Sustainable GDP，Higher Education Development and R&D Expenditure: Evidence from Shandong

Bing Li[1,a,*]

[1]School of International Economics and Trade, Shandong University of Finance and Economics, Jinan, Shandong, P.R. China

a. libingchina@sina.com

**corresponding author*

Keywords: sustainable GDP, higher education development, R&D expenditure

Abstract: This study aims at exploring the relationship among Shandong GDP growth, higher education development and R&D expenditure. The conclusion we obtain is a positive correlation among Shandong GDP, higher education development and R&D expenditure. Granger Causality test indicates that Shandong GDP could be explained as Granger causes of higher education development and enterprise' R&D expenditure increase in Shandong. This paper explains that the fast-higher education development in Shandong contributed to the Shandong GDP growth, and R&D expenditure had a much stronger influence upon Shandong GDP growth. So that public and private investment in higher education and enterprise' R&D expenditure are all very important factors in order to ensure a sustainable growth of GDP.

1. Introduction

Sustainable GDP growth is important in Shandong province, a large economic power in China. Many factors will influence the GDP growth such as private and government investment, residential consumption and net export but these factors are all in the short time period. In order to ensure a long-time sustainable GDP growth, studies have to be explored into the education and innovation. In this paper, focuses are placed upon the higher education development and enterprises R&D expenditure in Shandong to find the causes of Shandong sustainable GDP growth and their relationship.

2. Literature Review

Many researchers attempted to estimate the higher education development in provinces and in the all nationwide level by finding the relationship between the school enrollment ratio in colleges and universities. These efforts contributed a lot in the impact of GDP and higher education [1]. Other paper tried to analyze some influences of higher education and GDP in certain countries, such as China. Research indicated that co-integration existed in the variables and the interrelationship between the higher institution and GDP was the basis for the policy of expanding the education scale [2].

Researchers also studied some key influential things of the growth of GDP in the national innovation system. Based on the investigation of relative data in the expansion period of higher education enrollment from year 1995 to 2004, by means of factor analysis and cluster analysis, it takes regression analysis upon the five factors through a precise mathematical model, and draws an unusual conclusion [3]. There are many researches on the inter reactions of college education on the state level and provinces level in the US, the Europe and the Australia. The conclusion is that cities with more college and universities have higher GDP per capita [4]. Researchers also analyzed the relationship between school charges in colleges and the increase of the income of local citizens or GDP per person. The conclusion showed that the increased speed of yearly school charges in colleges is higher than increased speed of yearly average income of per resident or GDP per person [5].

In this paper, after the model and data are briefly explained, we shall do unit root test first, second we carry the cointegration test, finally we do the Granger causality test. The purpose to obtain the long-term relationship among GDP, higher education development, enterprises R&D expenditure in Shandong to find the causes of Shandong sustainable GDP growth.

3. Empirical Theories and Data Collection

We take VAR model to do the relevant time sequences analysis. The equation of the VAR model with only one lag can be written as follows:

$$Y_t = \alpha + \Phi Y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim IID(0,\Omega) \tag{1}$$

This empirical equation can be expressed in the following form as:

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \begin{pmatrix} 1-\phi_{22} & \phi_{12} \\ \phi_{21} & 1-\phi_{11} \end{pmatrix}\begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + \sum_{i=0}^{\infty}\begin{pmatrix} \varphi_{11}(i) & \varphi_{12}(i) \\ \varphi_{21}(i) & \varphi_{22}(i) \end{pmatrix}\begin{pmatrix} \varepsilon_{xt-i} \\ \varepsilon_{yt-1} \end{pmatrix} \tag{2}$$

In this study, Granger causality test method as a common approach is used to test the link between the different variables. In 1969, J. Granger proposed the idea initially. In the 1970s, Hendry and Richard further developed it. The basic idea is to establish a set of information set A_t, which contains at least (X_t, Y_t). The Granger method is to check if X_t could cause Y_t by studying to what extent the current Y_t can be interpreted by values of Y_t in the past period. We can also check if more past values of X_t can help explain the result or not. The Granger causality test is using the following two equations:

$$y_t = \sum_{i-1}^{q} a_i x_{t-i} + \sum_{j-1}^{q} \beta_j y_{t-j} + u_{1t} \tag{3}$$

$$x_t = \sum_{i-1}^{s} \lambda_i x_{t-i} + \sum_{j-1}^{s} \delta_j y_{t-j} + u_{2t} \tag{4}$$

In doing Granger causality test, what we have to do is test variable stationary or not. Because the non-stationarity of the sequences is one of the important factors which might lead to a false causal relationship. If the sequence is not a stationary one, it should be differenced one or more times to become stationary, and only then the Granger test can be done accordingly. A typical example of a non-stationary series like this:

$$y_t = y_{t-1} + \varepsilon_t \tag{5}$$

where ε_t is regarded as a disturbance term. *y* has a forecast value which we often think is conditioned on *t,* and the value is gradually increasing as time goes. The random walk is a differenced we think as the stationary ones since we take the first difference of *y* then get it stationary.

$$y_t - y_{t-1} = (1 - L)y_t = \varepsilon_t \tag{6}$$

We denote I(d) as a differenced stationary series and as an integrated one where *d* is the order. This means that how many unit roots in the series or we can say it is the number of the differencing ways of doing the test. So I(0) means no unit roots and I(1) has one unit root. So we have to be sure it is stationary before it is taken to the regression.

