<Economic Forecast>

Estimation of Potential Growth Rate with Structrual VAR

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Abstract

Korea’s potential growth rate has been gradually declining from 7.7 percent in the 1990s to 2.7 percent at present. Furthermore, the pace of decline is accelerating, suggesting that the Korean economy is on a low-growth stage.

According to the results of this research, the driving force behind Korea's economic growth is the supply-side shock of productivity increase rather than demand. And this shock has been reduced since the financial crisis. To promote Korea’s sustained growth in the future, it is essential to establish the inclusive economic institution that will increase supply-side productivity. To that end, the Korean government should implement a policy of removing unreasonable regulations and reforming the structure.

Ⅰ. Introduction

1. Research Background

The most popular article I saw in the economic newspaper this year was that the Korean economy will be depressed. Among them, especially the IMF, the Bank of Korea, many other institutions and experts have warned of a possible decline in Korea's growth rate. Previous research (Lee, 2019) has been conducted on the fall in potential growth rate. Referencing to the previous study, I would like to estimate the potential growth rate with Structural VAR and analyze the Factors of decline in potential growth rate and economic implications.

2. Definition and Economic Meaning of potential growth rate

Potential growth rate is Economic growth that can be achieved using all factors of production. It also means economic growth that can be achieved without triggering inflation. High potential growth rate is significant in that they can drive sustained growth. We can also use potential and real growth rates to get a GDP gap, which helps us identify depression, over-heating, and business cycle.

Ⅱ. Materials and Research Method

1. Materials

Time series data of GDP and GDP deflator were used to get growth rate and price change rate respectively. Gross domestic product (GDP) is a monetary measure of the market value of all the final goods and services produced in a specific time period, often annually. GDP deflator is a comprehensive price index covering all price factors affecting national income, indicating the price level of the commodity, GDP. It is calculated as (nominal GDP / real GDP).

The seasonally adjusted quarterly GDP data from the KOSIS (Korea Statistical Office) was used.

2. Structural VAR Analysis

I used Structural VAR analysis with long-run restriction proposed by Blanchard & Quah(1989). After dividing the change in GDP into changes caused by demand shocks and supply shocks, the change in potential GDP (long-term change in GDP) is assumed to be caused by supply shocks. The advantage of this analysis is that future potential growth rate can be estimated and trends can be analyzed for each shock factor. Above all, it is based on economic theory. Potential yield can be obtained in the order of reduced form VAR estimation, Cholesky deposition, structural VAR estimation, and IRF estimation.

2.1 Reduced form VAR model

Considering the macroeconomic model in which the equilibrium gross yield and the equilibrium price level are set by the aggregated supply and demand, I defined a reduced form VAR(p) model with two variables: growth rate and inflation rate.

$$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + A_3X_{t-3} + A_4X_{t-4} + E_t$$

Where $X_t = (Y_t \quad P_t)'$

$Et = (E_{1t} \quad E_{2t})'$

Y_t is real GDP growth rate

P_t is price(GDP deflator) change rate

Lag is 4 (selected by AIC)

2.2 Structural VAR model

Corresponding to above reduced form VAR model, Structural VAR model is defined as follows

$$AX_t = A(A_0 + A_1X_{t-1} + A_2X_{t-2} + A_3X_{t-3} + A_4X_{t-4} + E_t)$$

where A is short term impact matrix obtained by Cholesky decomposition

$$X_t = B_0 + NX_t + B_1X_{t-1} + B_2X_{t-2} + B_3X_{t-3} + B_4X_{t-4} + \varepsilon_t$$

Where N = $\left(\begin{matrix} 0 & \beta \\ 0 & 0 \end{matrix} \right)$

$\varepsilon_t = (\varepsilon_{as,t} \quad \varepsilon_{ad,t})'$

εas,t εad,t are white-noise disturbances and uncorrelated to each other.

Y_t and P_t are stationary

2.3 Impulse response function

The SVAR model is expressed as a form of vector moving average.

$$X_t = \sum_{i=0}^{\infty} \begin{pmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{pmatrix} \varepsilon_t$$

where ϕ is impulse response function

2.4 Potential Growth rate

Potential growth rate is defined as weighted average-accumulated effects using $\varepsilon_{as,t}$ and ϕ.

