The Structure of Public Education Expenditure and Economic Development: A Granger Causality Analysis

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Research Article

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Abstract

Clarifying the Granger causal relationship between the structure of public education expenditure and economic development is an essential prerequisite for optimizing the structure of public education expenditure. Based on the time series data released by the World Bank, this article takes the structure of public education expenditure in Sweden, Denmark and France as the primary objects. With the help of the Granger causality test and the Pearson correlation coefficient, the Granger causal relationship between primary education expenditure, secondary education expenditure, tertiary education expenditure and economic development rate (annually) have been analyzed in detail. The correlation between various levels of public education expenditure is analyzed. Finally, particular policy suggestions were put forward to optimize the hierarchical structure of public education expenditure and perfect the national economic development.

1. Introduction

During the development process of the economy, education has always played an essential role in promoting (Chandra, 2010). With the erupting of information, knowledge and intelligence, education has played an increasingly important role in promoting national economic growth and social progress (Hanushek et al., 2012). Nowadays, high-tech and outstanding talents have become the focus of international economic competition (Hanushek et al., 2012). In order to further improve the level of technology and to cultivate innovative or knowledgeable talents, all developed countries have placed education in an important position in economic development (Dahal, 2010) and have been committed to increasing their annual education expenditure for several consecutive years to promote the rapid development of their economies by continuously improving their national education quality and improving their citizens’ education level (Abhijeet, 2010) (Du Yuhong et al., 2020) (Dahal, 2010) (Hanushek et al. 2012).

Public education expenditure mainly refers to the various expenditures and expenses covered by government departments at all fiscal levels to promote educational development (Zheng, 2008). In general, according to the different financial funds or budget allocations, the structure of public education expenditure can be divided into two types: hierarchical structure and usage structure (Tian, 2014) (Du Yuhong et al., 2020). The hierarchical structure of public education expenditure refers to the specific allocation of public education funds at the three levels: primary education, secondary education, and tertiary education (Tian, 2014) (Du Yuhong et al., 2020). In contrast, the usage structure of public education expenditure refers to the distribution of public education funds in educational business and the corresponding infrastructures (Tian, 2014) (Du Yuhong et al., 2020). Unlike the structure of usage, the hierarchical structure of public education expenditure encompasses a more macroscopic content and plays a more fundamental role (Chen & Liu, 2019). In addition, optimizing the hierarchical structure of public education expenditure is also an essential prerequisite for achieving the properly allocating of public education funds (Dudzevičiūtė et al., 2018).
The increase in public education expenditure will have a direct and significant impact on the development of the national economy (Zheng, 2008). It has become a consensus in the vast majority of developed countries to gradually increase financial support for public education in a planned manner (Chen & Liu, 2019). At present, there are two main types of research around "public education expenditure and economic development". The first type is mainly about studying the contribution of specific education indicators to economic development. Researchers focused on the perspective of education level, years of education, literacy rate, student achievement, enrollment rate, number of teachers, graduate employment rate and other aspects, with the help of unit root test, cointegration test, vector autoregression analysis, Granger causality test, multiple regression analysis and other methods (Cai et al., 2015) (Akinwale et al., 2019) (Bai et al., 2015) (Du et al., 2020). The present empirical investigations are made of the impact of various educational indicators on the development of the national economy or the intrinsic link between them and the development of the national economy.

The second category mainly explores the relationship between the hierarchical structure of public education expenditure, the usage structure and economic development (Jeff-Anyeneh et al., 2019) (Kotásková et al., 2018) (Mallick et al., 2016). Through different empirical research and theoretical analysis, scholars have initially formed a basic consensus on "optimizing the structure of public education expenditure and the structure of its usage" and they believed that it is of great significance to rationally divide the proportion of public education expenditure in primary education, secondary education and tertiary education to improve the level of economic development (Sobiech, 2019) (Tian, 2014). In addition, some scholars have used case studies to discuss the changes in the substructure and economic development level of public education expenditure in one or several countries over the years and put forward a series of optimization suggestions, such as continuously increasing investment in primary education, attaching importance to the development of secondary education, and broadening the investment channels of tertiary education (Vegas & Coffin, 2015) (Zheng, 2008) (Feng et al., 2021) (Gemmell et al., 2016). However, the causal relationship between the structure of public education expenditure and the speed of economic development and the correlation between the three primary education levels have not attracted enough attention from researchers.

