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Economic growth and education in Morocco: Cointegration and Toda Yamamoto Granger Causality

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Abstract:

This paper aims to investigate the cointegration and causal effect of economic growth and education in the case of Morocco, over the period 1990 to 2019. Education in all of its forms, considered a fundamental factor of development. Therefore, a country needs to invest more in education. Without a significant investment in education (or human capital), no country can achieve sustainable economic development.

Several studies have used various proxies for education, which is the enrollment rate at primary, secondary and tertiary levels (Chatterji, 1998). However, in our study, the quantity dimension of education is proxied by primary, secondary, and tertiary enrolment ratios and an education index.

To investigate the relationship between education and economic growth the Auto-regressive Distributed Lag (ARDL) approach developed by Pesaran et al., (2001) and the Augmented Granger Causality approach given by Toda and Yamamoto (1995) are applied. To do that, we have used time-series data on economic growth, labor force, physical capital and four separate education indexes from 1990 to 2019. The data are collected from the World Development Indicators (WDI) and Human Development Reports (HDR). Furthermore, we used a global measure of education, called the education index, by adopting the UNDP methodology. The education index is a proxy for education development. The several indicators were used to demonstrate the robustness of the empirical results.

Our results of the ARDL-bound test show that there exist cointegration between economic growth and education. The results also show that there is bidirectional causality between education and economic growth. All levels of education Granger cause economic growth, while economic growth causes all indicators of education except gross enrollment ratio, primary in all cases of causality analysis.

These findings suggest that the government should invest in gross primary enrollment to accelerate economic growth, which leads to further education and thus economic growth.

Keywords: ARDL bounds test, Education index, Gross enrolment ratio, Economic growth, Toda-Yamamoto approach

JEL Classification: C5 C22, I25, O4

Paper type: Empirical research

1. Introduction

Morocco has attempted various education reforms since independence in 1956, none of which have yielded the desired outcomes. The education system has been the subject of continuous controversy and debate in a wide range of national forums. There have undoubtedly been successes throughout the years, but dysfunctions persist and the results are still below expectations.

In 2019, 66% of Moroccan children aged 10 were unable to read and understand simple text, which was 2.5 points below the regional average for the Middle East & North Africa and 10.7 points below the average for lower-middle-income countries (World Bank, 2021). Morocco has therefore adopted a new strategy, namely the strategic vision 2015-2030, which needs to construct a better school based on equity and equal opportunities, quality for everybody, and the promotion of the individual and society.

The effect of education level on economic growth has always caught the interest of economists. The theoretical analysis has investigated the relationship between human capital, education and economic growth, the term “human capital” was adopted, and a human capital theory was developed. According to this theory education was considered as an essential institutional mechanism of the production, accumulation and diffusion of human capital (Becker, 1962; Mincer & Polachek, 1974; Schultz, 1960, 1961). The role of education in economic welfare has historically ebbed and flowed. The theoretical growth literature has long been interested in the role of human capital investment, especially through education and training, on the economic growth and development of a nation. The theoretical approaches defend multiple and different theses and arguments on this subject. The human capital and endogenous growth theories consider education as an essential factor for developing and stimulating economic and development. Throughout the first half of the twentieth century, education was prioritized at the expense of physical capital accumulation. However, investment in physical capital is considered the predominant theory of economic growth. It was during the 1960s, that the importance of human capital became increasingly important. The focus was initially on the contribution of human capital to an individual’s standard of living (income per person), as well as its contribution to aggregate wealth, later, the focus shifted to its role in contributing to aggregate economic growth. Since the work of Schultz, (1960) and (Becker, 1962), has been developed extensive literature that contributed to the abandonment of the accumulation of physical capital and opened the way for a comprehensive analysis of the role of human capital. Schultz, (1960) argues that investment in physical capital is only useful as long as human capital is sufficient to apply new technologies. Education trains young people to understand and deal with the complexities of economic growth.

Distinguished economists have developed various theoretical methods and models about the relationship between human capital, education, and economic growth. According to this vast literature, there are mainly three mechanisms through which education may affect economic growth. First, the accumulation of human capital has long been considered as a major factor in economic development. Human capital as presented by education can contribute in the distribution and transmission of knowledge required to understand and process new information as well to successfully utilize new technologies developed by others, promoting economic growth once more (Benhabib & Spiegel, 1994; Nelson & Phelps, 1966). Second, as described in augmented neoclassical growth theories, education enhance human capital inherent in labor force, which increases labor productivity and thus transitional growth towards a higher equilibrium level of output (Mankiw et al., 1992). Third, education may help the economy become more innovative, and new information about new technology, goods, and processes can help the economy develop (as in theories of endogenous growth, Lucas, (1988), Romer, (1990), Howitt & Aghion, (1998)).

