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An investigation of causal relationship between public education expenditures and economic growth in Turkiye: Evidence from provincial level analysis*

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Abstract

This paper investigates the causal relationship between educational expenditures and economic growth in Turkiye at the provincial level by using annual panel data covering the period 2009-2021. The main finding suggests that the causal relationship between economic growth and public education spending is heterogenous: it varies from one province to the other. Although there is no causal relationship between total and primary and secondary education expenditures and economic growth in a majority of provinces, there is a unidirectional causal relationship between higher education expenditures and economic growth in 41 out of 81 provinces.

Key words: Panel causality, Public education expenditures, Provincial level economic growth, Provincial level public education expenditures.

JEL codes: H73, I21, O41

1. Introduction

The multi-disciplinary literature on the relationship between economic growth and public expenditures is rich with theoretical formulations and empirical analyses. On the one hand, public expenditures are seen as an outcome of economic growth. Wagner's Law suggests that with the increase of real income in a country, there is a tendency to spend more on public goods and services. Wagner's Law theorizes that the causal relationship runs from economic growth to public expenditures. On the other hand, public expenditures are seen as an exogenous factor simulating economic growth by others (Keynes, 1936). In this line of thinking, the causality runs from public expenditures to economic growth. There is a growing literature testing these two hypotheses using various econometric techniques at a single country as well as cross-country levels.

The main focus of the literature on the relationship between public expenditures and economic growth is at the national level. However, understanding the direction of causality between public expenditures and economic growth at the subnational level is also very important for public policy making in the context of addressing regional disparities. The literature on regional disparities in Turkiye documents economic inequalities between western and eastern parts of the country (Karaalp-Orhan, 2020). Several studies argue that differences in public investment expenditures across different parts of the country are responsible for this disparity (Çelebioğlu and Dall'erba, 2010; Saygılı and Ozdemir, 2017). However, differences in investments in human capital through public education expenditures are also contributing to these disparities.

It is important to understand the causal relationship between education spending and economic growth in designing public policies to address regional inequalities. If causality runs from education spending to economic growth, public policies should be designed to attract more public and private investments in education to lagging regions in line with neo-classical theory postulations. However,

if Wagner's Law holds, it is important to attract physical capital investments for economic growth for increasing education spending.

In the economic growth literature, human and physical capitals are the factors of production. The neo-classical growth theory posits that long-run economic growth is a function of capital accumulation, labor growth, and technological progress—all of which determine a country's growth rate and steady-state level of output (Solow, 1956; Swan, 1956). Later the endogenous growth models stressed the importance of internal factors like human capital (Barro and Sala-i Martin, 1992). Taking the endogenous growth theory to a step further, the convergence literature focused on spatial dimension of economic growth analyzing core-peripery relations. There have been several improvements in the original endogenous growth methodolgy by investigating the role of public investment (Fujita and Hu, 2001), foreign direct investment (Aroca et. al., 2004) and human capital (Lall and Yilmaz, 2001).

In line with the thinking of convergence models, a distinct possibility is the causality relationship at the subnational levels, which may vary from a province to the other due to heterogeneity. This study investigates the role of education expenditures in stimulating economic growth at the provincial level by using annual panel data covering the period 2009-2021 in Turkiye.

This study is the first attempt in analyzing the causal relationship between education spending for primary and secondary education and higher education and economic growth at the subnational level in Turkiye. Understanding this relationship is important as it can provide insights into how educational investments impact regional economic development and inform policymakers on optimizing education budgets for sustainable growth.

The rest of the paper is organized as follows: the next section discusses the main findings of the literature on public education expenditures and economic growth in general as well as in the context of Turkiye. The third section describes the data used in the analysis. The fourth section provides discussions on the methodology and the findings of empirical analysis. Finally, the last section concludes with discussions on the direction of future research.

2. Literature review

Governments contribute to human capital formation through education spending at all levels, from elementary schooling to higher education and vocational training. However, there is a debate in the literature on whether human capital formation through public education spending translates to economic growth. The relationship between economic growth and public education expenditure is a

reciprocal and interactive one. The direction of this relationship can be from economic growth to education expenditures, as well as from education expenditures to growth.

The economic growth models have identified human capital stock as an important contributor to long-term growth (Lucas, 1988; Temple, 1999). Although research established the link between public expenditures and human capital (Eckstein and Zilcha, 1994; Glomm and Ravikumar, 1997; Blankeanu, 2005), the relationship between public education and economic growth in some of the macroeconomic models is more ambiguous (Levine and Renelt, 1992; Easterly and Rebelo, 1993; Griliches, 1997; Krueger and Lindahl, 2001).

In the initial neo-classical growth models, the long run economic growth rate was determined by technological change, an issue which was not well explained (Solow, 1956; Swan, 1956). The economic growth literature has identified public physical capital accumulation and human capital formation as important factors explaining variation of economic performance of countries and/or regions.

The assumption that education expenditures play an important role in fueling economic growth is based on the endogenous growth models of Romer (1986) and Lucas (1988). The endogenous growth model emphasizes that in addition to physical capital, investments in human capital are among the determining dynamics of economic growth. Education is the most important factor in the development of human capital. Thus, the efficient and effective use of educational resources is important for the economic performance of countries.

Building on the neo-classical models, however, endogenous growth models embarked on explaining how innovations and technological advancements play a role in long term growth performance. Lucas (1988) has identified human capital accumulation as an important contributor to long term economic growth. Consequently, the research in the endogenous growth literature presents evidence of a strong positive relationship between education and economic growth (Barro, 1991; Barro and Sala-i Martin, 1995). The endogenous growth theory postulates that the causal link runs from public expenditure spending to economic growth (Eckstein and Zilcha, 1994; Glomm and Ravikumar, 1997; Blankeanu, 2005). More recently, Dornbusch et al. (2011) conclude that the ability of countries to grow sustainably depends on the deployment of educational resources.

Contrary to endogenous growth models, Wagner's Law hypothesizes that increasing national income increases demand for more public expenditures (Henrekson, 1993). In the Wagner's Law, the direction of long-term causality is from economic growth to public expenditures. Wagner's Law theorizes that as real income increases, there is a long-run tendency for the share of public expenditure to increase relative to national income (Henrekson, 1993). There is a large body of

literature on Wagner's Law in general and in the education sector specifically (See Table 1). Gupta (1967), for example, documents a positive relationship between GDP and government expenditures. Kolluri, Panik and Wahab (2000) found the impact of Wagner's Law on public expenditures in G7 countries for a period of 1960-1993.

In the education sector, Nord (1983) investigates the determinants of education expenditures in 100 countywide school districts in North Carolina for the 1970-71 school year. He shows that median family income in these jurisdictions have a positive impact on public education expenditures. In a cross-country study, Busemeyer (2007) finds a positive impact of GDP per capita on public education expenditures in 21 OECD countries for 1980-2001 period.

There is also a growing literature studying the Wagner's Law in the context of public expenditures in Turkiye. Their findings present a mixed picture: some confirming the Wagner Law suggesting that the causality runs from economic growth to public expenditures, whereas others couldn't find any causal relationship.

Gül and Yavuz (2010) have analyzed the Wagner's Law by panel data for Bulgaria, Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia, Slovakia and Turkiye over 1996-2008 period. They found (i) a positive correlation from economic growth to aggregate public expenditures; and (ii) a positive correlation from sub-categories of public expenditures (current, investment and transfer expenditures) to economic growth.