Therefore, based on the time-series data released by the World Bank, with the help of the unit root test, the Granger causality test and the Pearson correlation coefficient, this study analyzed the causal relationship between primary education expenditure, secondary education expenditure, tertiary education expenditure and economic development rate (annually) in France, Sweden and Denmark, and the correlation between the various levels of public education expenditure, and how to optimize the structure of public education expenditure in detail. Particular policy suggestions have been put forward to improve national economic development.

The remainder of this study will be developed in the following order: Section 2 sorts out the central literature related to "the structure of public education expenditure and economic development" and explains the six main assumptions proposed by this article. Section 3 discusses the principal
methodology used and the econometric models established. Section 4 presents the main findings. Section 5 summarizes the conclusions.

2. Theoretical Framework And Main Hypotheses

Expenditure on primary education, secondary education and tertiary education constitute the three primary levels of the structure of public education expenditure. Optimizing the hierarchical structure of public education expenditure mainly refers to scientifically improving the proportion of monetary funds or budgets at the three levels according to specific standards (Vegas & Coffin, 2015). Given the lack of thematic research on specific optimization criteria, after referring to the research results related to "the contribution of public education expenditure to economic development", this study takes the Granger causal relationship between the expenditure situation at all levels of public education and the GDP development rate as a filler which could fill gaps in the field, and it is expected that the specific strategy for optimizing the structure of public education expenditure can be obtained through empirical analysis.

2.1 Theoretical Framework

As a relatively particular factor of production, human capital has always attracted much attention (Chen et al., 2019). Human capital refers explicitly to the "non-material capital" such as workers' knowledge, skills, and experience (Akinwale et al., 2019). The features of self-enhancement and high rate of return make it different from "material capital" (Bai et al., 2015) (Chen et al., 2019). According to the theory of human capital and the economic growth model of Solo, it can be seen that education is an essential means to enhance human capital, and the expansion of public education expenditure is bound to bring about the optimization of human capital and the improvement of economic development (Chen et al., 2019) (Du et al., 2020) (Dudzevičiūtė et al., 2018). Therefore, optimizing the structure of public education expenditure, especially the hierarchical structure, is of great significance to improving human capital and promoting economic development (Du et al., 2020) (Dudzevičiūtė et al., 2018).

At present, quantitative research on the relationship between the structure of public education expenditure and economic development is abysmal, because most researchers tend to explore from the following perspectives: Firstly, starting from the connotation of public education through empirical methods such as multiple regression (Feng et al., 2021) (Gemmell et al., 2016). They explored the synergistic trend between specific public education indicators and GDP, then used these to construct a mathematical model that can assess economic growth (Jeff-Anyeneh et al., 2019) (Kotásková et al., 2018). Secondly, starting from the relevant indicators of public education, such as education funding, years of education, enrollment rate, number of teachers, etc., with the help of cointegration test and Granger causality test to detect the causal relationship between the specific educational indicator and national economic development (Mallick et al., 2016) (Si, 2011) (Sobiech, 2019) (Tian, 2014) (Meričková, 2017). Thirdly, starting from different stages of economic development, the impact of education on economic growth is analyzed by qualitative analysis (Tian, 2014) (Vegas & Coffin, 2015) (Zheng, 2008). Cai Fang's "four-stage theory" is reasonably representative of the third type of research. His judgment on the "T-shaped
development stage” that China is currently in (that is, after the Lewis turning point, the labour shortage appears, the labour cost rises, and the marginal return on capital begins to decrease), as well as the impact of education on economic development at this stage (mainly reflected in support of technological innovation, the cultivation of various types of scientific research talents, and the provision of more possibilities for technological innovation), have been widely recognized by the academic community (Cai, 2017, pp:60–80).

