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Dynamic Relationship Among Education Fiscal Expenditure, Economic Growth, and Human Capital in the Provincial Regions: Application of Standard Research Methodology and Suggestion*

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This study empirically analyzed the dynamic relationship among regional education fiscal expenditure, regional economic growth, and regional human capital by 16 cities and provinces in Korea from 1998 to 2021 to find "stylized facts" and how to use them to establish local fiscal policies. In addition to analyzing the 16 cities and provinces, the capital, non-capital, metropolitan-city, and provincial regions were analyzed and compared.

The main contents of the study are as follows. We used panel data such as regional education fiscal expenditure, human capital, and economic growth to perform the panel unit root test, panel cointegration test, panel Granger causality test, and estimated the Panel Vector Error Correction (PVEC) model for impulse response and forecasting error variance decomposition based on the standard research methodology.

The analysis results of this study are summarized as follows. First, as a result of the first and second-generation panel unit root tests, it was found that unit roots exist in all three variables. Second, as a result of the panel cointegration test, it was found that there was one independent cointegration relationship among the three variables. Third, we used the PVEC model according to the results of the panel unit root test and the panel cointegration test, and the PVEC model with a lag length of 4 was estimated. As a result of the panel Granger causality test, we found that the long-term causal relationship between regional education fiscal expenditure and regional economic growth to regional human capital exists. Fourth, according to the impulse response, the growth rate of the three variables is most affected by their shock. Fifth, regional education fiscal expenditure and regional human capital are limited but mutually explanatory. The mutual explanatory power of all three variables was more significant in the capital regions than in the non-capital regions and more significant in the provincial regions than in the metropolitan-city region.

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In this study, we obtained robust research results by applying all of the standard research methodologies used in the analysis using the VAR model. However, we need to utilize the characteristics of the panel data when the PVAR or PVEC model is used. We applied a methodology to analyze the entire region, capital region, non-capital region, metropolitan-city region, and provincial region. We compared the results and confirmed its usefulness. Therefore, we propose that this methodology be used as one of the standard research methodologies in future studies.

Key Words: dynamic relationship, Korea panel data, panel test, PVEC model, impulse response, forecasting error variance decomposition

Ⅰ. Introduction

Regarding the direction of the causal relationship between government fiscal expenditure activities and economic growth, there is a theory that the increase in government fiscal expenditure leads to economic growth, and economic growth leads to a rise in government fiscal expenditure. In recent years, the endogenous growth theory, which seeks to explain the factors of economic development centered on human capital, has been drawing significant attention.[1)]

Although there are many factors for the rapid growth of the Korean economy, it has been evaluated that the accumulation of high-quality human capital through education is one of the crucial factors. In the era of the 4th industrial revolution, the importance of education and human capital is growing. Establishing a growth base by increasing human capital investment expenditure at the national or local level is crucial. Therefore, it is necessary to empirically analyze the relationship among education fiscal expenditure, economic growth, and human capital and utilize it when establishing policies.

Many studies analyze the relationship between education fiscal expenditure and economic growth at the national level. However, only a few studies empirically examined the relationship among schooling fiscal expenditure, human capital, and economic growth at the local government level. Therefore, through empirical analysis, we try to find 'stylized facts' that appear in the relationship among education fiscal expenditure, human capital, and economic growth in 16 cities and provinces in Korea and use them to establish policies.

Kang and Cho (2022) calculated the smart tourism industry's aggregate economic effect

1) This theory claims that technological progress plays a crucial role in economic growth and emphasizes that investment in human capital can be a source of economic growth.

and compared its changes using the 2013 and 2015 Regional Input-Output Tables. After standardizing the total national production inducement coefficient, value-added inducement coefficient, and employment coefficient in 2013 and 2015 with three standardization methods, an aggregating indicator that measures the aggregate economic effect of the smart tourism industry was calculated and compared.

Lee et al. (2022) standardized the method and step of estimating Jeju tourism revenue based on production statistics related to national income.

The study's main contents are based on the standard methodology in analyzing the VAR (Vector Auto-Regressive) model. From 1998 to 2021, we used panel data such as regional education fiscal expenditure (special accounting expenditure for education), human capital (human capital index), and economic growth (gross regional domestic product) to perform panel unit root test, panel cointegration test, estimation of PVAR (Panel Vector Auto-Regressive) model or Panel Vector Error Correction (PVEC) model, panel Granger causality test, Impulse Response Function, Forecasting Error Variance Decomposition. In addition, we proposed a new methodology applied in this study. We want to examine the dynamic relationship among three variables through panel time series analysis.

Through this study, we expect to get the following implications for establishing an evidence-based policy for local governments in line with the era of the 4th industrial revolution. First, it will be possible to get empirical policy implications for the importance of the accumulation of regional human capital and regional education fiscal expenditure. Second, it will be possible to enhance an empirical understanding of the impact of regional education fiscal expenditure on regional economic growth and its mechanism.

This paper consists of the following. Following the introduction, Section II examines previous studies on the relationship between regional fiscal expenditure and regional economic growth. Then, we try to identify the difference between this study and previous studies. In Section III, we conduct empirical analysis using the panel time series model, focusing on the tools of the standard research method such as the panel unit root test, panel cointegration test, panel causality test, impulse response function, and forecasting error variance decomposition. Section IV summarizes the research results and concludes by drawing implications for establishing education fiscal policies for local governments.

Ⅱ. Review of previous studies

Among the studies that analyzed the impact of government fiscal expenditure on economic growth at the national level, some studies are particularly interested in the effect of education expenditure. Park (2008) found that education spending in the year significantly contributes to real GDP growth when short-term spending expands. Lee and Choi (1996) found that economic growth due to public education expenditure began to be realized three years after expenditure and disappeared after seven years.