We take all the data from "Shandong Statistical Yearbook". Because of data shortage, sample period is selected during 1995-2018 period. Variables in the model include the Gross domestic product (GDP), Number of higher education graduates （GRA） and R&D expenditure by the enterprises in Shandong (RDE). We change all the variables are into natural logarithm, that is, LNGDP, LNGRA and LNRDE. We use Eviews 9.0 as the software to analyse the data.

4. Tests Results and Discussion

4.1. Unit Root Test

Table 1: ADF test results.

Variables	Selection（c, t, p）	ADF Value	Prob	Critical Value	Stationary
LNGDP	(c, 0, 1)	-0.832285	0.7898	-3.769597***	No
LNGRA	(c,0, 1)	-1.064867	0.7115	-3.752946***	No
LNRDE	(C, 0, 1)	1.464336	0.9600	-2.669359***	No
DLNGDP	(c, 0, 1)	-10.79627	0.0000	-3.788030***	Yes
DLNGRA	(c,0,1)	-5.359858	0.0003	-3.769597***	Yes
DLNRDE	(0, 0, 1)	-19.20901	0.0001	-2.674290***	Yes

Note: In the Selection (c, t, p) c denotes constant, t denotes trends, p denotes differenced lagging order; D denotes difference; *** represents the Mack critical value at 1% significance.

Eviews9.0 statistical analysis software is used in this work for analysis. Specifically we use the ADF test method to test the variable's unit root. As results in Table 1 denote that the ADF values of the three sequences: LNGDP, LNGRA and LNRDE are higher than the critical value at 1 per cent Mackinnon critical value, which means that there are root units and those three variables are not stationary. But the first order differenced sequences of DLNGDP, DLNGRA and DLNRDE ADF value are lower than the critical value at 1 percent Mackinnon critical value, which means that no unit roots existing and those three variables are of stationarity. Thus, we can say that these three sequences in the ADF test are the 1-order differenced stationary one I (1), we can perform the following test.

4.2. Lag Number

We have to get the proper lag number in the cointegration test. We choose LR, PPE, AIC, SC and HQ criterion to find the appropriate lag number. Table 2 tells us that the empirical model with differenced sequences, minimizing lag number p = 2, with the LogL, LR, FPE, AIC, SC and HQ 's criteria.

Table 2: Lag Group Unit Root Test for LN*** in 1st Difference.

Lag Order's Criteria for selection
Endogenous variables: LNIEC, LNGDP, LNIEX, LNIFDI Exogenous variables: C

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-35.81001	NA	0.006838	3.528183	3.676961	3.563231
1	18.05498	88.14272	0.000117	-0.550453	0.044661	-0.410262
2	49.26275	42.55604*	1.65e-05*	-2.569341*	-1.527891*	-2.324007*

* denotes lag order taken by the criterion.
LR: is for sequenced LR statistic (each at 5%) FPE means Final prediction error
AIC means Akaike information criterion. SC means Schwarz information criterion. HQ means Hannan-Quinn information criterion

4.3. Cointegration Form

In the model analysis, ADF test shows that each variable of LNGDP LNGRA and LNRDE meets the I(1) first-order stationary conditions. In this work, we use the cointegration method which is proposed by Johansen and Juselius [6] to test the long-time and stabled relation which might exist among these data. We use the Trace to make the test and the test result indicates there is 1 cointegration equation exiting at the 0.05 level as shown in Table 3.

Table 3: VAR model variables cointegration.