Afsar (2009) reports one-way causality from education expenditures to economic growth by analyzing national level education expenditures for a period of 1963 and 2005.

Arisoy (2005) finds a unidirectional causality from economic growth to public expenditure at a disaggregated level—sub-categories of public expenditures such as current, investment, transfer and non-transfer expenditures. However, the study couldn't find any causal relationship between economic growth and total public expenditures. Contrary to Arisoy's study, Altunc (2011) finds results supporting Wagner's thesis for total public spending and not for disaggregated public expenditures. He investigates the Wagner's Law by using annual data for 1960-2009 period and finds that the direction of causality changes when the public expenditures are disaggregated into public consumption and public investment expenditures.

Other studies confirming the Wagner's Law include Oktayer (2011) and Bayrakdar et. al. (2015). They both use annual data for different periods. Oktayer (2011) analyzes the period between 1950-2009 and Bayrakdar et. al. (2015) confirms Wagner's Law using annual data for the period of 1998-2004.

Similar to other studies, Selen and Eryiğit (2009), Kanca (2011) and Gacener (2005) analyze the relationship between gross national product (GNP) and public

expenditures. Selen and Eryiğit (2009) have shown a positive relationship from GNP to public expenditures by using data for Turkiye over the period 1927-2006. By using a dynamic model, Kanca (2011) shows a positive relationship from public expenditures to GNP in the short run and the exact opposite in the long run. Gacener (2005) finds positive relationship between GNP and public expenditures validating Wagner's Law in Turkiye for a period of 1987-2003.

There are other studies that couldn't confirm the presence of Wagners' Law in Turkiye. Tuna (2013) analyzed the direction of public expenditures and economic growth in Turkiye by using Granger-causality test for a period of 1961-2012. Başar et. al. (2009) tested Wagner's Law by using annual data for 1975-2005 period by using bound test approach. Bağdigen and Beşer (2009) tested Wagner's Law by using annual data for a period of 1950-2005 by employing three different causality tests in seven different models. None of these studies revealed causality to support Wagner's thesis. Yıldırım et. al. (2011) investigates the direction of causality between education expenditures and economic growth for a period of 1973-2009 in Turkiye by using a national level dataset. Their results suggest that the causality is unidirectional running from GDP per capita to public education expenditures.

Table 1
Key Studies on Wagner's Law in the Education Sector

Author(s)	Countries, Period	Method	Variables	Result
Gupta (1967)	United Kingdom, West Germany, Canada, U.S.A., and Sweden	Cross-sectional	GDP, Public Expenditures	Wagner's Law effect observed
Kolluri, Panik and Wahab (2000)	G7 Countries 1960-1993	Panel Data	GDP, Public Expenditures	Wagner's Law effect observed
Nord (1983)	North Carolina 1970-71	Cross-sectional	Median Family Income, Public Education Expenditures	Positive relationship between family income and education spending
Busemeyer (2007)	21 OECD countries 1980-2001	Cross-country	GDP per capita, Public Education Expenditures	Positive impact of GDP per capita on public education expenditures
Gul & Yavuz (2010)	Bulgaria, Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia, Slovakia, and Turkiye 1996-2008	Panel Data	Economic Growth, Aggregate and Sub-categories of Public Expenditures	Positive correlation from economic growth to public expenditures
Afsar (2009)	National level 1963-2005	Time series	Education Expenditures, Economic Growth	One-way causality from education expenditures to economic growth
Arisoy (2005)	Turkiye 1960-2009	Panel Data	Economic Growth, Sub-categories of Public Expenditures	Unidirectional causality from economic growth to public expenditure
Altunc (2011)	Turkiye 1960-2009	Time series	Total Public Spending, Public Consumption, Public Investment	Support for Wagner's Law for total public spending

Author(s)	Countries, Period	Method	Variables	Result
Oktayer (2011)	Turkiye 1950-2009	Time series	GDP, Public Expenditures	Positive relationship supporting Wagner's Law
Bayrakdar et al. (2015)	Turkiye 1998-2004	Time series	GDP, Public Expenditures	Confirmation of Wagner's Law
Selen & Eryiğit (2009)	Turkiye 1927-2006	Time series	GNP, Public Expenditures	Positive relationship from GNP to public expenditures
Kanca (2011)	Turkiye 1960-2009	Dynamic Model	Public Expenditures, GNP	Positive short-term relationship; reverse in long-term
Gacener (2005)	Turkiye 1987-2003	Time series	GNP, Public Expenditures	Positive relationship validating Wagner's Law
Tuna (2013)	Turkiye 1961-2012	Granger causality	Public Expenditures, Economic Growth	No confirmation of Wagner's Law
Basar et al. (2009)	Turkiye 1975-2005	Bound test approach	Public Expenditures, Economic Growth	No causality to support Wagner's Law
Bagdigen and Beser (2009)	Turkiye 1950-2005	Various causality tests	Public Expenditures, Economic Growth	No causality supporting Wagner's Law
Yıldırım et. al. (2011)	Turkiye 1973-2009	National level, panel data	GDP per capita, Education Expenditures	Unidirectional causality from GDP to public education expenditures

3. Data

This study has focused on the panel data methods to examine the causal relationship between education expenditures and economic growth at the provincial level in Turkiye. The direction of the relationship between education expenditures and economic growth is analyzed by employing a panel data causality test developed by Dumitrescu and Hurlin (2012).

The study uses annual data for provincial level gross domestic product (GDP) and public education expenditures, both in per capita, for a period of 2009-2021. The main reason for the selection of the period from 2009 to 2021 is 2008 reforms in the national education system. The 2008 reforms extended compulsory education from 5 to 12 years, therefore, the dataset starts from 2009 to reflect this structural change in the compulsory education system.

All the series are log-transformed to reduce heteroscedasticity. Table 2 below provides information about the description and sources of data for the variables used in the study; whereas. Table 3 provides the descriptive statistics of all variables.

Table 2
Definition of Variables

Variable	*Definition*	*Unit of measurement*	*Source*
GRW	Provincial level GDP per capita is calculated by dividing total gross domestic product by mid-year population estimation of province.	Turkish Lira (TRY)	Turkish Statistical Institute Provincial GDP and Population data available at https://www.tuik.gov.tr/
ED	Provincial public education expenditure per capita is calculated by dividing total provincial public education expenditure by mid-year population estimation of province.	Turkish Lira (TRY)	Republic of Turkiye Ministry of Treasury and Finance Provincial Public Education Expenditures are available at https://en.hmb.gov.tr/
EDNUN	Provincial public education for primary and secondary education per capita is calculated by subtraction of total higher education budget from total public expenditure and by it by mid-year population estimation of province.	Turkish Lira (TRY)	Republic of Turkiye Ministry of Treasury and Finance Provincial Public Education Expenditures are available at https://en.hmb.gov.tr/
EDUU	Provincial public expenditure for higher education is calculated by aggregating the budgets of public universities in each province.	Turkish Lira (TRY)	Republic of Turkiye Ministry of Treasury and Finance - Council of Higher Education Provincial Public University Expenditures are available at https://en.hmb.gov.tr/ and https://istatistik.yok.gov.tr/

Tablo 3
Descriptive Statistics of Variables

Variable	*Number of Observations*	*Mean*	*Median*	*Standard Deviation*
GRW	1053	27381.57	21950	18765.96
ED	1053	1323.525	1250	667.5386
EDNUN	1053	987.4283	906	480.4129
EDUU	1053	336.0969	257	258.1396

The structure of the dataset is an important determinant of the type of test for diagnostic purposes in panel data analysis. This study employs a panel data set with a large cross-section dimension (N=81) and a small number of time periods (T=13). Panel data under conditions of N > T is often associated with estimation biases, including cross-sectional dependence and an invalid assumption of slope homogeneity. In the next section we provide test results for diagnostic tests.