Some studies also analyzed the impact of local education expenditure on regional economic growth at the regional level. Kim (1997) found that increased public education expenditure significantly impacted regional economic growth. In addition, the results of a study by Shim and Kim (2016) also showed that education expenditure positively affects regional economic growth.

Among the studies that empirically analyzed the relationship between education fiscal expenditure and economic growth or among education fiscal expenditure, human capital, and economic growth at the regional level, the primary studies related to this study are as follows. Using time series and panel data from six major cities in Korea from 1987 to 2009, Moon and Seong (2011) examined the relationship among regional economic growth, total expenditure, and investment fiscal expenditure, such as social development expenditure and economic development expenditure at the regional level. From a short-term perspective, economic and social development expenditures did not affect the local economy. Still, from a long-term perspective, social development expenditure partially has a long-term equilibrium with the regional gross domestic product and positively impacts the local economy. Moon and Kim (2012) examined the dynamic relationship among regional education fiscal expenditure, regional human capital, and regional economic growth using the panel VAR model for 16 local governments in Korea from 1995 to 2010.[2) A bi-directional causal relationship existed among regional education fiscal expenditure, regional economic growth, and human capital. Still, a unidirectional causal relationship existed between regional human capital and regional economic growth. In the impulse response function and forecasting error variance decomposition, changes in education expenditure have a positive effect on the regional economy, and regional economic growth increases the size of education expenditure. In other words, they found that regional economic growth increases regional education fiscal expenditure, contributing to regional human capital formation and regional economic growth. This virtuous cycle empirically shows that education is an economically valuable investment

2) As factors affecting regional economic growth, regional education fiscal expenditures and human capital by the region are used.

activity.

The differences between this study and previous studies are as follows. Among the analytical tools using the panel time series, Moon and Seong (2011) conducted a panel unit root test, a panel cointegration test, and a panel Granger causality test, but this study additionally analyzed the short-term and long-term panel causality test, impulse response function, and forecasting error variance decomposition.

This study is similar to Moon and Kim (2012) in the variable selection and analysis methodology, but they conducted empirical analysis on all regions using the PVAR model. On the other hand, this study analyzed and compared the capital regions, non-capital regions, metropolitan-city regions, and provincial regions in addition to all regions using the PVEC model.[3)]

The regional economic growth, regional education fiscal expenditures, and regional human capital are used in this study. The regional education fiscal expenditures include general and special accounts for education expenses, while the regional human capital is calculated using the educational background of people employed by the region.

Ⅲ. Empirical Analysis

1. Data

The data used in this study are as follows. We retrieved the special account expenditure for education by region from the 1998-2021 local fiscal yearbook.[4)] We calculated the human capital index(HCI) using the average years of schooling for employed people of the national statistical portal by region based on the human capital estimation method. In other words, the human capital index is the sum of the weight by education level times the number of schooling years. The larger this value, the higher the level of human capital education. We retrieved the Gross Regional Domestic Product by region from the national statistical portal.

The average expenditure on special accounts for education expenses from 1998 to 2021 of all regions was KRW 2,825.4 billion. The average expenditure of three capital regions was KRW 6,184.1 billion, thirteen non-capital regions was KRW 2,050.4 billion, seven metropolitan-city regions was KRW 2,555.7 billion, and nine provincial regions was KRW 3,035.3 billion. The standard deviation was

3) All empirical analyses were performed with EViews 12.
4) We used a nominal variable for special account expenditure for education by region because the impact of real GRDP and human capital can be considered real shocks. In contrast, nominal special account expenditure can be seen as a nominal shock. The analysis results can be compared using real special account expenditure or real GRDP and real special account expenditure per capita.

KRW 2,672.1 billion in 16 regions, KRW 4,302.9 billion in the capital regions, KRW 1,162.8 billion in the non-capital regions, KRW 2,149.6 billion in the metropolitan-city regions, and KRW 3,004.8 billion in the province regions. The average and standard deviation of the special account expenditure for education in capital regions are the largest, while those in non-capital regions are the smallest. As for the average Gross Regional Domestic Product, the average and standard deviation in capital regions are the largest, while those in non-capital regions are the smallest. The average regional human capital

〈Table 1〉 Sample Statistics

Classification	EDU	GRDP	HCI
All regions			
Mean	2,825.4	86,121.1	11.99386
Maximum	18,494.5	496,672.3	13.79604
Minimum	251.1	7,456.3	9.415493
Std. Dev.	2,672.1	94,404.4	0.88309
Capital regions			
Mean	6,184.1	229,616	12.65283
Maximum	18,494.5	496,672.3	13.79604
Minimum	770.5	37,317.4	11.61079
Std. Dev.	4,302.9	138,986.1	0.562208
Non-capital regions			
Mean	2,050.4	5,300.6	11.8418
Maximum	6,039.2	118,002	13.47771
Minimum	251.1	745.6	9.415493
Std. Dev.	1,162.8	2,642.6	0.874359
Metropolitan-city regions			
Mean	2.555.7	89,919.8	12.56533
Maximum	11,109.6	432,406	13.79604
Minimum	327.7	16,743.5	11.5528
Std. Dev.	2,149.6	100,375.1	0.553749
Province regions			
Mean	3,035.3	83,166.5	11.54939
Maximum	18,494.5	496,672.3	13.34601
Minimum	251.1	7,456.3	9.415493
Std. Dev.	3,004.8	89,611.8	0.83509

Note: EDU is measured in billion KRW, GRDP is measured in constant 2015 billion KRW, and HCI is the sum of the weight by education level times the number of schooling years.

in non-capital regions is the largest, while the standard deviation in metropolitan-city regions is the smallest.