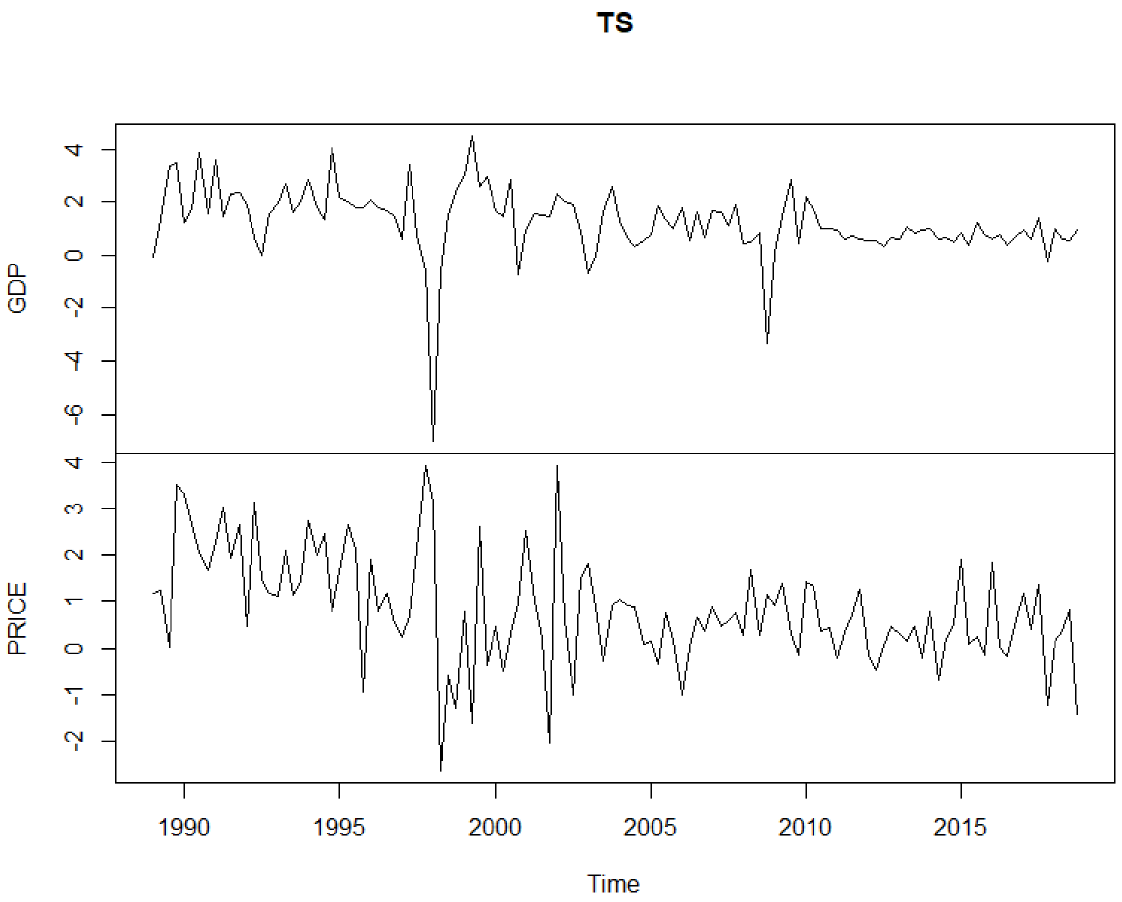
$$Y_{p,t} = = \sum_{i=0}^{\infty} \phi_{11}(i)\, \varepsilon_{as,t-i}$$

.