Observations included : 21 after the system adjusted
Trends: No
LNGDP LNGRA LNRDE
Lags in in first differences intervals : 1 to 2

Hypothesized No. of Con Eqa(s)	Eigenvalue	Trace	0.05 Value	Prob.
None *	0.899051	60.23878	24.27596	0.0000
At most 1	0.360137	12.08285	12.32090	0.0548
At most 2	0.120913	2.706308	4.129906	0.1181

Trace actually denotes there is only 1 cointegrating eqn(s) 0.05 level
* means a reject to the hypothesis 0.05 level
**Mac-H-M (1999) p-values

So, coefficients in model are estimated with a lag number of p equals to 2 as shown in Equation (8). The coefficients of equation indicates that a 1 per cent increase in LNGRA in the lag order of 1 or 2 will increase LNGDP by 0.1% and 0.02% respectfully, and that a 1 per cent increase in LNRDE in the lag order of 1 or 2 will increase LNGDP by 0.22% or 0.39% respectfully. The conclusion is that there existing a positive relationship among GDP, higher education development and R&D expenditure.

$$\begin{aligned} LNGDP = {} & 0.01*LNGDP(-1) + 0.003*LNGDP(-2) + 0.10*LNGRA(-1) \\ & + 0.02*LNGRA(-2) + 0.22*LNRDE(-1) + 0.39*LNRDE(-2) - 0.63 \end{aligned} \tag{7}$$

4.4. Granger Causality Results

Table 4: Granger causality results.

Sample: 1995 2018				
Null Hypothesis: does not Granger Cause=\=>	Observation	F-Statistic	Probability	Conclusion
LNGRA =\=> LNGDP	21	3.83434	0.0340	Reject
LNGDP =\=> LNGRA		1.88997	0.1777	Accept
LNRDE =\=> LNGDP	21	8.14455	0.0022	Reject
LNGDP =\=> LNRDE		22.1630	1.E-05	Reject
LNRDE =\=> LNGRA	21	1.04298	0.4041	Accept
LNGRA =\=> LNRDE		1.13552	0.3687	Accept

The Granger Causality result in Table 4 indicates, at 3rd lagging order and at a 5% significance level, that LNGRA does Granger cause LNGDP, but LNGDP does not Granger cause LNGRA. At the same time, results also indicate that LNRDE can Granger cause LNGDP and LNGDP does Granger cause LNRDE. This denotes a two-way Granger causal relationship between LNRDE and LNGDP. From table 4, we also know that LNRDE does not Granger cause LNGRA and that LNGRA does not Granger Cause LNRDE. This shows there is no Granger cause between LNRDE and LNGRA.

5. Conclusion

This study is exploring the relation among Shandong GDP growth, higher education development and R&D expenditure. After the unit root tests are performed, the results show that variables under study are all stationary in the 1st differences. Next the lag number of the equation is selected by the given criterion. So, the coefficients of cointegration equation under the VAR model are estimated. The conclusion we obtain is that a rather positive correlation exists among GDP, higher education development and R&D expenditure.

Granger Causality test in this study indicates that Shandong GDP could be explained as causes of higher education development and R&D expenditure increase in Shandong. But the higher education development in Shandong could not be explained in Granger causes by the Shandong GDP growth in the period under study. R&D expenditure increase and GDP growth in Shandong could be explained by Granger causes with each other. But the R&D expenditure increase and Shandong higher education development in the period under study did not have any Granger causes with each other.

This study indicates that the fast higher education development in Shandong contributed a lot in the Shandong GDP growth, but increased R&D expenditure had a much stronger influence upon Shandong GDP growth. The result proves that higher education development and R&D expenditure do accelerate the GDP growth as indicated in the principles of economics. Because investment in the higher education can improve the skill and innovation ability of the labor force that fundamentally labor force will have much higher productivity in the output of production. And the increased expenditure of R&D will produce more high technologies with intellectual property rights that can improve the efficiency and quality of the production. So that public and private investment in higher education and enterprise' R&D expenditure are all very important factors in order to ensure a sustainable growth of GDP.

Acknowledgments

Shandong social science planning research project: Research on dynamic collaborative development of Shandong manufacturing industry and producer services industry (19CDNJ31).

References

[1] Viracheat, I. , & Dash, T. R. . (2011). Growth of higher education and its relationship with per capita gdp in cambodia. International Journal of Business & Socialscience. 3, 6-12

[2] Huang, F. X. , & Li, C. . (2010). Dynamic effects of the Chinese GDP and number of higher education based on cointegrating. Canadian Social science, 6.34-40

[3] Zhe-Jian, L. , Qian, L. I. , & Lei, Z. . (2014). The relationship between the enrollment number of higher education in china and the growth of gdp based on spss——an empirical study about the factors influencing the growth of gdp in the national innovation system. Journal of Langfang Teachers College(Natural science Edition).10:67-73

[4] Sloka, Biruta, & Vilcina, Anastasija. (2009). Contribution of regional higher education institutions for regional development. Economic science for Rural Development.11:130-139

[5] Ju-Hui, Z. , & Shu-Long, S. . (2008). An analysis of the relationship between tuition fees in higher education and the income of residents or the increase of gdp per person in china. Journal of Liaoning Normal University (Social science Edition).8：80-91

[6] Johansen, S. and Juselius, K. Maximum (1990). Likelihood Estimation and Inferences on Cointegration with Application to the Demand for Money. Oxford Bulletin of Economics and Statistics, 52:169-210.