4. Methodology and empirical results

The research question of the study is "What is the causal relationship between education expenditures and economic growth at the provincial level in Turkiye?" To investigate this question, a panel causality analysis has been conducted using the Dumitrescu and Hurlin (2012) test. This test was chosen due to its ability to accommodate heterogenous causality relationship across cross-sectional units, making it suitable for the provincial-level data in Turkiye.

Before conducting a causality analysis in a panel dataset context, it is important to conduct diagnostic tests to investigate *cross-sectional dependence*, *slope homogeneity* and *stationarity of series*. The results of diagnostic tests for these issues help researchers to select the right causality test according to the properties of the dataset. The diagnostic test results suggest cross-sectional dependence and heterogeneity of slope but a stationary series. Therefore, the Granger non-causality approach of Dumitrescu and Hurlin (2012) has been used to examine the direction of causality between GRW and ED. This approach allows us taking into account the individual heterogeneity in causal relation and cross-sectional dependence. Dumitrescu and Hurlin's (2012) test can be applied under both N > T and T > N situations. Before examining the causality, the diagnostic test results for cross-sectional dependence, stationarity, and slope homogeneity issues are presented below.

4.1. Cross-sectional dependence

Cross-sectional dependence is an important issue in econometrics, especially when working with panel data. Pesaran (2006) points out that ignoring cross-sectional dependence may to lead to inconsistent and upward-biased estimation. Thus, it is important to test the existence of cross-sectional dependence before the analysis. Various cross-sectional dependency tests are developed in the econometric literature. Unlike the traditional Breusch-Pagan (1980) LM test, the Pesaran (2004) CD test is more suitable for panel data with a large number of cross-sectional units (N) observed over T time periods. In cases where N > T, the Breusch and Pagan LM test may not perform well due to statistical limitations such as size distortions and unreliable asymptotic behavior. Therefore, the Pesaran (2004) CD test is a more appropriate choice for detecting cross-sectional dependence, as it is more robust when the number of cross-sectional units exceeds the number of time periods. This test is commonly applied in situations like the one in this study, where N > T.
The Pesaran CD test statistic can be formulated as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}\hat{\rho}_{ik}\right)} \quad (1)$$

where T is the time interval, N is the number of cross-section units, and $\hat{\rho}_{ik}$ is the pair-wise correlation between cross-sections. The CD statistic is assumed to be asymptotically normally distributed under the null hypothesis. The null hypothesis of test assumes that cross-section units are independent, against the alternative hypothesis of the dependence between cross-section units.

Table 4
The Cross-Sectional Dependence Test Results

Variables	*Statistic*	*p-value*
lnGRW	204.09*	0.000
lnED	202.42*	0.000
lnEDNUN	199.44*	0.000
lnEDUU	198.99*	0.000

Notes: (i) The null hypothesis of no cross-sectional dependence
(ii) * illustrates 1% statistical significance.

The CD test results presented in Table 4 indicate that the null hypothesis of no cross-sectional dependence is rejected at 1% statistical significance level. The finding points out that there is cross-sectional dependence in the variables of ED, EDNUN, EDUU and GRW.

4.2. Slope homogeneity test

The causality from one variable to another variable by imposing the joint restriction for the whole panel is the strong null hypothesis (Granger, 2003). Breitung (2005) points out that slope homogeneity will result in inaccurate predictions if the panels are perhaps heterogeneous. Hence, cross-sectional homogeneity must be regulated when performing empirical studies with panel data. This study tests for the slope homogeneity in the data series with the Pesaran and Yamagata (2008) standardized version of the Swamy (1970) homogeneity test. This test is commonly called $\tilde{\Delta}$ test. Pesaran and Yamagata (2008) developed two different test statistics.

For large samples, $\tilde{\Delta}$ test statistics is as follows:

$$\tilde{\Delta}= \sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}\right)\sim\chi_k^2 \tag{2}$$

where N denotes number of cross-section units. $\tilde{S}$ and k present Swamy test statistics and number of explanatory variables, respectively. For the case of small samples, the adjusted $\tilde{\Delta}$ test statistics is as follows:

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S}-E(\tilde{Z}_{it})}{Var(\tilde{Z}_{it})}\right)\sim N(0,1) \tag{3}$$

where $E(\tilde{Z}_{it}) = k$ and $Var(\tilde{Z}_{it}) = \frac{2k(T-k-1)}{T+1}$ present mean and variance, respectively.

Table 5
Homogeneity Test Results

Test	*Statistics*		
	lnED	*lnEDNUN*	*lnEDUU*
$\tilde{\Delta}$	2.882*	4.985*	15.201*
$\tilde{\Delta}_{adj}$	3.286*	5.684*	17.332*

Notes: (i) the null hypothesis of the slope coefficients being homogenous.
(ii) * illustrates 1% statistical significance.

The slope homogeneity is tested by using both large and small sample tests of Pesaran and Yamagata (2008). Table 5 reports the results of homogeneity test. The estimated statistics for the delta and the adjusted delta point out that the null hypothesis of the slope coefficients being homogenous is rejected at 1% statistical significance level. The rejection of slope homogeneity implies that if the panel causality analysis imposes homogeneity restrictions on the variable of interest, there will be misleading statistical inferences (Wu et al., 2016). The presence of cross-sectional dependence and heterogeneity over the sample period implies that the panel causality imposes homogeneity restriction and does not account for spillover effects across units which may result in misleading inferences. The results suggest that the selected series are heterogeneous across various cross-sectional units. In other words, it implies the existence of heterogeneity for the panel dataset. Therefore, heterogeneous panel data methods have been used.

4.3. Unit root test

The stationarity of data has been investigated by conducting a unit root test. Several methods for estimating stationarity are reported in the literature. Panel unit root tests are divided into two as first and second-generation tests. The test results so far points to cross sectional dependency and heterogeneity. In this situation, the first-generation panel unit root tests may not produce reliable results due to the low power of the test. To overcome this problem, we employed a second-generation panel unit root test that is called the cross-sectional Pesaran, and Shin (CIPS) unit root test developed by Pesaran (2007). The CIPS test takes into account the cross-sectional dependence of the observations and the heterogeneity of the parameters. CIPS test can be applied in cases where N > T. It produces consistent and unbiased results even when cross-sectional dependency and heterogeneity are present.
CIPS test, statistics can be obtained as follows:

$$CIPS(N,T) = N^{-1}\sum_{i=1}^{N} t_i(N,T) = \frac{\sum_{i=1}^{N} CADF_i}{N} \quad (4)$$

where $t_i(N,T)$ is the cross-sectionally augmented Dickey-Fuller test statistic for the i[th] cross section unit in the CADF regression. $CADF_i$ is the cross-sectionally augmented Dickey–Fuller statistic for the i[th] cross-sectional unit. This statistic is a modification of the t-bar (IPS) statistic proposed by Im et al. (2003). The null hypothesis of CIPS is that all the time series are non-stationary and the alternative hypothesis of CIPS is that all the time series are stationary processes.

In this study, since the cross-section dependency between the provinces in the panel dataset has been identified, the CIPS unit root test has been employed. Table 6 reports the test results. The unit root statistics are reported for the variables in level and in first difference.