In reality, expanding public education expenditure into developing the national economy and enhancing human capital is an inevitable choice for most developed countries (Akinwale et al., 2019) (Bai et al., 2015). As for the specific expansion of education expenditure at which level to better achieve this goal, it is necessary to explore in-depth the causal relationship between the change in the proportion of expenditure at all levels of public education and economic development and the correlation between each level of public education. The traditional theoretical analysis has constructively elaborated on the relationship between optimizing the hierarchical structure of public education expenditure and promoting economic development. However, the specific optimization strategies of the hierarchical structure of public education expenditure have different opinions and disagreements (Zheng, 2008) (Tian, 2014) (Si, 2011) (Bai et al., 2015). Therefore, it is necessary to carry out a corresponding empirical analysis.

2.2 Main Hypotheses

The proportion of expenditure at each level of public education is mainly affected by the total amount of public education expenditure and the allocation of specific expenditure (Bai et al., 2015). Specifically, when the total amount of public education expenditure remains unchanged, expanding any of the "three levels" will inevitably reduce the proportion of expenditure in the other two levels (Si, 2011). However, when the total amount of public education expenditure is expanded or decreased, although the amount of expenditure at each education level will also increase or decrease compared with before, if the proportion of expenditure they account for does not change, then, in fact, this "unilateral expansion of total expenditure, without adjusting the proportion of expenditure" initiative can not achieve the optimization of the structure of public education expenditure (Sobiech, 2019) (Tian, 2014). In order to better optimize the structure of public education expenditure, this paper stands on the perspective of whether there is a Granger causal relationship between the change of public education expenditure at all levels and the annual development of national economy, and proposes six main hypotheses for the specific situation of France, Sweden and Denmark. Firstly, there is a Granger causal relationship between the proportion of essential education expenditure and the rate of GDP development (H1). Secondly, there is a Granger causal relationship between the proportion of secondary education expenditure and the rate of GDP development (H2). Thirdly, there is a Granger causal relationship between the proportion of higher education spending and the rate of GDP development (H3). Fourthly, there is a positive correlation between expenditure on primary education and expenditure on secondary education (H4). Fifthly, there is a positive correlation between secondary education expenditure and higher education expenditure (H5). Lastly, there is a positive correlation between primary education expenditure and higher education expenditure (H6).
3. Methodology

The dataset selected for the study is from the World Bank's latest education and economic development indicators (annually) released in 2021. The dataset (1970–2021) belongs to the time series data, which covers all the valid data of Sweden, Denmark and France since 1970 in the four aspects of "proportion of basic education expenditure", "proportion of secondary education expenditure", "proportion of higher education expenditure" and "annual GDP growth rate".

3.1 Data and variable description

Although the World Bank has been collecting relevant data on education and economic themes since 1970, due to the influence of many objective factors, there are still certain problems in the integrity and continuity of statistics. In order to ensure the completeness of statistical data content and the continuity of time, this study roughly selects three relatively close periods according to the actual situation. Among them, Sweden (1998–2016) and Denmark (1998–2014) were chose the same period, while France (1970–1996) intercepted the period relatively early. Therefore, when doing a comparative analysis between countries, the focus of the discussion will be on the first two countries.

Clarifying the variables is a prerequisite for in-depth exploration of the Granger causal relationship between the structure of public education expenditure and economic development. This study takes the change in the rate of GDP development (annual basis), the annual change in the proportion of basic, secondary and higher education (all these indicators are on annual basis) as the main variables, using Sweden, Denmark and France as the foothold, and tests the Granger causal relationship and the correlativity that exist between them, with the help of two specific econometric methods. Additionally, the proportion of expenditure on primary/secondary/tertiary education (in percentage) should be taken as a percentage of total expenditure on primary/secondary/tertiary education of a country respectively.

A comprehensive understanding of the basic situation of each variable is an essential prerequisite for the successful completion of this survey. So in the beginning, we investigated the basic situation of the proportion of essential education expenditure, the proportion of secondary education expenditure, the proportion of higher education expenditure and the GDP development rate over the years, and found their respective maximums, minimum values and standard deviations (as shown in Table 1).