Ⅲ. Results

1. Stationarity test

```
> Resource<-read.csv(file="E:/숭실대/2019-2/기업경제예측론/GDP_def.csv",
col.names=c("GDP", "PRICE"),header=T)
> TS<-ts(Resource, start=c(1989,1), end=c(2018,4), frequency=4)
> plot(TS)
```




```
#Yt(real GDP growth rate)
> GDP<- ts(Resource$GDP, start=c(1989,1), end=c(2018,4), frequency=4)

#Pt(Price change rate)
> PRICE<- ts(Resource$PRICE, start=c(1989,1), end=c(2018,4),
frequency=4)

#Test H0 : γ(Dickey Fuller)=0  vs  H1 : γ≠0
> adf.test(GDP, alternative = "stationary")

Augmented Dickey-Fuller Test

data:  GDP
Dickey-Fuller = -5.6855, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

```
> adf.test(PRICE, alternative = "stationary")

Augmented Dickey-Fuller Test

data:  PRICE
Dickey-Fuller = -4.1509, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

In Augmented Dickey-Fuller Test,

$Y_t = a_0 + \sum_{i=1}^{p-1} a_i Y_{t-i} + e_t$

$\triangle Y_t = a_0 + \sum_{i=2}^{p} \beta_i \triangle Y_{t-i+1} + e_t$

$\gamma = -(1 - \sum_{i=2}^{p} a_i)$

If $\gamma = 0$, Y_t has a unit root.

From the above results, γ of Yt and Pt are not zero with law p-value, 0.01. Therefore, Y_t and P_t are stationary process.

2. Reduced form VAR model

```
> VTS<-VAR(TS,type="const", ic="AIC", lag.max=10)
> summary(VTS)

Estimation results for equation GDP:
====================================
GDP = GDP.l1 + PRICE.l1 + GDP.l2 + PRICE.l2 + GDP.l3 + PRICE.l3 +
GDP.l4 + PRICE.l4 + const

        Estimate Std. Error t value Pr(>|t|)
GDP.l1    0.32540    0.09740   3.341  0.00115 **
PRICE.l1 -0.16528    0.10828  -1.526  0.12986
GDP.l2    0.15813    0.10364   1.526  0.13003
PRICE.l2  0.07609    0.10840   0.702  0.48424
GDP.l3   -0.07909    0.10639  -0.743  0.45887
PRICE.l3  0.19300    0.10488   1.840  0.06852 .
GDP.l4   -0.02136    0.10141  -0.211  0.83358
PRICE.l4  0.03547    0.10112   0.351  0.72645
const     0.62545    0.21892   2.857  0.00514 **


Estimation results for equation PRICE:
======================================
PRICE = GDP.l1 + PRICE.l1 + GDP.l2 + PRICE.l2 + GDP.l3 + PRICE.l3 +
GDP.l4 + PRICE.l4 + const

        Estimate Std. Error t value Pr(>|t|)
GDP.l1    0.11212    0.08059   1.391   0.1670
PRICE.l1  0.04099    0.08959   0.457   0.6482
GDP.l2    0.17320    0.08575   2.020   0.0459 *
PRICE.l2  0.04297    0.08969   0.479   0.6329
GDP.l3    0.24344    0.08803   2.765   0.0067 **
PRICE.l3  0.03020    0.08678   0.348   0.7286
GDP.l4   -0.05604    0.08390  -0.668   0.5056
```

```
PRICE.l4  0.34759    0.08367   4.154 6.58e-05 ***
const    -0.18627    0.18113  -1.028   0.3061
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Covariance matrix of residuals:
         GDP   PRICE
GDP    1.4713 -0.2588
PRICE -0.2588  1.0072


# Coefficients matrix of reduced form VAR
> A0<-matrix(c(0.62545200,-0.18627009),2,1)
> A1<-matrix(c(0.32539609, 0.11211905,-0.16527803,  0.04098555),2,2)
> A2<-matrix(c(0.15812592,0.17320110,0.07608662,0.04296556),2,2)
> A3<-matrix(c(-0.07909229, 0.24343885, 0.19299639, 0.03019500),2,2)
> A4<-matrix(c(-0.02135947, -0.05604426, 0.03547106, 0.34759087),2,2)


> TR<-t(Resource)
> R<- t(resid(VTS))
> E<-matrix(R,2) # Residuals of reduced form VAR

> k<-2 #number of endogenous variables
> p<-4 #number of lags
> t<-120 #number of observations

# Reduce form VAR model
> R_VAR<-matrix(0,k,t)
> R_VAR[,1]<-TR[,1]
> R_VAR[,2]<-TR[,2]
> R_VAR[,3]<-TR[,3]
> R_VAR[,4]<-TR[,4]
> for (i in (p+1) : t) {
+     R_VAR[,i] <-A0 + A1%*%R_VAR[,i-1] + A2%*%R_VAR[,i-2] +
A3%*%R_VAR[,i-3] + A4%*%R_VAR[,i-4] + E[,i-p] }
```