2. Panel unit root test

As panel data is used extensively in empirical analysis, various time series analysis tools have been developed and used in panel models. Since the number of time series data samples in certain countries (or regions) is smaller than that of panel data samples, time series analysis may have limitations compared to panel analysis in estimation or tests.

The existence of a unit root in a time series means that the time series has a stochastic trend. In this case, the effect of the impact generated in the t period persists without dissipating over time. Various unit root test methods have been developed and used in the time series model, and many panel unit root tests have recently been developed and used in the panel time series model.

Because there may be heterogeneous panel problems in the panel model, the unit root may appear in the time series data of a particular country (or region) in the panel unit root test but not in other countries (or regions). We have to use a panel unit root test when using panel time series data because it solves the dependence among panels and has high power.

There are many methods of testing the panel unit root, but it depends on the setting of the null and alternative hypotheses. First, Levin, Lin, and Chu (2002) developed the LLC test method with the null hypothesis that all panel groups have unit roots. The alternative hypothesis is that all panel groups are stationary time series and have the same parameters.[5)]

Meanwhile, Im, Pesaran, and Shin (2003) developed the average t-test method of a unit root, and the null hypothesis is the same as the LLC test method in the setting of the null hypothesis. Still, the alternative hypothesis sets some panel groups as stationary time series. Therefore, the IPS considers individual heterogeneity of data compared to LLC.[6)]

The LLC and IPS tests assume the cross-sectional independence of data, which is called the first-generation panel unit root test. The assumption of cross-sectional independence using the first-generation panel unit root test can be difficult to justify because common forces or factors often influence cross-sections. Therefore, tests that account for cross-sectional dependence have been called the second-generation panel unit root test.

5) Refer to Hurlin and Mignon's paper (2007) for a detailed description.
6) The LLC test assumes that the regression coefficients are the same across each cross-section and have a common unit root. The IPS, ADF-Fisher, and PP-Fisher tests assume that the regression coefficients of each cross-section are heterogeneous.

The second-generation unit root test relaxes the cross-sectional independence assumption. The issue of the second-generation unit root test is how to specify these cross-sectional dependencies. One group sets the cross-sectional dependencies as a common factor model, while the other group imposes few or no restrictions on the covariance matrix of residuals.

This study used the first and second-generation panel unit root tests. We use Breitung's (2000) test as the first-generation panel unit root test because it has the highest power and the smallest size distortion among all panel unit root tests based on the assertion Hlouskova and Wagner(2006) made. Meanwhile, we take Pesaran's (2003, 2007) Cross-sectionally Augmented IPS (CIPS) as the second-generation panel unit root test. Pesaran (2003) proposes a one-factor model with heterogeneous loading factors for residuals. We need to use the second-generation panel unit root test according to the result of the cross-section dependence test.[7)]

According to the Breitung unit root test in 〈Table 2〉, unit root exists in all three types of GRDP. Unit root exists in two types except for intercept and trend in the case of EDU, while unit root exists in both types except for no intercept and trend in the case of HCI.[8)] According to the results of the CIPS unit root test, a second-generation panel unit root test, the p-value is greater than 0.1, and thus, unit roots exist at all significance levels in the case of GRDP. On the other hand, the p-value is less than 0.1, so there is a unit root at the 10% significance level in the case of EDU

〈Table 2〉 Panel Unit Root Test in level

Variable	Breitung									CIPS		
	No Intercept			Intercept			Intercept & trend					
	S[2)]	P[2)]	L[2)]	S[2)]	P[2)]	L[2)]	S[2)]	P[2)]	L[2)]	S	P	Spec[2)]
ln(GRDP)	-0.26	0.39	4	0.14	0.55	4	1.45	0.92	4	-1.27	〉=0.1	Constant
ln(EDU)	-0.94	0.17	4	-0.30	0.38	4	-2.97	0.00	4	-2.71	〈0.1	Constant and trend
ln(HCI)	-4.66	0.00	4	-0.07	0.46	4	0.17	0.57	4	-2.75	〈0.1	Constant and trend

Note: 1) We determined the optimal lag length based on the SC.
2) S, P, L, and Spec represent Statistic, P-Value, Lags, and Specification, respectively.

7) Breusch-Pagan's LM statistics, which test the null hypothesis that there is no cross-section dependence (correlation) for each GRDP, EDU, and HCI variable, were found to reject the null hypothesis, respectively.

8) As a result of testing the existence of unit roots of the first difference variable, we found that the first difference of three variables was a stationary time series by rejecting the null hypothesis that all panel groups had unit roots at the 1% significance level.

and HCI.

Banerjee et al. (2001) argue that because of cross-unit cointegration and long-run relationships among countries, panel unit root tests often reject the null hypothesis even when the hull hypothesis is true. Based on this argument, we conclude that all variables have a panel unit root.

3. Panel cointegration test

In the multivariate time series model, if all variables are nonstationary time series, it is essential to examine whether a cointegration relationship may exist between them. Engle and Granger (1987) defined the linear combination relationship as cointegration when a linear combination generates a stationary time series between them. However, it is a nonstationary time series with unit roots individually. Therefore, testing the cointegration relationship between time series examines whether time series with individual stochastic trends have a common trend.

When the first difference of a nonstationary process is stationary, the process is said to be integrated of order one, denoted I(1). When a linear combination of several I(1) series is stationary, the series are said to be cointegrated. We test for cointegration because it implies that the I(1) series are in long-run equilibrium. A cointegration test provides evidence that there is (or is not) a long-run relationship between these series, even if these series tend to deviate temporarily.