3.2 Specific methods

This study mainly used the following two research methods: the Granger causality test and Pearson correlation coefficient. The Granger causality test is to verify whether there is a significant causal relationship between the hierarchical structure of public education expenditure and economic development, while the Pearson correlation coefficient is to find out what type of correlation exists in the proportion of expenditure at each level within the public education expenditure. The ADF test is a kind of unit root test and it is the mainstream method to detect the stationarity of time series data, and it is also the basic premise of the Granger causality test. Considering the database is on annual basis (low number
of observations), a safer unit root test could be KPSS. So, this article implemented the KPSS test primarily.

Different from the causal relationship in reality, the Granger causality test belongs to a statistical significance estimation, which is mainly used to analyze the causal relationship between economic variables (Granger, 1980). Granger (1980) once pointed out that due to the lack of collection and arrangement of the original literature, many researchers had many inappropriate applications in the process of applying the Granger causality test, which led to some rather absurd conclusions (Granger, 1980). For example, some studies have proved that the Shanghai Composite Index and the SZSE Component Index contain the forecast information for each of them (Cao, 2006) (Pang & Chen, 1999). But in fact, this conclusion may be false, because theoretically, the transmission channel of mutual influence between them is difficult to be reasonably explained, and if we take the supply and demand of funds into account, then the so-called causal relationship between them is likely to disappear (Cao, 2006) (Pang & Chen, 1999). Therefore, before using the Granger test, it is necessary to reasonably define the information set and clarify the essential variables. In addition, although the original definition of Granger causality does not explicitly specify the stationarity of the variables, if the Granger test is performed stubbornly on non-stationary data sets, problems can be found easily, and skewed results can be generated (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980). The causality test between the money supply and GDP is a typical case (Pang & Chen, 1999). In addition, the reason for using the Pearson correlation coefficient is mainly to measure the linear relationship between the hierarchical structure of public education expenditure and to estimate the strength of this linear relationship.

Unlike the natural sciences, the study of economics usually has a large uncertainty, so the method of using probability theory to infer causality has become a common method for economic researchers (Pang & Chen, 1999). The Granger causality test is a familiar approach among them. Besides the theoretical analysis, variable-controlling, cross-correlation coefficient, regression analysis, etc. can also be used to deduce the causal relationship between two variables (Mallick et al., 2016) (Si, 2011) (Sobiech, 2019) (Tian, 2014) (Si, 2011) (Bai et al., 2015). Among these methods of using probability theory to detect causality, the simplest is the detection method proposed by Suppes (Reiss, 2016), that is, if the occurrence of event A increases the probability of event B’s presence, so event A constitutes the cause of event B. An obvious shortcoming of Suppes’ approach is that it lacks of an exploration of the sequence of events (Reiss, 2016). Therefore, the causal relationship tested by this method can only be proved to be a causal relationship supported by prima facie evidence (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980). In order to solve the problem of the order of occurrence of events, Granger creatively proposed a new causal relationship test method by introducing a series of concepts and methods, such as information sets, that is, Granger causality test (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980). For the operation of the Granger causality test, it is important to accurately define the information set and determine the stationarity of the related variables. Because the absence of important variable information and the non-stationary nature of related variables can lead to false causal relationships or weaken the credibility of conclusions (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980).
In the scope of economics, causation is a relatively important concept (Granger, 1980). However, the confirmation of causality tends to be a difficult problem (Cao, 2006) (Pang & Chen, 1999). While statistical methods can be used to estimate Granger causation in observational data, it is worth noting that the Granger causality test has many problems (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980). For example, the transformation of variables, the pre-whitening of residuals, and metrical errors can all distort the causal relationship between the original variables (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980). In addition, the characteristics of the Granger test determine that it is only suitable for causality tests of time series data (with stationarity), and it is difficult to use it to test the causality or nonlinear causality between cross-sectional data (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980).

The conclusion of the Granger causation test is only statistical causality, not necessarily true causation (Cao, 2006) (Pang & Chen, 1999) (Granger, 1980). While it can be used as a support for true causation, and it cannot be used as a basis for affirming or denying causation (Cao, 2006) (Pang & Chen, 1999). Even if Granger causation is not equal to actual causation, it does not hinder its reference value. Because the causal relationship in the statistical sense is also meaningful, it can still play an important role in economic forecasting.