Table 6
The Second-Generation Unit Root Test Results

Variables	*Constant*	*Constant & Trend*
lnGRW	-2.553*	-2.664**
lnED	-2.682*	-2.972*
lnEDNUN	-2.883*	-3.115*
lnEDUU	-3.238*	-2.983*

Notes: (i) The null hypothesis indicates that the series is homogeneous non-stationary.
(ii) *,** illustrates 1% and 5% statistical significance, respectively.

As shown in Table 6, the null hypothesis of unit root for the series of ED, EDNUN, EDUU and GRW has been rejected in both constant and constant & trend models at 1 percent significance level for ED, EDNUN, EDUU and 5 percent level for GRW. It confirms EDNUN, EDUU, ED and GRW to be stationary at level, I(0).

4.4. Panel causality test

After the diagnostic tests, the Dumitrescu and Hurlin (2012) test has been employed to understand the direction of causality in our dataset. The Dumitrescu and Hurlin (2012) test provides consistent results in the presence of cross-section dependence and heterogeneity. The modeling of Dumitrescu and Hurlin panel causality test is as follows:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t}$$

$$i = 1,2,\dots,N \;\; t = 1,2,..,T \qquad (5)$$

where y and x represent two stationary variables identified for N individual in T periods. α_i denotes individual effects that is assumed to be fixed in the time dimension. $\gamma_i^{(k)}$ and $\beta_i^{(k)}$ represent the autoregressive parameters and the regression coefficients slopes, respectively. The autoregressive parameters and the regression coefficients slopes vary across units. Lag orders K are identical for all cross-section units of the panel and the panel is balanced.

The null hypothesis of test assumes that there is no causal relationship in the panel (the so-called homogeneous noncausality hypothesis), against the alternative hypothesis which explains that the causal relationship exists in at least one cross section unit (the so called heterogeneous non-causality hypothesis). This approach comprises two statistics, i.e., W-statistics and Z-statistics. The above-stated hypothesis can be tested through an average Wald statistic is expressed as:

$$W_{N,T}^{HNC} = \frac{1}{N}\sum_{i=1}^{N} W_{i,T} \tag{6}$$

where $W_{i,T}$ represents for the individual Wald statistics for each cross-sectional unit. We emphasize that the test is designed to detect causality at the panel-level, and rejecting null hypothesis does not exclude non-causality for some individuals. Under the assumption that the Wald statistics $W_{i,T}$ are independently and identically distributed across individuals, it can be showed that the standardized statistic Z_N^{HNC} follows a standard normal distribution:

$$Z_N^{HNC} = \frac{\sqrt{N}\left(W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} E(W_{i,T})\right)}{\sqrt{N^{-1}Var(W_{i,T})}} \qquad N \to \infty, N(0,1) \tag{7}$$

If Z_N^{HNC} are larger than the standard critical values, then one should reject null hypothesis and conclude that Granger causality exists. In the study, we only reported the Z_N^{HNC} statistics which can be reasonably considered for large N but relatively small T datasets. Dumitrescu and Hurlin (2012) deal with stationary series, and the testing procedure considers the heterogeneity of causal relationships.

To investigate the causality between variables, series must be stationary. The results of unit root test revealed that the series of ED, EDNUN, EDUU and GRW is I(0).

The causality test equations for the variables addressed in the study are adapted based on Equation 5, in line with the methodology proposed by Dumitrescu and Hurlin (2012). These equations are designed to address the research question and provide insights into the causal relationships between the variables. Due to the large number of equations, each is not presented individually to avoid complexity.

Table 7 offers the results of Dumitrescu and Hurlin (2012) panel Wald Statistic, the Z-bar statistics and their associated probability value.

Table 7
The Results of Causality Test

Null hypothesis	*W-statistic*	*Z-statistic*	*p-value*	*Z-statistic Tilde*	*p-value*	*Causality*
lnED→ ln GRW	2.8508	11.7783	0.0000	6.1243	0.0000	Yes
lnGRW →lnED	3.9242	18.6093	0.0000	10.3246	0.0000	Yes
lnEDNUN→ lnGRW	2.9389	12.3392	0.0000	6.4692	0.0000	Yes
lnGRW →lnEDNUN	3.6345	16.7656	0.0000	9.1909	0.0000	Yes
lnEDUU→ ln GRW	1.8608	5.4784	0.0000	2.2505	0.0244	Yes
lnGRW →lnEDUU	10.0837	57.8083	0.0000	34.4275	0.0000	Yes

Notes: (i) The null hypothesis of no causal relationship between variables

(ii) The W-statistics yields the test average statistics, while the standard normal distribution is represented by the Z-statistics (Dumitrescu and Hurlin 2012).

(iii) "→" means the direction of the causality relationship.

(iv) The number of lags was selected as 1 based on the AIC and BIC

The null hypothesis of this panel causality test is that there is no causal relationship in the panel, whereas the alternative hypothesis is that there is a causal relationship in at least one cross-section unit. The test results in Table 7 show that the null hypothesis of homogeneous causality is clearly rejected at a 1% level of significance.

Based on the Dumitrescu and Hurlin causality test results, it is confirmed that there is a Granger causality between the education expenditures and economic growth for the whole provinces of Turkiye. However, the findings point out that the causality relationship is heterogenous. In this case, the nature of causality relationship between education expenditures and economic growth is different from one province to the other.

Since there is heterogeneity among the provinces regarding total education expenditures (ED) and economic growth (GRW), the direction of causality between DRW and ED for each province is investigated. Table 8 presents the Dumitrescu and Hurlin causality test results for each province. The findings are:

1) There is a unidirectional causality relationship from GRW to ED in 18 provinces: Ağrı, Bitlis, Burdur, Elazığ, Gümüşhane, Hakkari, Kirsehir, Mardin, Rize, Sakarya, Sinop, Tunceli, Şanlıurfa, Uşak, Şırnak, Bartın, Iğdır and Düzce. The

Wald statistics value for lnGRW→lnED is significant for these provinces at least at 5 percent level. In these provinces, an increase in economic growth increase spending on public education.

2) There is a unidirectional causality relationship from ED to GRW in 11 provinces: Adana, Ankara, Bilecik, Bolu, Gaziantep, Mersin, Kayseri, Kirklareli, Samsun, Sivas, and Trabzon. The Wald statistics value for lnED→lnGRW is significant for these provinces at least at 5 percent level. In these provinces, education expenditures cause economic growth.

3) There is a bidirectional causality relationship between education expenditures and economic growth only in one province: Çankırı. Bidirectional causality means both education expenditures and economic growth are causal to each other at the same time. This result points out that education expenditures can influence both directly and indirectly economic growth process, and vice-versa. The causality relationship for Cankiri can be summarized as follows: lnED↔lnGRW.

4) The results point out that there is no causal relationship between educational expenditures and economic growth for the rest of the 51 provinces. These provinces include: Adiyaman, Afyonkarahisar, Amasya, Antalya, Artvin, Aydin, Balikesir, Bingol, Bursa, Canakkale, Corum, Denizli, Diyarbakir, Edirne, Erzincan, Erzurum, Eskisehir, Giresun, Hatay, Isparta, Istanbul, Izmir, Kars, Kastamonu, Kocaeli, Konya, Kutahya, Malatya, Manisa, Kahramanmaras, Mugla, Mus, Nevsehir, Nigde, Ordu, Siirt, Tekirdag, Tokat, Van, Yozgat, Zonguldak, Aksaray, Bayburt, Karaman, Kirikkale, Batman, Ardahan, Yalova, Karabuk, Kilis, and Osmaniye.