3. Cholesky decomposition

```
# Variance-Covariance matrix
> x<-matrix(c(1.4713, -0.2588, -0.2588, 1.0072),2,2)

> Ainv<-chol(x)
> A<-solve(Ainv)
> A
          [,1]      [,2]
[1,] 0.8244216 0.1793694
[2,] 0.0000000 1.0197302
```

4. Structural VAR model

```
# Structural VAR model
> SV<- matrix(0,k,t)
> SV[,1]<-TR[,1]
> SV[,2]<-TR[,2]
> SV[,3]<-TR[,3]
> SV[,4]<-TR[,4]

> for (i in (p+1) : t) {
+ SV[2,i] <- ((A%*%A0)[2,] +                    (A%*%A1%*%SV)[2,i-1] +
(A%*%A2%*%SV)[2,i-2] + (A%*%A3%*%SV)[2,i-3] + (A%*%A4%*%SV)[2,i-4] +
(A%*%E)[2,i-p])/A[2,2]
+ SV[1,i] <- ((A%*%A0)[1,] - A[1,2]*SV[2,i] + (A%*%A1%*%SV)[1,i-1] +
(A%*%A2%*%SV)[1,i-2] + (A%*%A3%*%SV)[1,i-3] + (A%*%A4%*%SV)[1,i-4] +
(A%*%E)[1,i-p])/A[1,1] }

# Residuals of structural VAR
> e <- matrix(0,2,116)
> e[1,] <- (A%*%E)[1,]/A[1,1]
> e[2,] <- (A%*%E)[2,]/A[2,2]
```