4. Findings

As shown in Table 2: In terms of trends, the correlation between secondary education expenditure and primary education expenditure and tertiary education expenditure will vary slightly from country to country. Usually, with the continuous improvement of the national economy and public education expenditure, the level of public education expenditure at all levels will also increase. However, it has been calculated that Sweden and Denmark are in line with this situation, and the correlation coefficients in the proportion of expenditure at all levels of public education in the two countries have a strong positive correlation. Therefore, only from the perspective of the synergistic trend of change between the various levels of education, public education expenditure in Denmark and Sweden has a better development trend in terms of hierarchical structure than in France. In addition, after considering the results of KPSS test presented by Table 3, due to the T-statistic of France, Sweden and Denmark are smaller than the critical value shown by the note, so the variables are stationary. Then the Granger causality test can be applied accordingly.

In detail, in Sweden, three Granger reasons change the proportion of primary education expenditure named the development rate of GDP, the proportion of expenditure on secondary education and the proportion of expenditure on tertiary education. By looking at Figs. 1, 2, 3, 4, 5 and 6, it can be found that H1 is established in France, H2 is established in Sweden and France, and H3 is established in Denmark and Sweden. In contrast, the Granger reason of GDP development has only one content called the proportion of spending on secondary education and the proportion of spending on tertiary education. However, it is worth noting that both have a "closed-loop structure" (as shown in Figs. 1 and 2) due to the Granger causality test. Furthermore, the expenditure on secondary and tertiary education is precisely in an essential position of this "closed-loop structure", which means that they play a decisive role in the growth
rate of GDP development and the increase or decrease of primary education expenditure. In Denmark, the change in the proportion of tertiary education expenditure is a Granger reason in GDP development, while in France, it is mutually causal between it and the change in the proportion of secondary education expenditure. In addition, the proportion of primary education expenditure in France is another important Granger reason for GDP development.

In short, expanding the proportion of secondary education and tertiary education expenditure is an inevitable choice to promote GDP development and significantly increase tertiary education expenditure because this measure can rapidly enhance the human capital of workers in a short period and inject strong "cultural vitality" and "cultural vitality" into the short-term development of the national economy.

5. Conclusions

Based on the latest Education and Economic Development Indicators (1970–2021) released by the World Bank in 2021, the study took all the valid data of Sweden, Denmark and France in the four aspects of "proportion of primary education expenditure", "proportion of secondary education expenditure", "proportion of tertiary education expenditure" and "annual GDP growth rate" as the primary research objects, and used the unit root test, the Granger causality test and the Pearson correlation coefficient to explore the causal relationship between the structure of public education expenditure and the speed of economic development. The specific conclusions of the study are as follows: Firstly, in Sweden, the change in the proportion of secondary education expenditure and the change in the proportion of tertiary education expenditure are both Grangerine of the rate of GDP development, and there is a significant positive correlation between the change in the proportion of tertiary education expenditure and the change in the proportion of education expenditure at other levels. Secondly, in Denmark, the change in the share of tertiary education spending is Grangeine, the rate of GDP development. Thirdly, in France, the change in the proportion of secondary education expenditure is a Granger reason for the rate of GDP development, and the change in the proportion of tertiary education expenditure and the change in the proportion of secondary education expenditure are mutual Granger reasons. There is a significant positive correlation between the two. Fourthly, from the perspective of coordinated development and structural optimization, the hierarchical structure of Swedish education expenditure has obvious comparative advantages and the value of in-depth research.

Based on the above findings, this study attempts to put forward the following policy recommendations to optimize the hierarchical structure of public education expenditure: Firstly, adjusting the hierarchical structure of public education expenditure according to the main objectives of the current economic development. An effective way to achieve economic prosperity in the short term is to continuously expand the proportion of expenditure on tertiary education in the structure of public education expenditure, while the proportion of expenditure on secondary and primary education is to continuously increase the proportion of expenditure on secondary and primary education in order to achieve the further development goals of the national economy. Secondly, it is recommended that developing countries should learn more deeply from Sweden's public education expenditure structure and continue to promote
the synergistic growth of tertiary education expenditure, secondary education expenditure and primary education expenditure.

