fluctuation of science and technology, and the fluctuation of employment, which are the results of the impact of all the random variables such as external debt, Internet, urbanization, industrialization, agricultural labor productivity, revenue, export, FDI and fixed capital stock. In order to analyze the influence of

July-August 2020
ISSN: 0193-4120 Page No. 1413- 1426

combination impact on the fluctuation of state variable and control variable of national innovation system, it has great difficulties in previous research, but by establishing DSGE model with random impact, the influence of combination impact on state variable and control variable by simulation method can be analyzed[19].

Tab.4 Variable value for impact of combination

Impact of variable	Impact value
External debt	-0 .005
Internet	0 .005
Informatization	0 .005
ICT industry	0 .005
Urbanization	0 .005
Industrialization	0 .005
Agricultural modernization	0 .005
Population	0 .005
Assets- Liability ratio	0 .005
Industrial capacity utilization ratio	0 .005
Financial expenditure	0 .005
Knowledge-intensive industry	0.01
Environmental protection funds/GDP	0 .005
Environment-related taxes	0 .005
The proportion of high energy-consuming industry	-0 .005
Research and development personnel of university	0 .005
Funds from abroad	0 .005
Basic research funds	0 .005
Research and development personnel of private enterprise	0 .005
Technology trade	0 .005
Export	0 .005
FDI	0 .005
Fixed capital stock	0.01

The influence of combined impact on state variables and control variables was simulated in Table 4, such as external debt, the Internet, information and other impact values as detailed. In such a combination of impact scenarios, the state variables and control variables that the authorized patent which South Korea obtained in the United States, research and development funds and others, were shown a positive wave response at the beginning, especially made a fairly positive reaction in 2-3 years, and then gradually in the steady state, of which, the biggest response of the combined impact was the interest rate of South Korea, up to 5%, followed by GDP and technology, respectively, 1.7% and 1%, and energy consumption rate was to make a negative response, see Figure 2.

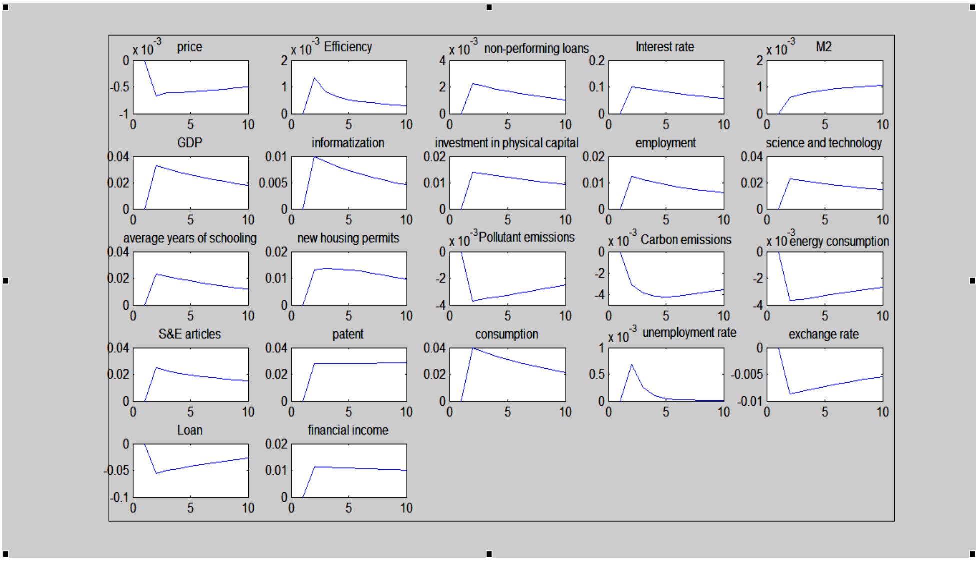

Fig.2 Response of each variable to combined impact

5. CONCLUSION

Based on the research of DSGE method on South Korean economic growth, this paper draws the following 4 conclusions:

(1) Based on the synergy theory of economic growth and the theory of reform of supply-side structure, this paper sets up a DSGE model group which includes residents, enterprises, science and technology, foreign trade, currency, finance and environment. And the unified optimization objective function is adopted, instead of each main body being optimized separately. In these models, the structure variables such as urbanization, informatization and industrialization are fully adopted, which expand the field of research and realize the synthesis of structural reform, innovation-driven, financial stability, opening-up, energy saving and emission reduction and economic growth.

(2) The supply-side industrial structure reform is the main driving factor of the rapid growth in South Korea. According to the simulation, the proportion of knowledge-intensive industry, such as computer and electronic products and equipment manufacturing, has gradually increased with GDP. The stochastic impact of value-added in knowledge-intensive industry had an important effect on the variance decomposition of state variables and most control variables. For example, the impact on GDP was 58%, the impact on fixed asset investment was 100%, the impact on loans was 95%, and the impact on technology investment was 80%.