Table 8
The Results of Causality in Provinces between GRW and ED

	lnGRW →lnED				lnED→ ln GRW		
Province	*Wald-statistic*	*Province*	*Wald-statistic*	*province*	*Wald-statistic*	*Province*	*Wald-Statistic*
Adana	0.9815	Konya	2.3449	**Adana**	**18.2818***	Konya	3.1589
Adıyaman	3.3025	Kütahya	3.2549	Adıyaman	0.2093	Kütahya	0.7924
Afyonkarahisar	3.7081	Malatya	2.5399	Afyonkarahisar	1.8895	Malatya	1.0090
Ağrı	**6.3388****	Manisa	1.1476	Ağrı	0.7569	Manisa	4.7312
Amasya	4.3121	Kh.Maraş	2.5755	Amasya	1.2939	Kh.Maraş	0.0007
Ankara	0.0340	**Mardin**	**5.4103****	**Ankara**	**7.4015****	Mardin	0.1499
Antalya	1.5605	Muğla	0.1918	Antalya	3.7332	Muğla	0.0180
Artvin	0.7172	Muş	3.2258	Artvin	1.6164	Muş	1.6654
Aydın	0.8129	Nevşehir	0.9129	Aydın	1.3366	Nevşehir	0.0035
Balıkesir	0.9635	Niğde	4.6302	Balıkesir	3.5620	Niğde	0.00002
Bilecik	2.4168	Ordu	3.6669	**Bilecik**	**8.7100****	Ordu	3.2682
Bingöl	4.3740	**Rize**	**6.4686****	Bingöl	3.3303	Rize	3.3679
Bitlis	**5.4789****	**Sakarya**	**5.2342****	Bitlis	1.0062	Sakarya	0.4110
Bolu	1.7315	Samsun	4.3953	**Bolu**	**6.3913****	**Samsun**	**7.0153****
Burdur	**10.7034***	Siirt	1.8484	Burdur	3.8494	Siirt	0.6375
Bursa	1.6289	**Sinop**	**6.0464****	Bursa	0.5701	Sinop	0.0447
Çanakkale	2.7320	Sivas	2.0494	Çanakkale	0.7580	**Sivas**	**8.6976****
Çankırı	**11.4168***	Tekirdağ	0.0491	**Çankırı**	**5.2776****	Tekirdağ	4.7051
Çorum	3.6156	Tokat	5.0801	Çorum	2.6451	Tokat	2.1132
Denizli	3.0055	Trabzon	4.2346	Denizli	3.3254	**Trabzon**	**21.1204***
Diyarbakır	3.2709	**Tunceli**	**6.7099****	Diyarbakır	0.4275	Tunceli	0.5538
Edirne	1.0252	**Şanlıurfa**	**6.7047****	Edirne	1.9851	Şanlıurfa	0.2590
Elazığ	**11.2503***	**Uşak**	**5.9497****	Elazığ	0.9909	Uşak	1.4581
Erzincan	0.6201	Van	1.1276	Erzincan	1.2457	Van	0.3350
Erzurum	3.5296	Yozgat	3.2676	Erzurum	4.1835	Yozgat	0.1827
Eskişehir	4.3286	Zonguldak	2.4766	Eskişehir	1.9196	Zonguldak	0.0089
Gaziantep	0.9188	Aksaray	4.2220	**Gaziantep**	**5.6687****	Aksaray	2.3605

Giresun	3.4633	Bayburt	0.2432	Giresun	0.0684	Bayburt	0.1165
Gümüşhane	**5.9687****	Karaman	3.8236	Gümüşhane	1.3811	Karaman	0.2688
Hakkari	**5.8559****	Kırıkkale	0.7582	Hakkari	1.2234	Kırıkkale	1.0324
Hatay	4.4310	Batman	2.4239	Hatay	1.3798	Batman	1.9151
Isparta	3.6339	**Şırnak**	**33.3015***	Isparta	3.6707	Şırnak	0.3736
Mersin	1.2664	**Bartın**	**7.9685****	**Mersin**	**13.4432***	Bartın	2.8283
İstanbul	2.2884	Ardahan	4.0013	İstanbul	0.7105	Ardahan	0.1169
İzmir	3.2495	**Iğdır**	**5.4737****	İzmir	1.8587	Iğdır	0.5990
Kars	2.2970	Yalova	4.0607	Kars	0.4429	Yalova	1.3412
Kastamonu	2.5587	Karabük	0.4712	Kastamonu	4.9696	Karabük	0.0697
Kayseri	2.4359	Kilis	3.1053	**Kayseri**	**17.3071***	Kilis	0.5764
Kırklareli	2.7780	Osmaniye	3.7304	**Kırklareli**	**8.3663****	Osmaniye	0.9279
Kırşehir	**7.3514****	**Düzce**	**8.8856****	Kırşehir	2.8905	Düzce	2.3072
Kocaeli	1.4791			Kocaeli	0.2907		

*,** refer to significance at 1 and 5 percent level respectively.

The analysis for the causal relationship between total public education spending and economic growth suggests no relationship between the two in a majority of provinces. This is counterintuitive and begs the need for better understanding of the relationship between education expenditures and economic growth. Therefore, there is a need to analyze this relationship by breaking up total education expenditures into its constituent two groups: (i) education expenditures before higher education (EDNUN) and (ii) education expenditures for higher education (EDUU). Table 9 presents the causality direction between public expenditures for primary and secondary education (EDNUN) and economic growth (DRW) for each province. The findings are:

(i) There is a unidirectional causality relationship from GRW to EDNUN in 16 provinces: Ağrı, Hatay, Kastamonu, Kirsehir, Mardin, Rize, Sakarya, Sinop, Tokat, Şanlıurfa, Uşak, Karaman, Şırnak, Bartın, Yalova, and Düzce. The Wald statistics value for lnGRW→lnEDNUN is significant for these provinces at least at 5 percent level. In these provinces, an increase in economic growth increase spending on public education for primary and secondary education (EDNUN).

(ii) On the other hand, there is a unidirectional causality relationship from EDNUN to GRW in 11 provinces: Adana, Ankara, Bilecik, Bolu, Gaziantep, Icel,

Kayseri, Kirklareli, Samsun, Sivas, and Trabzon. The Wald statistics value for lnEDNUN→lnGRW is significant for these provinces at least at 5 percent level. In these provinces, primary and secondary education expenditures cause economic growth.

(iii) There is a bidirectional causality relationship between primary and secondary education expenditures and economic growth only in one province: Burdur. This result points out that primary and secondary education expenditures can cause both directly and indirectly economic growth in Cankiri (lnEDNUN↔lnGRW).

(iv) The results point out that there is no causal relationship between educational expenditures (EDNUN) and economic growth for the rest of the 53 provinces. These provinces include: Adiyaman, Afyonkarahisar, Amasya, Antalya, Artvin, Aydin, Balikesir, Bingol, Bitlis, Bursa, Canakkale, Cankiri, Corum, Denizli, Diyarbakir, Edirne, Elazig, Erzincan, Erzurum, Eskisehir, Giresun, Gumushane, Hakkari, Isparta, Istanbul, Izmir, Kars, Kocaeli, Konya, Kutahya, Malatya, Manisa, Kahramanmaras, Mugla, Mus, Nevsehir, Nigde, Ordu, Siirt, Tekirdag, Tunceli, Van, Yozgat, Zonguldak, Aksaray, Bayburt, Kirikkale, Batman, Ardahan, Igdir, Karabuk, Kilis, and Osmaniye.