Declarations

Data Availability Statement

Some or all data used during the study were provided by a third party called the World Bank (https://databank.worldbank.org/home.aspx). Direct requests for these materials may be made to the provider.

Acknowledgment

Thanks for professor Zhou Wenzhang, and he offered lots of valuable instructions that developed my analysis.

References


Tables
### Table 1
Descriptive statistics of relevant variables in France, Sweden, and Denmark

<table>
<thead>
<tr>
<th></th>
<th>GDP annual growth rate %</th>
<th>Proportion of expenditure on primary education%</th>
<th>Proportion of expenditure on secondary education%</th>
<th>Proportion of expenditure on tertiary education%</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Max</td>
<td>6.34</td>
<td>51.06</td>
<td>18.37</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>−0.96</td>
<td>42.97</td>
<td>13.35</td>
</tr>
<tr>
<td></td>
<td>Std.dev.</td>
<td>1.85</td>
<td>2.34</td>
<td>1.67</td>
</tr>
<tr>
<td>Sweden</td>
<td>Max</td>
<td>5.95</td>
<td>39.68</td>
<td>29.08</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>−4.34</td>
<td>27.39</td>
<td>24.09</td>
</tr>
<tr>
<td></td>
<td>Std.dev.</td>
<td>2.42</td>
<td>4.55</td>
<td>1.50</td>
</tr>
<tr>
<td>Denmark</td>
<td>Max</td>
<td>3.91</td>
<td>40.00</td>
<td>32.09</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>−4.91</td>
<td>32.10</td>
<td>26.12</td>
</tr>
<tr>
<td></td>
<td>Std.dev.</td>
<td>2.01</td>
<td>2.03</td>
<td>1.67</td>
</tr>
</tbody>
</table>
Table 2
Correlation and significance of public education levels in France, Sweden and Denmark

<table>
<thead>
<tr>
<th></th>
<th>Proportion of expenditure on primary education (PEPE)</th>
<th>Proportion of expenditure on secondary education (PESE)</th>
<th>Proportion of expenditure on tertiary education (PETE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>none</td>
<td>Negative Significance -0.76</td>
<td>Negative Significance -0.66</td>
</tr>
<tr>
<td></td>
<td>PESE</td>
<td>none</td>
<td>Positive Significance 0.81</td>
</tr>
<tr>
<td></td>
<td>PETE</td>
<td>Positive Significance 0.81</td>
<td>none</td>
</tr>
<tr>
<td>Sweden</td>
<td>none</td>
<td>Positive Significance 0.72</td>
<td>Positive Significance 0.57</td>
</tr>
<tr>
<td></td>
<td>PESE</td>
<td>none</td>
<td>Positive Significance 0.68</td>
</tr>
<tr>
<td></td>
<td>PETE</td>
<td>Positive Significance 0.68</td>
<td>none</td>
</tr>
<tr>
<td>Denmark</td>
<td>none</td>
<td>Positive Significance 0.39</td>
<td>Positive Significance 0.07</td>
</tr>
<tr>
<td></td>
<td>PESE</td>
<td>none</td>
<td>Positive Significance 0.21</td>
</tr>
<tr>
<td></td>
<td>PETE</td>
<td>Positive Significance 0.21</td>
<td>none</td>
</tr>
</tbody>
</table>
### Table 3
Results of KPSS for variables in France, Sweden and Denmark

<table>
<thead>
<tr>
<th>Proportion of expenditure on primary education</th>
<th>Proportion of expenditure on secondary education</th>
<th>Proportion of expenditure on tertiary education</th>
<th>GDP annual growth rate</th>
<th>Whether it is stationary or not</th>
</tr>
</thead>
<tbody>
<tr>
<td>The T-statistic of France</td>
<td>0.054</td>
<td>0.044</td>
<td>0.056</td>
<td>0.102</td>
</tr>
<tr>
<td>The T-statistic of Sweden</td>
<td>0.106</td>
<td>0.093</td>
<td>0.050</td>
<td>0.066</td>
</tr>
<tr>
<td>The T-statistic of Denmark</td>
<td>0.067</td>
<td>0.109</td>
<td>0.108</td>
<td>0.051</td>
</tr>
</tbody>
</table>

Note: The critical value should be 0.119 (10%), 0.146 (5%), and 0.216 (1%).