The economic meaning of this cointegration is that there is a long-term and stable equilibrium relationship among variables. In other words, if one variable cannot hold a stable relationship with another variable in a cointegration relationship for any reason, this state does not last long and necessarily returns to the previous stable relationship. Therefore, testing whether there is a cointegration relationship between time series variables with unit roots examines whether there is an economically stable equilibrium relationship between these variables.

Various cointegration tests have also been developed and used in time series analysis, and cointegration tests in panel times series analysis have been developed and used in recent years. For example, the cointegration test on a panel of Kao (1999) and Pedroni (1999, 2004) has a common null hypothesis of no cointegration. The alternative hypothesis is that the variables are cointegrated in all panels. The Westerlund (2005) test has two versions of the alternative hypothesis. One version is that the variables are cointegrated in some of the panels, and another is that the variables are cointegrated in all the panels.

In addition, due to the heterogeneous panel problem in the panel time series model, even if the variable subject to analysis of all regions has a unit root, it is a question of whether or not one cointegration vector can be estimated because it can be estimated differently from region to region.

In this study, since all three variables have unit roots as a result of the panel unit root test, it is necessary to check the panel cointegration relationship of the variables because if there is a panel cointegration relationship, a panel vector error correction (PVEC) model including an error correction term should be set in the dynamic panel time series model.

Pedroni's (1999, 2001, 2004) test was conducted in this study to examine a long-run equilibrium relationship among variables for panel data. 〈Table 3〉 shows the results of the panel cointegration test. Since the null hypothesis is that no cointegration exists, if the p-value that rejects this is less than 0.05, the null hypothesis is rejected. It is judged that there is a cointegration relationship. Since eight of the 11 test statistics reject the null hypothesis under the 5% significance level, we reject the null hypothesis according to the majority rule. Accordingly, we conclude that a cointegration relationship exists.

Three models can be used depending on the results of the cointegration test. First, suppose that the level variables of regional education fiscal expenditure (EDU), regional economic growth (GRDP), and regional human capital (HCI) are nonstationary time series with panel unit roots. At the same time, there is no cointegration relationship among the level variables. We should set the PVAR model with the first difference variables. Second, if the level variables of three variables are nonstationary time series with panel unit roots, and at the same time, there is one cointegration relationship among the level variables. We should set the PVEC model with the first difference variables. Third, if two independent cointegration relationships exist, the PVAR model with level variables should be set because each level variable is stationary time

〈Table 3〉 Panel Cointegration Test (Pedroni)

Classification	Statistic	P value	Weighted Statistic	P value
Panel v-Statistic	1.892699	0.0292**	2.261269	0.0119**
Panel rho-Statistic	-0.184098	0.4270	-0.583502	0.2798
Panel PP-Statistic	-2.050184	0.0202**	-2.590462	0.0048***
Panel ADF-Statistic	-2.308938	0.0105**	-2.763958	0.0029***
Group rho-Statistic	0.065887	0.5263		
Group PP-Statistic	-3.815409	0.0001***		
Group ADF-Statistic	-4.968584	0.0000***		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

〈Table 4〉 Panel Cointegration Test (Johansen Fisher)

Hypothesized No. of CE(s)	Fisher Stat (from trace test)	Probability	Fisher Stat (from max-eigen test)	Probability
None	125.8	0.0000***	93.84	0.0000***
At most 1	59.32	0.0023***	41.10	0.1300
At most 2	42.62	0.0993*	42.62	0.0903*

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

series without a panel unit root.

The number of cointegration relationships is important when there is a panel cointegration relationship. Thus, the number of independent cointegration relationships was examined in this study using Johansen Fisher's method. 〈Table 4〉 shows the results of a panel cointegration test to determine whether regional education fiscal expenditure (EDU), regional economic growth (GRDP), and regional human capital (HCI) maintain a long-term equilibrium relationship. There may be no cointegration relationship among the three variables or one or two independent cointegration relationships if a cointegration relationship exists. The Trace test statistic shows two cointegration relationships at the 5% significance level, while the Maximum Eigenvalue test statistic shows one cointegration relationship at the 5% significance level.

4. Empirical model

The empirical model of this study is a PVEC model with the first difference variables based on the results of the panel unit root test and the panel cointegration test, which has the advantage of including the heterogeneity of individual groups.[9] Using the PVEC model, we can perform the dynamic structure and policy analysis of the model with analytical tools such as the causality test that can analyze the causal relationship between variables,[10] the impulse response function that can analyze the dynamic response of endogenous variables to shocks, and the forecasting error variance decomposition that can measure the relative importance of shocks.

The PVEC model, as shown in the following (1)-(3), was set as three variables: regional education fiscal expenditure (x_{it}), regional

9) Suppose all three variables are nonstationary time series with unit roots, and there is a cointegration relationship among the three variables. A PVEC model with the first difference variables should be set. A PVAR model with the first difference variables should be developed as an empirical analysis model if there is no cointegration relationship among the three nonstationary variables.