Tablo 9

The Results of Causality in Provinces between GRW and EDNUN

	lnGRW→ ln EDNUN				lnEDNUN →lnGRW		
Province	*Wald-statistic*	*Province*	*Wald-Statistic*	*Province*	*Wald-statistic*	*Province*	*Wald-statistic*
Adana	1.0403	Konya	1.4484	**Adana**	**25.8171***	Konya	3.4423
Adıyaman	4.9734	Kütahya	3.0848	Adıyaman	0.0343	Kütahya	1.6210
Afyonkarahisar	2.5728	Malatya	0.2536	Afyonkarahisar	1.0294	Malatya	1.2358
Ağrı	**6.2187****	Manisa	0.1878	Ağrı	0.5049	Manisa	5.4233
Amasya	4.2543	Kahramanmaraş	2.0530	Amasya	1.2058	Kahramanmaraş	0.0092
Ankara	0.0992	**Mardin**	**5.1564****	**Ankara**	**7.3133****	Mardin	0.0040
Antalya	2.1735	Muğla	0.2008	Antalya	2.6293	Muğla	0.0145
Artvin	0.3919	Muş	2.4434	Artvin	1.0936	Muş	1.1500
Aydın	0.6445	Nevşehir	1.0514	Aydın	1.9000	Nevşehir	0.0692
Balıkesir	0.0420	Niğde	4.8374	Balıkesir	3.0896	Niğde	0.0007
Bilecik	4.0275	Ordu	3.7130	**Bilecik**	**6.0648****	Ordu	3.4285

Bingöl	4.1370	**Rize**	**8.1558****	Bingöl	1.2701	Rize	2.6285
Bitlis	4.9424	**Sakarya**	**5.6414****	Bitlis	0.5004	Sakarya	1.3698
Bolu	2.3809	Samsun	2.2591	**Bolu**	**7.3180****	**Samsun**	**9.1564****
Burdur	**6.9058****	Siirt	1.1646	**Burdur**	**5.6472****	Siirt	0.4586
Bursa	2.2130	**Sinop**	**5.3773****	Bursa	0.7832	Sinop	0.0066
Çanakkale	2.5600	Sivas	0.2640	Çanakkale	1.1110	**Sivas**	**13.5749***
Çankırı	7.3010	Tekirdağ	0.0039	Çankırı	0.5266	Tekirdağ	1.9874
Çorum	4.4130	**Tokat**	**6.4024****	Çorum	3.6159	Tokat	3.4337
Denizli	1.3884	Trabzon	3.0192	Denizli	4.3579	**Trabzon**	**22.934***
Diyarbakır	3.0933	Tunceli	3.6239	Diyarbakır	0.7565	Tunceli	0.0046
Edirne	0.2562	**Şanlıurfa**	**5.5207****	Edirne	3.3326	Şanlıurfa	0.6790
Elazığ	2.5352	**Uşak**	**6.7150****	Elazığ	2.8043	Uşak	1.7193
Erzincan	0.6505	Van	1.9276	Erzincan	0.9825	Van	0.9427
Erzurum	2.3684	Yozgat	3.9829	Erzurum	6.1402	Yozgat	0.3028
Eskişehir	4.0915	Zonguldak	2.4793	Eskişehir	1.5556	Zonguldak	0.2191
Gaziantep	0.6108	Aksaray	4.4565	**Gaziantep**	**5.3061****	Aksaray	2.6942
Giresun	4.0041	Bayburt	0.8473	Giresun	0.0207	Bayburt	0.1946
Gümüşhane	4.9446	**Karaman**	**5.3885****	Gümüşhane	0.0633	Karaman	0.0343
Hakkari	4.3856	Kırıkkale	1.5216	Hakkari	2.4901	Kırıkkale	0.0725
Hatay	**5.3513****	Batman	2.7284	Hatay	1.6328	Batman	1.6773
Isparta	4.0412	**Şırnak**	**28.1948***	Isparta	2.4011	Şırnak	0.6786
İçel	1.1726	**Bartın**	**10.0552****	**İçel**	**11.7571***	Bartın	1.8529
İstanbul	2.3270	Ardahan	3.6920	İstanbul	1.1213	Ardahan	0.6235
İzmir	3.7749	Iğdır	0.9326	İzmir	2.1431	Iğdır	0.0152
Kars	2.4307	**Yalova**	**8.3076****	Kars	0.0533	Yalova	1.0453
Kastamonu	**6.2922****	Karabük	2.9401	Kastamonu	1.0810	Karabük	0.4059
Kayseri	2.0546	Kilis	2.9425	**Kayseri**	**17.5372***	Kilis	0.7317
Kırklareli	4.4803	Osmaniye	3.8598	**Kırklareli**	**7.6946****	Osmaniye	0.7712
Kırşehir	**7.8442****	**Düzce**	**6.9055****	Kırşehir	2.6389	Düzce	3.9861
Kocaeli	1.2589			Kocaeli	0.1235		

*,** refer to significance at 1 and 5 percent level respectively.

The results for the analysis of the relationship between economic growth and education expenditures before higher education (EDNUN) are very similar to the earlier analysis. There seems to be no relationship between the two variables in 53 out of 81 provinces. Therefore, it is necessary to proceed with the analysis for the relationship between higher education expenditures (EDUU) and economic growth. In Table 10, we present the causality direction between public expenditures for higher education (EDUU) and economic growth (DRW) for each province. The findings are:

(i) There is a unidirectional causality relationship from GRW to EDNUN in 41 provinces: Adana, Adıyaman, Afyonkarahisar, Ağrı, Amasya, Ankara, Aydın, Balıkesir, Bolu, Burdur, Diyarbakır, Edirne, Elazığ, Erzurum, Eskişehir, Gaziantep, Isparta, İçel, İstanbul, İzmir, Kastamonu, Kırşehir, Konya, Malatya, Manisa, Kahramanmaraş, Mardin, Nevşehir, Niğde, Sakarya, Samsun, Sinop, Siirt, Sivas, Trabzon, Tunceli, Şanlıurfa, Batman, Kilis, Osmaniye, and Düzce. The Wald statistics value for lnGRW→lnEDNUU is significant for these provinces at least at 5 percent level.

(ii) There is a unidirectional causality relationship from EDUU to GRW in five provinces: Antalya, Bilecik, Bingol, Bitlis and Van. The Wald statistics value for lnEDUU→lnGRW is significant for these provinces at least at 5 percent level. In these five provinces, higher education expenditures cause economic growth.

(iii) There is a bidirectional causality relationship between higher education expenditures and economic growth in three provinces: Çankırı, Gümüşhane and Muş. In these three provinces higher education expenditures and economic growth influence each other (lnEDUU↔lnGRW).

(iv) The results point out that there is no causal relationship between higher education expenditures (EDNUN) and economic growth for the rest of the 32 provinces. These provinces include: Artvin, Bursa, Canakkale, Corum, Denizli, Erzincan, Giresun, Hakkari, Hatay, Kars, Kayseri, Kirklareli, Kocaeli, Kutahya, Mugla, Ordu, Rize, Tekirdag, Tokat, Usak, Yozgat, Zonguldak, Aksaray, Bayburt, Karaman, Kirikkale, Sirnak, Bartin, Ardahan, Igdir, Yalova and Karabuk.