The current resurrection in interest began with the seminal papers by Barro, (1991) and Mankiw et al. (1992) and a vast literature has developed in recent years (Benhabib & Spiegel, 1994; Bouzahzah, 2021; Gemmell, 1996; Hanushek, 1995; Hanushek & Wößmann, 2007; Krueger & Lindahl, 2001; Shobande & Asongu, 2021; Temple, 2002). We can divide the impact of human capital investment on economic growth into quantitative and qualitative dimensions. Education quantity measured by schooling enrolment ratios (Barro, 1991; Levine & Renelt, 1992; Mankiw et al., 1992; Romer, 1989), the average years of schooling (Hanushek & Wößmann, 2007; Krueger & Lindahl, 2001), adult literacy rate (Durlauf & Johnson, 1995; Romer, 1989) and education spending (Baldacci et al., 2008).

Various researchers have utilized different proxies for human capital, education is measured by using its proxy as enrollment rate of primary, secondary and tertiary level (Chatterji, 1998). However, in this study, the quantity dimension of education is proxied by primary, secondary, tertiary enrolment ratios and an education index. The economic advantages of education to improve growth rates appear to be substantial. A better education community leads to higher rates of economic growth and, as a result, the government's capacity to reduce poverty. Education is often regarded as a powerful instrument for reducing poverty, boosting economic growth, empowering individuals, increasing private wages, providing a flexible and healthy environment, and promoting a competitive economy.

We pose the following problems: "There is a relationship between education measured by four indicators and economic growth in the long-term?" "Does education Granger cause economic growth or there exist a two-way causality between variables?"

Study objectives:

- Is there a long-run relationship between education and economic growth?
- Is it the case that education granger causes economic growth or on the contrary, it is economic growth Granger causes education?

This study aims to answer empirically these issues using the ARDL method of cointegration and Toda Yamamoto Granger Causality. We examine these issues at the Moroccan level by using four different variables to proxy for education, labor, and physical capital as a variable of control.

To meet these objectives, we have established a review of the theoretical and empirical literature (2), described the methodology and specification adopted to conduct the study (3), presented its results and discussions in section (4) and finally, we have listed some conclusions and policy implications (5). That is the plan for this study.

2. A Review of the Theoretical and Empirical Literature

Education was generally one of the most important components of human capital, and it is considered a key indicator of economic development (Goode, 1959; Schultz, 1961). The pioneering work of (Schultz, 1960) and (Becker, 1962), both have developed and analyzed growth models augmented with human capital and found a significant positive association between human capital formation and economic growth. Human capital is directly or indirectly contributing to the determination of economic growth. Since then, human capital theory has been an important part of economic theory. According to human capital theory, education directly helps to growth by improving the knowledge, qualifications, skills, and productive capacity of individuals. Education, as the main component of human capital, improves the socio-economic factors. In general, the influence of human capital investment on growth may be divided into two categories: quantitative and qualitative. The quantitative component is described by the number of available employees and hours worked, which measure the entire labor force available in a particular period. In this case, health is very important since it influences labor force growth as well as available work hours. The qualitative component, on

the other hand, addresses the problem of job performance quality, which involves both education in the form of individual skills and personal knowledge and, once again, healthy, which has a good impact on productivity. As a result, not only physical capital investments but also human capital investments should be included as growth factors.

To understand the theoretical debate on the impact of education on economic growth. Education has long been considered a key factor in determining economic welfare. At least three mechanisms through which education can contribute to economic growth are highlighted in the theoretical growth literature. First, according to neoclassical growth theories, (Mankiw et al., 1992) demonstrate that an augmented Solow model that incorporates both human and physical capital accumulation gives an excellent description of the cross-country data, they found a positive link between economic growth and working-age population in secondary school for 1960-1985 in 121 countries. Second, endogenous growth models, assume that the “human capital” plays a central role in several approaches to growth theory (Lucas, 1988 and Romer, 1990). This works focuses on education, which is considered as one of the factors of education. Education, according to (Lucas, 1988), is a mechanism for the accumulation of human capital and should be evaluated as a factor of production among labor and physical capital. This signifies those improvements in the labor force's educational attainment have a positive impact on productivity, leading to improved overall economic performance. Externalities are also generated by human capital. Third, Aghion & Cohen, (2004) analyzed the impact of education on economic growth, which show that the mechanisms through which education affects economic growth are multiple and well-identified. The authors highlight the essential impact of the level of technological development and accumulation of human capital. Through the accumulation of human capital, an individual cannot become productive without passing through the educational system. On the other hand, a higher level of education allows for the development or adoption of new technologies more easily. Benhabib & Spiegel, (2005) generalizes the Nelson & Phelps, (1966) model of technology diffusion, Admit the possibility that the technology diffusion model is exponential. This specification predicts that nations will exhibit positive catch-up in growth rates. and this catch-up only works with a critical level of human capital/education.