### Appendix

Download the corresponding database from the World Bank and import the database into Stata 17.0 (Stata is a complete and integrated statistical software that provides its users with data analysis, data management and professional charting). Next, enter the following commands in Stata 17.0:

**Input:** “browse”

The Stata 17.0 will show: The database you just imported

The purpose of this step: Reconfirm the correctness of the database you imported

**Input:** “summary”

The Stata 17.0 will output: Table 1 Descriptive statistics of relevant variables in France, Sweden, and Denmark

The purpose of this step: To observe the basic situation of all statistics

**Input:** “tsset year”


The purpose of this step: Tell Stata that the database you import is a time series database
Input: “summary”

The Stata 17.0 will output: Table 1 Descriptive statistics of relevant variables in France, Sweden, and Denmark

The purpose of this step: To observe the basic situation of relevant variables in France, Sweden, and Denmark

Input: “kpss y1, kpss y2, kpss y3, kpss a1, kpss a2, kpss a3, kpss b1, kpss b2, kpss b3, kpss c1, kpss c2, kpss c3”

The Stata 17.0 will output: Table 3 Results of KPSS for variables in France, Sweden and Denmark

The purpose of this step: To test the stationarity of variables in France, Sweden and Denmark

Input: “var l1.y1 l1.a1 l1.a2 l1.a3, vargranger, var l1.y2 l1.b1 l1.b2 l1.b3, vargranger, var l1.y3 l1.c1 l1.c2 l1.c3, vargranger”

The Stata 17.0 will output: Fig. 1, Fig. 2, Fig. 3

The purpose of this step: To test the Granger causal relationship between variables in France, Sweden and Denmark

Notes: y1 represents the GDP annual growth rate in France, y2 represents the GDP annual growth rate in Sweden, y3 represents the GDP annual growth rate in Denmark. a1 represents the proportion of expenditure on primary education in France, a2 represents the proportion of expenditure on secondary education in France, a3 represents the proportion of expenditure on tertiary education in France. b1 represents the proportion of expenditure on primary education in Sweden, b2 represents the proportion of expenditure on secondary education in Sweden, b3 represents the proportion of expenditure on tertiary education in Sweden. c1 represents the proportion of expenditure on primary education in Denmark, c2 represents the proportion of expenditure on secondary education in Denmark, c3 represents the proportion of expenditure on tertiary education in Denmark.

**Figures**
Figure 1  Granger causal relationship (at the first difference) between the structure of public education expenditure and economic development in France

Proportion of expenditure on secondary education

Granger causation**

GDP annual growth rate

Granger causation**

Proportion of expenditure on tertiary education

Granger causation**

Proportion of expenditure on primary education

Granger causation*

Note: **indicates that the significance test passed the 0.05 level, *indicates that the significance test passed the 0.10 level.

Figure 1

See image above for figure legend.
Figure 2 Granger causal relationship (at the first difference) between the structure of public education expenditure and economic development in Sweden

Note: ** indicates that the significance test passed the 0.05 level,
* indicates that the significance test passed the 0.10 level.
Figure 3  Granger causal relationship (at the first difference) between the structure of public education expenditure and economic development in Denmark

Proportion of expenditure on tertiary education $\rightarrow$ Granger causation** $\rightarrow$ GDP annual growth rate $\rightarrow$ Granger causation* $\rightarrow$ Proportion of expenditure on primary education

Note: ** indicates that the significance test passed the 0.05 level, * indicates that the significance test passed the 0.10 level.

Figure 3

See image above for figure legend.

Figure 4 GDP annual growth rate, primary education expenditure, secondary education expenditure in France

Figure 4

See image above for figure legend.
Figure 5

See image above for figure legend.

Figure 6

See image above for figure legend.