Tablo 10

The Results of Causality in Provinces between GRW and EDUU

	lnGRW→ ln EDUU				lnEDUU →lnGRW		
Province	*Wald-statistic*	*Province*	*Wald-Statistic*	*Province*	*Wald-statistic*	*Province*	*Wald-statistic*
Adana	**5.7192****	**Konya**	**15.2255***	Adana	1.8977	Konya	0.5037
Adıyaman	**18.5934***	Kütahya	3.9577	Adıyaman	2.0782	Kütahya	0.1989
Afyonkarahisar	**11.3709***	**Malatya**	**13.0291***	Afyonkarahisar	2.3102	Malatya	0.1532
Ağrı	**10.5206****	**Manisa**	**19.3715***	Ağrı	3.9858	Manisa	1.1039
Amasya	**9.5546****	**Kahramanmaraş**	**7.0619****	Amasya	1.1225	Kahramanmaraş	0.0277
Ankara	**7.6586****	**Mardin**	**9.0515****	Ankara	3.2801	Mardin	4.5418
Antalya	2.0878	Muğla	2.9419	**Antalya**	**6.3996****	Muğla	1.4833
Artvin	3.9429	**Muş**	**39.7379***	Artvin	2.7571	**Muş**	**5.5952****
Aydın	**7.6716****	**Nevşehir**	**14.4373***	Aydın	0.5055	Nevşehir	1.0212
Balıkesir	**13.7198***	**Niğde**	**7.2479****	Balıkesir	1.2084	Niğde	0.0408
Bilecik	2.1621	Ordu	4.2889	**Bilecik**	**6.5847****	Ordu	1.2783
Bingöl	8.7069	Rize	4.2937	**Bingöl**	**4.9349****	Rize	1.4356
Bitlis	4.8220	**Sakarya**	**7.9263****	**Bitlis**	**5.3711****	Sakarya	0.6222
Bolu	**6.5512****	**Samsun**	**42.5169***	Bolu	0.8526	Samsun	0.1224
Burdur	**20.0033***	**Siirt**	**18.5674***	Burdur	0.0010	Siirt	2.3699
Bursa	4.8807	**Sinop**	**13.3458***	Bursa	0.2210	Sinop	2.6800
Çanakkale	4.9362	**Sivas**	**20.2135***	Çanakkale	0.2599	Sivas	0.0682
Çankırı	**13.5173***	Tekirdağ	3.8324	**Çankırı**	**7.4764****	Tekirdağ	1.1141
Çorum	1.9520	Tokat	4.5272	Çorum	0.6408	Tokat	0.1074
Denizli	2.9296	**Trabzon**	**44.9982***	Denizli	0.8541	Trabzon	0.0025
Diyarbakır	**6.7290****	**Tunceli**	**9.3761****	Diyarbakır	0.1452	Tunceli	2.3409
Edirne	**5.8006****	**Şanlıurfa**	**10.2900****	Edirne	0.1597	Şanlıurfa	4.6961
Elazığ	**21.5057***	Uşak	2.4266	Elazığ	0.3331	Uşak	0.0578
Erzincan	2.6821	Van	4.5396	Erzincan	1.9312	**Van**	**5.4005****
Erzurum	**10.6612***	Yozgat	1.9938	Erzurum	0.0786	Yozgat	0.0112
Eskişehir	**6.8536****	Zonguldak	5.9409	Eskişehir	1.1976	Zonguldak	2.0047

Gaziantep	**22.1573***	Aksaray	3.8696	Gaziantep	0.0706	Aksaray	0.9440
Giresun	2.5474	Bayburt	0.9507	Giresun	0.2626	Bayburt	0.0005
Gümüşhane	**11.3888***	Karaman	4.1093	**Gümüşhane**	**10.8715***	Karaman	2.1777
Hakkari	2.8053	Kırıkkale	1.2226	Hakkari	0.5389	Kırıkkale	4.5416
Hatay	4.4172	**Batman**	**5.6967****	Hatay	0.1096	Batman	2.6676
Isparta	**21.1961***	Şırnak	2.7979	Isparta	0.0406	Şırnak	0.1059
İçel	**22.3261***	Bartın	2.2118	İçel	1.8185	Bartın	1.0504
İstanbul	**6.0070****	Ardahan	3.9363	İstanbul	0.5952	Ardahan	0.4702
İzmir	**8.2061****	Iğdır	5.0309	İzmir	0.1662	Iğdır	3.4791
Kars	3.7304	Yalova	0.6468	Kars	4.3070	Yalova	0.8698
Kastamonu	**72.7766***	Karabük	0.3305	Kastamonu	5.3960	Karabük	0.0006
Kayseri	4.6460	**Kilis**	**8.1520****	Kayseri	5.5763	Kilis	0.0314
Kırklareli	3.1795	**Osmaniye**	**6.0693****	Kırklareli	3.6489	Osmaniye	1.2573
Kırşehir	**6.5674****	**Düzce**	**28.3615***	Kırşehir	3.0648	Düzce	0.0219
Kocaeli	4.7679			Kocaeli	1.1712		

*,** refer to significance at 1 and 5 percent level respectively.

The analysis for the relationship between higher education expenditures (EDUU) and economic growth presents a very different picture than the analysis for the total education expenditures and the expenditures for primary and secondary education. Table 11 below summarizes the findings for the relationship between economic growth (GRW) and total education expenditures and its constituent components at the provincial level. Although there is no causal relationship between total (ED) and primary and secondary education expenditures (EDNUN) and economic growth in a majority provinces (51 out of 81 for ED & 53 out of 81 for EDNUN), there is a unidirectional causality relationship between higher education expenditures and economic growth in 41 out of 81 provinces. This unidirectional causality from GRW to EDNUN is in line with the hypothesis of the Wagner's Law.

Table 11
The Relationship between GRW and ED/EDNUN/EDUU

Province	GRW & ED				GRW & EDNUN				GRW & EDUU			
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Adana		X				X			X			
Adıyaman				X				X	X			
Afyonkarahisar				X				X	X			
Ağrı	X				X				X			
Amasya				X				X	X			
Ankara		X				X			X			
Antalya				X				X		X		
Artvin				X				X				X
Aydın				X				X	X			
Balıkesir				X				X	X			
Bilecik		X				X				X		
Bingöl				X				X		X		
Bitlis	X							X		X		
Bolu		X				X			X			
Burdur	X						X		X			
Bursa				X				X				X
Çanakkale				X				X				X
Çankırı			X					X			X	
Çorum				X				X				X
Denizli				X				X				X
Diyarbakır				X				X	X			
Edirne				X				X	X			
Elazığ	X							X	X			
Erzincan				X				X				X
Erzurum				X				X	X			
Eskişehir				X				X	X			
Gaziantep		X				X			X			

Giresun				X				X				X
Gümüşhane	X							X			X	
Hakkari	X							X				X
Hatay				X	X							X
Isparta				X				X	X			
İçel		X				X			X			
İstanbul				X				X	X			
İzmir				X				X	X			
Kars				X				X				X
Kastamonu				X	X				X			
Kayseri		X				X						X
Kırklareli		X				X						X
Kırşehir	X				X				X			
Kocaeli				X				X				X
Konya				X				X	X			
Kütahya				X				X				X
Malatya				X				X	X			
Manisa				X				X	X			
Kahramanmaraş				X				X	X			
Mardin	X				X				X			
Muğla				X				X				X
Muş				X				X			X	
Nevşehir				X				X	X			
Niğde				X				X	X			
Ordu				X				X				X
Rize	X				X							X
Sakarya	X				X				X			
Samsun		X				X			X			
Siirt				X				X	X			
Sinop	X				X				X			
Sivas		X				X			X			