"TR", "R_VAR" and "SV" have same vector values

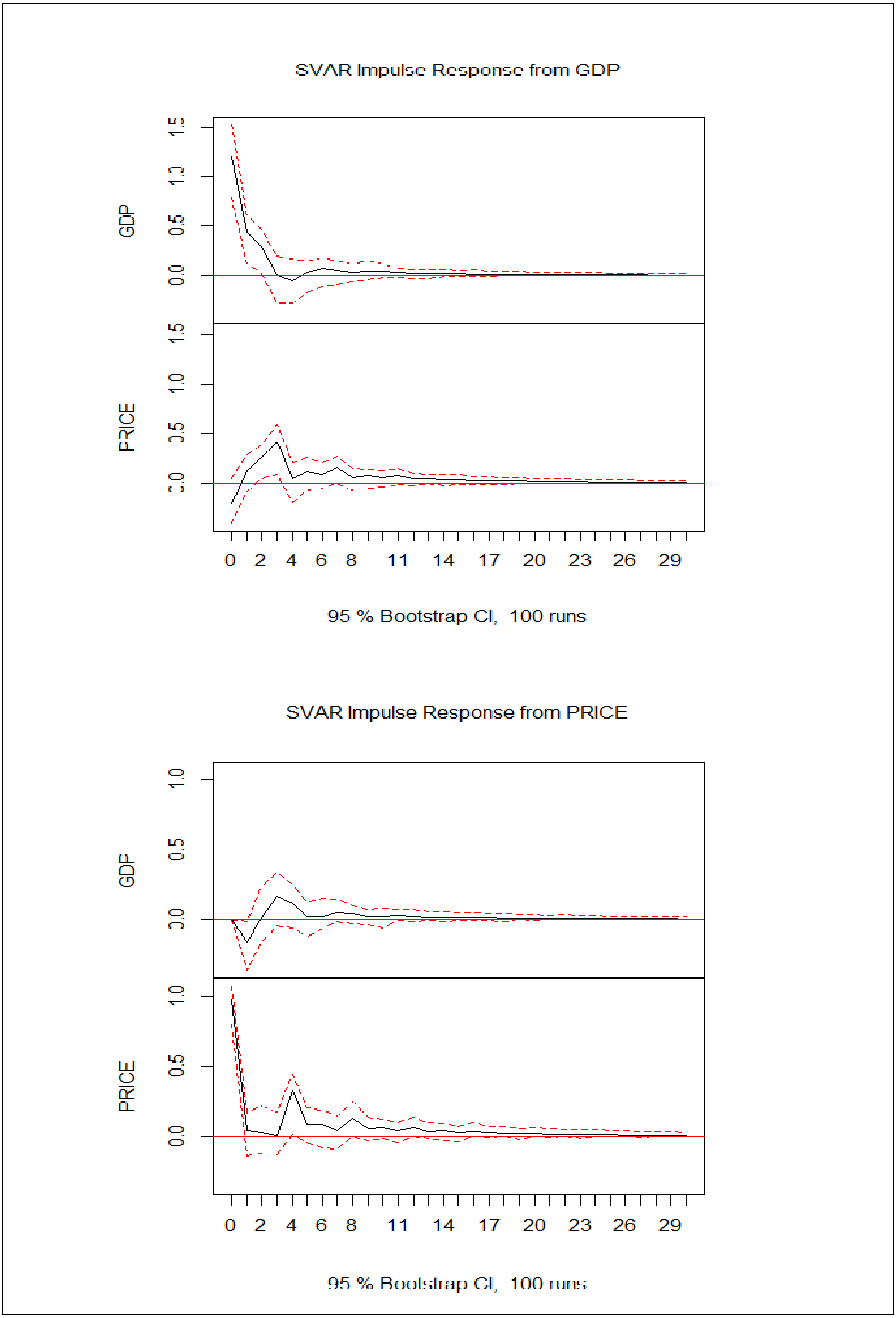
5. Impulse Response Function

```
> amat<-matrix(NA,2,2)
> amat[1,2]<-0
> SVAR(VTS, Amat=amat)

SVAR Estimation Results:
========================


Estimated A matrix:
         GDP PRICE
GDP   0.8244  0.00
PRICE 0.1794  1.02

phi<-irf(SVAR(VTS, Amat = amat),n.ahead=30)
plot(phi)
```


SVAR Impulse Response from GDP
GDP
PRICE
1.5
1.0
0.5
0.0
0 2 4 6 8 11 14 17 20 23 26 29
95 % Bootstrap CI, 100 runs
SVAR Impulse Response from PRICE
GDP
PRICE
1.0
0.5
0.0
0 2 4 6 8 11 14 17 20 23 26 29
95 % Bootstrap CI, 100 runs

6. Estimation of Potential Growth Rate

Potential growth rate is defined as weighted average-accumulated effects using $\varepsilon_{as,t}$ and ϕ.

$$Y_{p,t} = = \sum_{i=0}^{\infty} \phi_{11}(i)\, \varepsilon_{as,t-i}$$

V. Conclusions and Implications

Based on the above results, we can see that the driving force of the Korean economy is supply shock rather than demand shock. When 1 standard deviation supply shock occurs, the real GDP will increase by 1.2 percent and the effect will gradually disappear over the 20th quarter. I think the reason is that Korean economy is more like an open small economy with high dependence on exports rather than an economy in which the domestic market has been revitalized.

Due to the heavy reliance on the supply side, the Korean economy should increase its potential growth rate by inducing supply shocks to sustain growth. Structural reform and removing unreasonable regulation are the tasks that the Korean government needs to take care of.

VI. References

Lee SeungSeok. (2019). Estimation of Potential Growth Rate and Implications of the Korean Economy (우리 경제의 잠재성장률 추정 및 시사점). *KERI research report.*

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KOSIS (KOrean Statistical Information Service) : http://kosis.kr/eng/