10) In the case of the PVAR model, only a short-term causality test is possible, but we can perform a long-term causality test in addition to the short-term causality test in the case of the PVEC model.

economic growth (y_{it}), and regional human capital (z_{it}). It is assumed that panel group i follows the same process for the endogenous variable.

$$\Delta x_{it} = \alpha_1 + \sum_{k=1}^{p} \alpha_{1k} \Delta x_{it-k} + \sum_{k=1}^{p} \alpha_{2k} \Delta y_{it-k} + \sum_{k=1}^{p} \alpha_{3k} \Delta z_{it-k} + \lambda_1 ECT_{it-1} + u_{1,it} \quad (1)$$

$$\Delta y_{it} = \beta_1 + \sum_{k=1}^{p} \beta_{1k} \Delta x_{it-k} + \sum_{k=1}^{p} \beta_{2k} \Delta y_{it-k} + \sum_{k=1}^{p} \beta_{3k} \Delta z_{it-k} + \lambda_2 ECT_{it-1} + u_{2,it} \quad (2)$$

$$\Delta z_{it} = \gamma_1 + \sum_{k=1}^{p} \gamma_{1k} \Delta x_{it-k} + \sum_{k=1}^{p} \gamma_{2k} \Delta y_{it-k} + \sum_{k=1}^{p} \gamma_{3k} \Delta z_{it-k} + \lambda_3 ECT_{it-1} + u_{3,it} \quad (3)$$

where i(i=1, 2,..., N) is the number of regions in the panel, t(t=1, 2,..., T) is the number of periods, Δx_{it}, Δy_{it}, Δz_{it} denote the first difference variable of ln(EDU), ln(GRDP), ln(HCI) respectively and Δx_{it-k}, Δy_{it-k}, Δz_{it-k} are lag variables of Δx_{it}, Δy_{it}, Δz_{it}, p is the lag length, ECT is the error correction term, and u=($u_{1,it}$, $u_{2,it}$, $u_{3,it}$) are the random error term with $E(u)=0$ and $E(uu')=\Omega$.

5. Optimal lag length

We must set the optimal lag length of the model to conduct empirical analysis using the PVEC model. If the lag length is too short, it may not sufficiently reflect the model's dynamic relationship, whereas the data loss problem occurs if the lag length is too long due to over-estimation. We used the Akaike Information Criterion (AIC) and Schwarz Criterion (SC) for optimal lag length determination.

Since the smallest values of AIC and SC represent the optimal leg length, the optimal leg length is four according to AIC, while the optimal leg length is three according to SC, as shown in 〈Table 5〉.

Meanwhile, 〈Table 6〉 shows the results of the Wald test that tested the null hypothesis that a specific lag length in the model is not jointly and statistically significant after estimating the PVEC model with a lag length of 5. For example, in three estimation equations of the PVEC model, the null hypothesis with a degree of freedom of 9 that the estimated coefficient of lag length 1 for each equation is not jointly and statistically significant is rejected because the χ^2 test statistic is 42.19685,

〈Table 5〉 Optimal lag length

Criterion	lag=1	lag=2	lag=3	lag=4
AIC	-14.3753	-14.49155	-14.78184	-14.82209*
SC	-14.17773	-14.18482	-14.3579*	-14.27187

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

〈Table 6〉 Lag Exclusion Test

Classification	lag=1	lag=2	lag=3	lag=4	lag=5
Statistic	42.19685	27.70256	59.6387	22.56502	12.99256
Prob.	0.0000***	0.0011***	0.0000***	0.0073***	0.1629
df	9	9	9	9	9

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

and the significance probability is 0.0000. The null hypothesis was rejected, respectively, from the lag length of 1 to the lag length of 4. We found from the Wald test that the optimal lag length is four because we failed to reject the null hypothesis at the lag length of five.

6. Panel causality test

Granger (1969) proposed the concept of causality using forecasting errors. If Y can be predicted better using X and Y's past information than Y with only Y's past information, X is considered the cause variable of Y. In other words, if the forecasting error for Y can be reduced with the past information of X, X is regarded as the cause variable of Y. The method of the Granger causality test estimates the regression equation of Y as lag variables of Y and X. It performs a joint test on the statistical significance of the regression coefficients of lag variables of X.

In equations (1)-(3) of the PVEC model, the ECT is an error correction term, and the estimated coefficient λ_i (i=1,2,3) represents the long-term causality among variables. At the same time, we perform the Wald test for the short-term causality.

〈Table 7〉 shows the results of a short-term and long-term Granger causality test after estimating the PVEC model with a lag length of 4. Suppose the error correction term has a positive value showing a higher state than the long-term equilibrium. In that case, the sign of the adjustment coefficient, which represents the recovery rate to the long-term equilibrium, should be shown as negative. As a result of the analysis, we found that all adjustment coefficients were negative. Still, there was only a long-term causal relationship between regional education fiscal expenditure, regional economic growth, and regional human capital at the 5% significance level. We also found the short-term causal relationship that there is a bilateral causal relationship between regional education fiscal expenditure and regional economic growth, and there is a unidirectional causal relationship from regional economic growth to regional human capital. Another unidirectional causal relationship from regional human capital to regional economic growth to regional education fiscal expenditure

〈Table 7〉 Panel Granger Causality Test

Class.	Long-term Causality		Short-term Causality (From ln(EDU))			Short-term Causality (From ln(GRDP))			Short-term Causality (From ln(HCI))		
	Stat.	t-value (Prob.)	Stat.	Prob.	df	Stat.	Prob.	df	Stat.	Prob.	df
ln(EDU)	-0.0035	-1.4622 (0.144)	-			23.14	0.0001***	4	9.07	0.0591*	4
ln(GRDP)	-0.0007	-0.6035 (0.5462)	29.91	0.0000***	4	-			4.79	0.3089	4
ln(HCI)	-0.002	-7.2637 (0.0000)***	3.14	0.5344	4	17.86	0.0013***	4	-		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

exists at the 10% significance level.