Tekirdağ				X				X				X
Tokat				X	X							X
Trabzon		X				X			X			
Tunceli	X							X	X			
Şanlıurfa	X				X				X			
Uşak	X				X							X
Van				X				X		X		
Yozgat				X				X				X
Zonguldak				X				X				X
Aksaray				X				X				X
Bayburt				X				X				X
Karaman				X	X							X
Kırıkkale				X				X				X
Batman				X				X	X			
Şırnak	X				X							X
Bartın	X				X							X
Ardahan				X				X				X
Iğdır	X							X				X
Yalova				X	X							X
Karabük				X				X				X
Kilis				X				X	X			
Osmaniye				X				X	X			
Düzce	X				X				X			
TOTAL	18	11	1	51	16	11	1	53	41	5	3	32

1: lnGRW →lnED **2:** lnED→lnGRW **3:** lnED↔lnGRW **4:** No Relationship between GRW and ED

5: lnGRW→lnEDNUN **6:** lnEDNUN→lnGRW **7:** lnEDNUN↔lnGRW **8:** No relationship between GRW and EDNUN **9:** lnGRW→lnEDNUU **10:** lnEDUU→lnGRW **11:** lnEDUU↔lnGRW **12:** No relationship between GRW and EDNUN

5. Conclusion

This paper has investigated the causal relationship between educational expenditures and economic growth in Turkiye at the provincial level by using annual panel data covering the period 2009-2021. The study is unique in analyzing the causality between public expenditures and economic growth at the subnational level. The other studies in the literature are either cross-country analysis or a single country analysis at the national level for a period of time. The analysis in this paper is at the subnational level covering all of the 81 provinces of Turkiye for a period of 2009-2021. To our knowledge, it is the only study analyzing Wagner's law at the provincial level.

The diagnostic results suggested the presence of cross-section dependence and heterogeneity; therefore, a Granger non-causality test for heterogenous panel data models developed by Dumitrescu and Hurlin (2012) has been applied. The main finding is that there is bi-directional Granger causality between the education expenditures and economic growth at the provincial level. Further investigation revealed that this causality relationship between economic growth and public education spending is heterogenous. The causality relationship varies among provinces. More importantly, the analysis for the two main categories of education spending, namely primary and secondary education spending and higher education spending, present totally different picture. The analyses clearly show that the direction of causality between education expenditures and economic growth is province specific. It seems economic growth causes more higher education spending in a majority of provinces as hypothesized by the Wagner's Law.

The unidirectional relationship between higher education spending and economic growth in a majority of provinces as hypothesized by the Wagner's Law is not surprising. There were a limited number of universities in Turkiye until 2000s concentrating mainly in metropolitan cities in the more developed part of Western regions. Until 1990s, there were only 29 universities of which 21 were in big metropolitan cities in more urbanized provinces, mostly to the west of the Samsun-Iskenderun line (Sargin 2007). These metropolitan cities contributed more than 80 percent of the country's GDP. With the increased economic activity in the lagging regions in 1990s and 2000s, additional universities were established in medium-sized cities in lagging provinces. In 2006, the number of universities in Turkiye has increased to 93—most of the newly established universities were established in medium-sized cities with a population between 50,000 and 120,000 (Sargin 2007). As of January 2024, there are 209 universities in all over the country. The existence of universities in lagging regions significantly increases the chances for economic growth by fostering innovation, developing a skilled workforce, and attracting investment. However, the ultimate impact depends on the economic structure of

provincial economies. In 41 provinces, economic growth increases higher education spending. These provinces represent both eastern and western regions of the country. They are the engines of economic growth in the country accounting a significant share of the Turkish GDP.

The other main finding of our research suggests that the causal relationship between economic growth and public primary and secondary education expenditures is heterogeneous at the provincial level in Turkiye. The direction of the relationship varies from one province to the other. The main factor in the heterogeneity of causality across provinces is the recent change in the education policy preferences. Since the 2000s, primary and secondary education is compulsory for all boys and girls of education age. As such, in the allocation of public education resources, the dominant factor is not economic considerations according to the supply and demand forces; rather policy priorities drive the allocation decisions. As a result, the causality of economic growth and education expenditure theorized in the literature is distorted. This is particularly pronounced when we consider the role of private primary and secondary education. The demand for private education is particularly high in more developed provinces of the country, whereas, in lagging regions, the supply is low because demand constraints.

The heterogeneity of the the causal relationship between economic growth and public primary and secondary education expenditures across provinces can be explained by different factors at play. Turkiye is large and heterogenous country. There are huge variations in the size, the level of education expenditures and economic performance of provinces. A significant share of the population (nearly 80 percent) lives to the west of Iskenderun-Samsun line and the GINI coefficient for regions ranges from 0.342 to 0.449. In terms of contribution to the national GDP, only five provinces (all of which are in the western part of the country) are responsible for more than half of the national GDP. In this diversity, provinces are at different stages of economic growth (Rostow 1959). The stages and transition periods may occur at varying lengths from province to province. In the early stages of the economic development level, the primary preoccupation of localities is physical development. After a certain level of physical development, priorities shift to human capital development to attract more businesses to make local economy more competitive.

These findings have important implications for the design of the regional development policies especially education policies. The presence of heterogeneity of causality of economic growth and education expenditures across provinces suggests the devolution of more responsibilities to provincial administrations in the allocation of budgetary resources. Due to the proximity of provincial administrations to the beneficiaries of public expenditures they have better

information about the needs of citizens and economic growth dynamics in their localities. More importantly, provincial administrations are better positioned to design comprehensive regional development policies taking education and other expenditures and economic growth into consideration.

However, further research is needed to provide micro level policy recommendations. A potentially important area of research is analyzing spatial patterns in various regions of the country. Rey and Montouri (1999) show how spatial dependence can be a determinant factor in analyzing economic performance of states in the U.S. In context of Turkiye, several studies present evidence for regional socio-economic dynamics playing a role of economic performance of provinces. Another line of inquiry is the educational outcomes at the provincial level. Public spending on education doesn't guarantee education outcomes in the provinces. Analyzing education outcomes at the provincial level might shed a light to the causal relationship between education spending and economic growth.

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Özet

Türkiye’de kamu eğitim harcamaları ile ekonomik büyüme arasındaki nedensellik ilişkisinin incelenmesi: İl düzeyinde bir analiz

Bu çalışma, Türkiye’de il düzeyinde kamu eğitim harcamaları ile ekonomik büyüme arasındaki nedensellik ilişkisini, 2009–2021 dönemini kapsayan yıllık panel verileri kullanarak incelemektedir. Temel bulgu, ekonomik büyüme ile kamu eğitim harcamaları arasındaki nedensellik ilişkisinin heterojen olduğunu; bir ilden diğerine değişiklik gösterdiğini ortaya koymaktadır. Toplam kamu eğitim harcamaları, ilköğretim ve ortaöğretim harcamaları ile ekonomik büyüme arasında çoğu ilde bir nedensellik ilişkisi bulunmamakla birlikte, 81 ilin 41’inde yükseköğretim harcamaları ile ekonomik büyüme arasında tek yönlü bir nedensellik ilişkisi gözlemlenmiştir.

Anahtar kelimeler: Panel nedensellik, Kamu eğitim harcamaları, İl düzeyinde ekonomik büyüme, İl düzeyinde kamu eğitim harcamaları