(3) It was correctly revealed the causes of the South Korean financial crisis. December 1997, the South Korean outbreak of a serious financial crisis, marked by a significant devaluation of the Won, from January 1997, Won against the dollar 844:1 fell to the end of December 2,060:1, the fuse was the external debt repayment crisis: December 24, 1997, South Korea's total external debt of up to 200 billion U.S. dollars, the short-term external debt of 66 billion trillion U.S. dollars, and 200~300 billion of billions of U.S.dollars in debt to be repaid at the end of 1997, when the central bank of Korea can be

used to repay foreign exchange reserves of only 30 billion U.S. dollars, the debt repayment crisis immediately erupted, and caused a currency crisis [20].The variance decomposition of Table 2 shows that the stochastic impact of external debt on Korean M2 fluctuation was 88%, the decision effect on interest rate fluctuation was 74%, the decision function of exchange rate fluctuation was 51%, the decision effect on price fluctuation was 78%, and the decisive effect on the fluctuation of non-performing assets was 33%.

(4) The adjustment of industrial structure and the investment of environmental protection funds were the main reasons for South Korea's energy saving and emission reduction and pollution prevention. The impact of knowledge-intensive industry on the fluctuation of energy consumption in South Korea was 40%, the decisive effect on the fluctuation of carbon emission was 78%. The impact of pollution control funds on the fluctuation of pollutant emissions was 96%, and the impact of high energy consuming industry on energy consumption fluctuation had a decisive effect of 40%.

ACKNOWLEDGMENTS

This work was supported by the Social Science Fund of Heilongjiang Province (NO.18JYD395)

REFERENCES

1. Junhee, Wooheon Rhee. Financial factors in the business cycle of a small open economy: The case of Korea[J]. Open Econ Rev. 2013, (24): 881-900.
2. LIU Bin. The development of DSGE model in China and its application in the analysis of monetary policy [J]. Journal of Financial Research, 2008, (10): 1-21.
3. Smets F, Wouters R. Shocks and frictions in US business cycles:A Bayesian DSGE approach [J]. American Economic Review, 2007, 97(3): 586-606.
4. LI Shuang. Research on China's economic fluctuation under the DSGE framework[D]. Huazhong University of Science and Technology, Hubei, Wuhan, 2011.
5. HUANG Sui-lin. An analysis of technology and labor supply effect on China's economic fluctuation [J]. Journal of Finance and Economics, 2006, (6): 98-109.
6. LI Dong-hua. Korea's model and experience of scientific-technological development: From introduction to innovation[M]. Beijing: Social Sciences Academic Press, 2009.
7. Coe, D, Helpman, E. International R&D spillovers[J]. European Economic Review. 1995, 39(5): 859-887.
8. GAO Xi-rong, ZHOU Chang-lin. Analysis on human capital condition of China's innovation transformation--based on the experience of Korea's innovation transformation[J]. Science & Technology Progress and Policy, 2015, (01): 141-146.
9. LIU Wei. China Economic Growth Report 2006[M]. Beijing: China Economic Publishing House, 2006.
10. LI Ping, Li Lei-lei. The effect of basic research on technological progress of late-developing countries--based on the perspective of technology innovation and technology import[J]. Studies in Science of Science. 2014, 32(5): 677-685.
11. Korea Science and technology Innovation Situation Analysis Report Research Group. A review of science, technology and innovation policy in the Republic of Korea[M]. Beijing: Science Press, 2011.
12. Fabio Milani, Sung Ho Park. The effects of globalization on macroeconomic dynamics in a trade-dependent economy: the case of Korea[J]. Economic Modelling. 2015, (48): 292-305.
13. YANG Quan. Government role in financial field of economic development--A case study of Korea[J]. Asia-pacific Economic Review, 2005, (1): 34-35.
14. CAO Ling. Research on Korean trade effects of outward FDI [D]. Jilin University, Changchun, Jilin, 2013.
15. HUANG Lin-yun, FAN Yan-xia, LIU Xia-peng. The research of FDI technology spillovers based on the technological innovation of host country[J]. China Soft Science, 2007, (3): 30-34.

16. LIU Ya-jun. Research on the development of Korea's low-carbon economy[D]. Jilin University, Changchun, Jilin, 2015.
17. SONG Bing-luo. The rise of Korean economy[M]. New York: Oxford University Press, 2003.
18. LIU Jian-hua, JIANG Zhao-hua. Innovation-driven and transformation upgrade under the new normal condition:Taking Henan province as an example[M]. Beijing:Science Press, 2016.
19. LIU Shuang. The Research on rapid economic growth of South Korea driven by innovation based on DSGE[D]. Dalian University of Technology, Dalian, Liaoning, 2016.
20. WANG Yu. Korean currency crisis triggered by foreign debt dependency and pegged exchange rate system [J]. China Finance, 2005 (16): 60-62.