7. Impulse response function

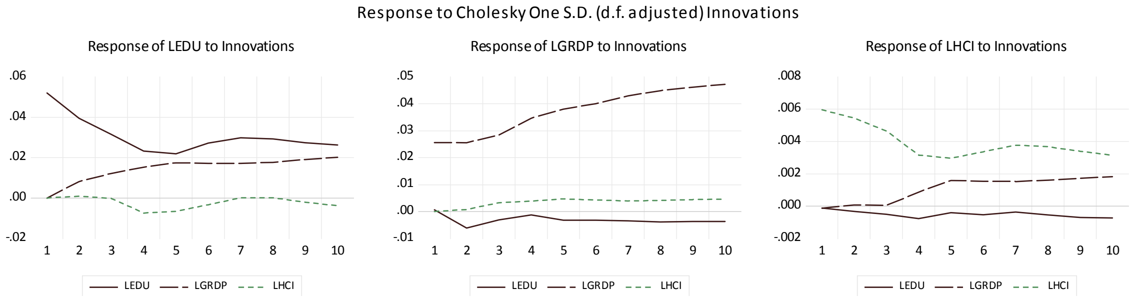
The impulse response function, one of the analytical tools of the PVEC model, shows how all variables in the model respond to each shock over time when an unexpected change (impact) occurs to a specific variable in the model.

According to the impulse response function of 〈Figure 1〉, if the growth rate of regional education fiscal expenditure is shocked by one standard deviation, the growth rate of regional education fiscal expenditure rises by 0.0519 a year later. Then it falls to its lowest level five years later and reaches a steady-state. When the regional economic growth rate is shocked by one standard deviation, regional education fiscal expenditure growth continues to rise, reaching a steady-state of 0.0179 increase after five years. Suppose the regional human capital growth rate is shocked by one standard deviation. In that case, the regional education fiscal expenditure growth rate shows a small 2-4 year cycle fluctuation and reaches a steady-state.

Suppose the growth rate of regional education fiscal expenditure is shocked by one standard deviation. In that case, the regional economic growth rate falls to a steady state by 0.0021, decreasing four years later. If the regional economic growth rate is shocked by one standard deviation, the regional economic growth rate continues to rise to a steady-state by 0.0471 increase ten years later. And if the regional human capital growth rate is shocked by one standard deviation, the regional economic growth rate slowly rises to a steady-state by 0.0033 increase three years later.

Suppose the growth rate of regional education fiscal expenditure is shocked by one

〈Figure 1〉 Impulse Response Function

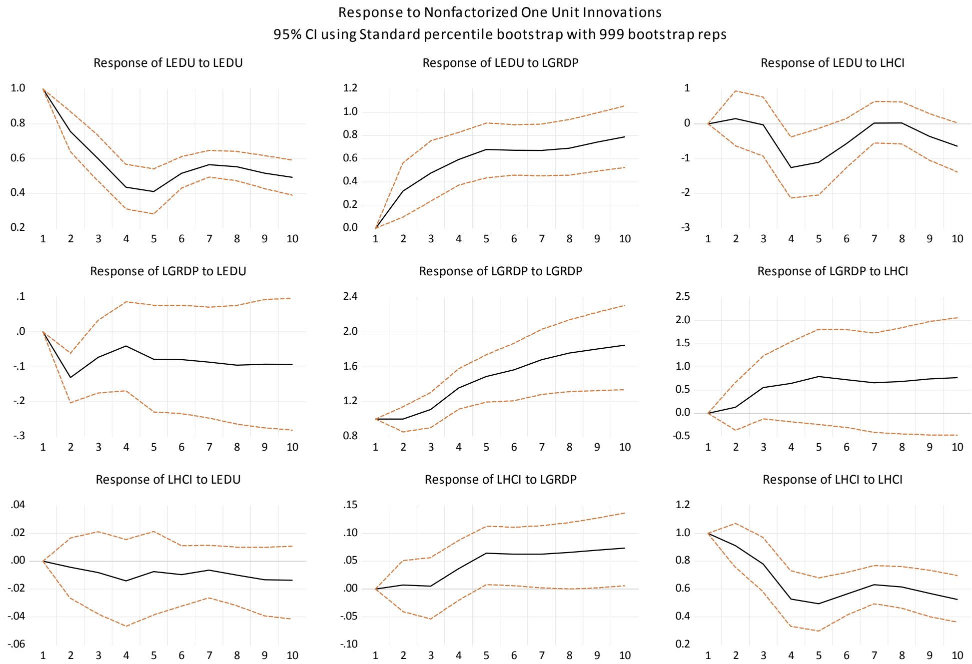


standard deviation. In that case, the growth rate of regional human capital will reach a steady-state, which has fallen by 0.0008 four years later. When the regional economic growth rate is shocked by one standard deviation, the regional human capital growth rate slowly rises and reaches a steady-state that has increased by 0.0016 five years later. In addition, when the regional human capital growth rate is shocked by one standard deviation, the regional human capital growth rate rises by 0.0059 a year later, falls rapidly, and then slowly rises by 0.0038 seven years later.

In summary, the growth rate of regional education fiscal expenditure is most affected by the shock of itself, positively affected by the shock of regional economic growth, and negatively affected by the shock of regional human capital growth. The regional economic growth rate is most affected by the shock of itself, negatively affected by the shock of regional education fiscal expenditure, and positively affected by the shock of the regional human capital growth rate. The regional human capital growth rate is most affected by the shock of itself, negatively affected by the shock of regional education fiscal expenditure, and positively affected by the shock of the regional human capital growth rate.

The Confidence Interval of the impulse response is used to determine the statistical significance of the estimated impulse response function. If the confidence interval for the impulse response does not include the x-axis, we can conclude that our impulse response function is significantly different from 0. 〈Figure 2〉 represents the impulse response with 95% Confidence Interval. The growth rate of regional education fiscal expenditure responds only after 4-5 years to the regional human capital growth rate shock and responds to other shocks at all times. The regional economic growth rate responds to its shock. Still, it does not respond to the regional human capital growth rate shock and only responds to the regional education fiscal ex-

〈Figure 2〉 95% Confidence Interval of Impulse Response Function



penditure shock growth rate two years later. We found that the regional human capital growth rate responds to its shock but not other shocks.