The empirical literature on the relationship between education and economic growth starts with cross-section studies; see for examples (Azariadis & Drazen, 1990; Romer, 1989), both have found that literacy is significantly positive with economic growth. They worked on 112 economies data between 1960-1985 and 71 low-and middle-income countries during 1960-1980. Barro, (1991) reveals that the enrollments ratios primary and secondary are positively related to economic growth, while the student-teacher ratio is negatively related to growth in 98 countries during 1960-1980.

In general, quantitative studies conducted over the previous three decades reveals that there exists a positive relationship between education and economic growth (Abbas & Foreman-Peck, 2008; Acemoglu & Zilibotti, 1999; Barro, 1999; Benhabib & Spiegel, 1994; Bils & Klenow, 2000). Some of the most solid studies even suggested that higher levels of education had a stronger influence on economic growth, which is especially true in industrialized nations where research and development are critical.

Gylfason and Zoega, (2003) examined the relationship and interactions between equality, education, and economic growth in a sample of 87 industrial and developing countries during the period 1965-1998. Using seemingly unrelated regression analysis, they found that education and inequality have a significant, independent impact on economic growth, education seems to encourage economic growth. Hassan and Ahmed, (2008) found that all five measures of human capital have a positive causal relationship with per capita GDP, using cross-section panel data regression of Sub-Saharan countries. Baldacci and al., (2008) using panel data from 118 developing countries during 1971-2000, showed that both education and health have a positive

and significant impact on economic growth, any increase in education spending by one percentage point of GDP is associated with 3 additional years of schooling on average and increases annual GDP per capita growth by 1.4 percentage points over 15 years.

Islam et al., (2007) investigated the direction causal link between education and economic growth. They used a multivariate causality test (Vector Error Correction Model) to examine the relationship between education and economic growth in Bangladesh during 1976-2003. They found bidirectional causality between education and economic growth and the long-run relationship between variables in the presence of labor and capital. In the case of Bangladesh, it appears that education and growth are mutually beneficial. Pradhan, (2009) examine the causal link between education and economic growth in India during 1951-2001, the study found that there is a unidirectional causality between education and economic growth running from economic growth to education. In recent studies, (Afzal and al., 2011) used the ARDL Model of cointegration and Augmented Granger Causality given by (Toda and Yamamoto, 1995) to test cointegration and causal link between education (measured by different indicators of education) and economic growth. The results showed that there is cointegration among education and growth and also indicate bidirectional causality between education and economic growth. The study proposes more investment in university education to promote economic growth, which leads to further education and hence economic growth. (Rahman, 2011) examined the causal link between health expenditure, education expenditure, and economic growth in the case of Bangladesh. Including health and education expenditure as an investment in health, the study found the existence of bidirectional causality running from education expenditure to economic growth and from education expenditure to health expenditure and one-way causality from health expenditure to economic growth. (Sharma & Sahni, 2015) examine the causation between human capital investment (education and health investment) and economic growth in India using time series data from 1991-92 to 2012-13. The study found a long-run link between education investment, health investment, and economic growth. It also found two-way causation between education investment and economic growth, as well as between health and economic growth.

Essardi and Razzouk, (2017) in the case of Morocco, investigated the relationship between human capital and economic growth, using two methods of estimation, firstly, Johansen multivariate cointegration test and Granger causality. Secondly, Bayesian Model Averaging. Using four proxies of human capital, the results show that the average years of schooling, life expectancy index and the indicator of the quality of health affect positively GDP per worker. Also, the causality shows that only the indicator of the quality of health causes the GDP per worker. Sarania, (2020) examined the relationship between education expenditure, higher education, and economic growth in India during the period 1971-2015 based on Vector Autoregression (VAR) and Johansen's cointegration procedure. The findings indicate unidirectional causality runs from education expenditure to economic growth and one-way causality runs from economic growth to higher education. Esen & Keçili, (2021) investigate the effects of health expenditure on economic growth in Turkey. The author's results showed unidirectional causality from health expenditure to economic growth in the short term.