8. Forecasting error variance decomposition

Forecasting error variance decomposition measures the relative importance of each shock in a model by indicating the fluctuation of each variable at the rate explained by each shock in the model. 〈Table 8〉 shows the forecasting error variance decomposition over time after estimation by the PVEC model. The ratio of forecasting error variance on the growth rate of regional education fiscal expenditure explained by regional education fiscal expenditure is 79.92-100%. The ratio of forecasting error variance on the same variable explained by regional economic growth and regional human capital is 0-19.05% and 0-1.41%, respectively. The forecasting error variance ratio on the regional economy's growth rate explained by regional education fiscal expenditure is 0.07-2.82%. The ratio of forecasting error variance on the same variable explained by regional economic growth and regional human capital is 97.14-99.93% and 0-1.03%, respectively. In addition, the ratio of forecasting error variance on the growth rate of regional human capital explained by regional education fiscal expenditure is 0.04-1.53%. The ratio of forecasting error variance on the same variable explained by regional economic growth and regional human capital are 0.04-9.08% and 89.39-99.92%, respectively.

Regional education fiscal expenditure is explained by 20.07% of regional economic growth and regional human capital at steady-state. Regional economic growth is explained by 1.77% of regional education fiscal expenditure and regional human capital, and regional human capital is explained by 10.61% of regional education fiscal expenditure and regional economic growth.

In short, regional education fiscal expenditure and regional human capital are limited but mutually explanatory. In contrast, regional economic growth has little mutual explanatory power with regional education fiscal expenditure and regional human capital.

Meanwhile, 〈Table 9〉 compares the relative importance of each variable at steady-state by dividing the capital, non-capital, metropolitan-city, and provincial regions. The ratio of regional education fiscal expenditure explained by regional economic growth and regional human capital was the largest at 34.51% in the capital region and 13.02-17.34% in other regions. The ratio of regional economic growth explained by regional education fiscal expenditure and regional human capital was the largest at 25.83% in the capital region and 1.15-10.53% in other regions. The ratio of regional human capital explained by regional education fiscal expenditure and regional economic growth was the largest at 17.12% in the provincial region and 5.05-8.92% in other regions.

In addition, the mutual explanatory power

〈Table 8〉 Forecasting error variance decomposition

Year \ Variable	LEDU			LGRDP			LHCI		
	LEDU	LGRDP	LHCI	LEDU	LGRDP	LHCI	LEDU	LGRDP	LHCI
1	100.00	0.00	0.00	0.07	99.93	0.00	0.04	0.04	99.92
2	98.43	1.55	0.02	2.82	97.14	0.05	0.18	0.03	99.79
3	96.04	3.94	0.02	2.19	97.28	0.53	0.43	0.03	99.54
4	91.96	7.14	0.90	1.45	97.78	0.77	0.98	0.79	98.24
5	88.00	10.60	1.41	1.22	97.79	1.00	1.02	3.00	95.98
6	85.77	12.87	1.36	1.06	97.91	1.03	1.13	4.56	94.31
7	84.43	14.38	1.19	0.97	98.05	0.98	1.09	5.68	93.23
8	83.19	15.75	1.06	0.92	98.13	0.95	1.16	6.73	92.11
9	81.64	17.36	1.00	0.87	98.19	0.94	1.35	7.87	90.78
10	79.92	19.05	1.02	0.83	98.23	0.94	1.53	9.08	89.39

〈Table 9〉 Comparison of Forecasting error variance decomposition (at steady-state)

Region \ Variable	LEDU			LGRDP			LHCI		
	LEDU	LGRDP	LHCI	LEDU	LGRDP	LHCI	LEDU	LGRDP	LHCI
All	79.92	19.05	1.02	0.83	98.23	0.94	1.53	9.08	89.39
Capital	65.48	17.57	16.94	0.55	74.15	25.28	7.30	1.21	91.48
Non-capital	86.97	10.43	2.59	0.72	98.83	0.43	1.99	3.06	94.04
Metropolitan-city	82.65	6.90	10.44	4.39	89.45	6.14	0.18	8.74	91.07
Province	84.12	15.63	0.23	1.17	98.63	0.19	12.97	4.15	82.86

Note: All are the results of using the PVEC model, and the lag length of the model is 4 in all regions, 3 in the capital regions, 5 in the non-capital regions, 3 in the metropolitan-city regions, and 5 in the provincial regions.

of all three variables was more significant in the capital regions than in the non-capital regions and more significant in the provincial regions than in the metropolitan-city region.

Ⅴ. Summary and Conclusion

This study empirically analyzed the dynamic relationship among regional education fiscal expenditure, regional economic growth, and regional human capital by 16 cities and provinces in Korea from 1998 to 2021 to find “stylized facts” and how to use them to establish local fiscal policies. In addition to analyzing the 16 cities and provinces, the capital, non-capital, metropolitan-city, and provincial regions were analyzed and compared.

The analysis results of this study are summarized as follows. First, as a result of the first and second-generation panel unit root tests, it was found that unit roots exist in all three variables. Second, as a result of the panel cointegration test, it was found that there was one independent cointegration relationship among the three variables. Third, we used the PVEC model according to the results of the panel unit root test and the panel cointegration test, and the PVEC model with a lag length of 4 was estimated according to the results of the optimal lag length test. As a result of the panel Granger causality test, we found that the long-term causal relationship between regional education fiscal expenditure and regional economic growth to regional human capital exists. At the same time, there is a bilateral causal relationship between regional education fiscal expenditure and regional economic growth. A unidirectional causal relationship exists from regional economic growth to regional human capital. Fourth, according to the impulse response, the growth rate of regional education fiscal expenditure is most affected by the shock of regional education fiscal expenditure, positively affected by the shock of regional economic growth, and negatively affected by the shock of regional capital growth. The growth rate of the regional economy is most affected by the shock of the regional economic growth, negatively affected by the shock of regional education fiscal expenditure, and positively affected by the shock of the regional human capital. The regional human capital growth rate is most affected by the shock of the regional human capital growth rate, negatively affected by the shock of regional education fiscal expenditure, and positively affected by the shock of the regional human capital growth rate. Fifth, regional education fiscal expenditure and regional human capital are limited but mutually explanatory. In contrast, regional economic growth has little mutual explanatory power with regional education fiscal expenditure and regional human capital, according to the forecasting error variance decomposition. The mutual explanatory power of all three variables was more significant in the capital regions than in the non-capital regions and more significant in the provincial regions than in the metropolitan-city region.

Based on the results of this study, the implications for local fiscal policy are as follows. First, we can say that regional economic growth theoretically increases regional education fiscal expenditure, and regional education fiscal expenditure forms a virtuous cycle relationship that contributes to regional human capital formation and regional economic growth. As a result of this study, it isn't easy to find such a virtuous cycle. Still, there is a long-term equilibrium of regional education fiscal expenditure and regional economic growth on regional human capital, so the local government needs to establish an evidence-based policy using it. Second, strategic expenditure on regional education fiscal expenditure, which increases with regional economic growth, can promote the accumulation of regional human capital. Therefore, it is necessary to establish a mechanism that can lead to regional economic revitalization, such as regional economic growth and employment growth, by promoting the accumulation of regional human capital. Finally, the limitation of this study is the scope of regional education fiscal expenditure. Local education-related expenditures include special accounts for education expenses for kindergartens, elementary and secondary schools, special and lifelong education, education expenditures included in general accounts of local finances, and university-related fiscal expenditures. Regional education fiscal expenditure in this study includes only a special account for education expenses due to difficulties in collecting data. In this case, the increase in regional education fiscal expenditure has a limited impact on regional economic growth and the formation of the regional human capital of universities. If this is reflected in the future, it can be a realistic and explanatory study.

In this study, we obtained robust research results by applying the standard research methodologies to analyze the VAR model. However, we need to utilize the characteristics of the panel data when the PVAR or PVEC model is used. We applied a methodology to analyze the entire region, capital region, non-capital region, metropolitan-city region, and provincial region. We compared the results and confirmed its usefulness. Therefore, we propose that this methodology be used as one of the standard research methodologies in future studies.

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지방교육재정, 지역경제성장 및 지역인적자본 간 동태적 관계: 표준 연구방법론 적용 및 제언

강기춘* · 곽영식**

요 약

본 연구는 1998년부터 2021년까지 우리나라 16개 시・도별 지역교육재정지출, 지역경제성장 및 지역인적자본 간의 동태적 관계를 실증적으로 분석하여 ‘정형화된 사실’을 찾아내고 이를 지방재정정책 수립에 활용하는 방안을 모색하였다. 16개 시・도를 분석함과 아울러 수도권, 비수도권, 광역시권 및 도 지역을 분석 비교하였다.

연구의 주요 내용은 다음과 같다. 지역교육재정지출, 인적자본, 경제성장 등의 패널자료를 이용하여 표준 연구방법론에 따라 패널 단위근 검정, 패널 공적분 검정, 패널 그랜저 인과성 검정을 수행하고 충격반응과 예측오차분산분해를 위한 패널벡터오차수정(PVEC) 모형을 추정하였다.

본 연구의 분석 결과를 요약하면 다음과 같다. 첫째, 1세대와 2세대 패널 단위근 검정 결과 세 변수 모두 단위근이 존재하는 것으로 나타났다. 둘째, 패널 공적분 검정 결과 세 변수 중에서 독립적인 공적분 관계가 1개 존재하는 것으로 나타났다. 셋째, 패널 단위근 검정과 패널 공적분 검정 결과에 따라 PVEC 모형을 사용하여 시차 길이가 4인 PVEC 모형을 추정하였다. 패널 그랜저 인과성 검정 결과, 지역교육재정지출과 지역경제성장 간에 지역인적자본에 대한 장기 인과관계가 존재하는 것으로 나타났다. 넷째, 충격반응에 따르면 세 변수의 성장률은 자기 충격에 가장 큰 영향을 받는다. 다섯째, 지역교육재정지출과 지역인적자본은 제한적이지만 상호 설명력이 있다. 세 변수 모두의 상호 설명력은 비수도권보다 수도권에서, 광역시권보다 도 지역에서 유의한 것으로 나타났다.

본 연구에서는 VAR 모형을 이용한 분석에서 사용되는 표준 연구방법론을 모두 적용하여 강건한 연구결과를 얻었다. 다만, PVAR이나 PVEC 모형을 사용할 경우 패널자료의 특성을 활용할 필요가 있어 분석대상을 지역 전체, 수도권, 비수도권, 광역시권, 도 지역으로 구분하여 분석하는 방법론을 추가로 적용하였다. 그 결과를 비교하여 그 유용성을 확인하였다. 이에 향후 유사한 연구에서 이 방법론을 표준 연구방법론의 하나로 활용할 것을 제안한다.

※ 주요어: 동태적 관계, 한국패널자료, 패널 검정, PVEC모형, 충격반응, 예측오차분산분해

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