3. Econometric methodology and data

3.1. Data

We have used the time-series data on GDP_t , real physical capital (RPC_t), the labor force (LF_t) and four separate education variables in Morocco context from 1990 to 2019. The data are collected from the World Development Indicators (WDI, 2020) and Human Development Reports (HDR). Furthermore, we used a global measure of education, called the education index, adopting the UNDP methodology. The Education Index measures a nation's relative

achievement in adult literacy index (ALI) and cumulative total enrollment in primary, secondary, and tertiary education. First, the adult literacy index and the combined gross enrollment index are calculated, these indices are first combined to create the education index, with a two-third weighting for adult literacy rate (ALR) and with one-third for combined primary, secondary, and tertiary gross enrollment ratio index (GEI). The adult literacy indicates the ability to read and write, while the gross enrollment ratio indicates the level of education.

$$\text{Education index} = \frac{2}{3} \times ALI + \frac{1}{3} \times GEI$$

For the rest of the paper, we will use the following notations: $\ln(\text{GDP})$ is the logarithm of gross domestic product per capita (constant 2010 US\$), $\ln(\text{RPC})$ is the logarithm of the real physical capital, we take also the $\ln(\text{LF})$ as the logarithm of the labor force and we have four separate indicators for education, $\ln(\text{edu}_{1t})$ is the education index as described above, $\ln(\text{edu}_{2t})$ the Gross enrolment ratio, secondary, $\ln(\text{edu}_{3t})$ is Gross enrolment ratio, tertiary, $\ln(\text{edu}_{4t})$ Gross School enrollment, primary. The figures below show the evolution of these variables between 1990-2019 (Figure 1 in the appendix).

The GDP per capita as can be seen in the figure present an increasing trend between 1990 to 2019. The average value during this period was 2447,91 U.S. dollars, with a minimum of 1704,69 U.S. dollars, in 1993 and a maximum of 3396,06 U.S. dollars, in 2019. Morocco is classified as a lower-middle-income country. The country's annual growth rate is predicted to be between 3 and 5 percent. This expansion is the outcome of a more diverse economy and a commitment to advance the industrial sector. It is believed that advances in the manufacturing sector will aid in reducing persistently high unemployment, which is expected to continue above 9%. Currently, the agricultural sector accounts for 13% of economic growth, but production capacity is heavily dependent on annual rainfall. Nearly 30% of economic growth is ascribed to the industrial sector, while the remaining 60% is assigned to services. With an average annual growth rate of 7.40%, the gross enrollment rate in higher education climbed from 10.35% in 2009 to 38.08% in 2019. Furthermore, the secondary enrollment rate increased significantly from 37.35% to 80.58%, increasing at an average annual rate of 14.51% in 2017, with a 1.20% reduction in 2019. Furthermore, the primary school enrollment rate was 114.8 percent, up from 67.44% in 1990 to 115.35% in 2019, with an average yearly growth rate of 1.13%. A graphical representation in logarithmic form as we can see below, shows that all series seems to have an increasing trend over our case study. We can conclude that the series seems to be non-stationary in the level. To avoid the spurious regression problem, we will examine the data series to see if they contain unit-roots.

3.2. Econometric Model

This section introduces the econometric model framework used to test of cointegration and causality between education and economic growth. Holding in perspective the theoretical assumptions of the relationship between GDP, labor force, real physical capital, and human capital. We estimate equations similar to that used by (Afzal et al., 2011).

To understand the empirical association between education and economic growth, we consider the two following econometric log-linear models:

$$\ln \text{GDP}_t = \beta_0 + \beta_1 \ln \text{edu}_{it} + \beta_2 \ln \text{RPC}_t + \beta_3 \ln \text{LF}_t + u_t \quad (1)$$

$$\ln \text{edu}_{it} = \alpha_0 + \alpha_1 \ln \text{GDP}_t + \alpha_2 \ln \text{RPC}_t + \alpha_3 \ln \text{LF}_t + u_t \quad (2)$$

In those equations, \ln is the natural logarithm, GDP_t the Gross domestic product per capita used as a proxy for economic growth, LF_t the labor force comprises people ages 15 and older; it includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers, RPC_t the real physical capital measured as gross fixed capital formation deflated by GDP deflator. edu_{it} measures education level. In our study education was measured by different indicators such as: edu_{1t} = Education index proxy for education

development, edu_{2t} = Gross enrollment ratio, secondary, edu_{3t} = Gross enrollment ratio, tertiary, edu_{4t} = Gross enrollment ratio, primary. Our data and definitions are summarized in Table 1 below. We include summary statistics.

Table 1: Variable definitions and sources

Variables	Definition and source	Obs	Mean
Ln(GDP)	Gross Domestic per capita (constant 2010 US\$); World Development Indicators.	30	7.77
Labor Force (lnLF)	Labor force comprises people ages 15 and older; World Development Indicators.	30	16.12
Real physical capital (lnRPC)	Gross fixed capital formation (constant 2010 US\$); World Development Indicators.	30	23.55
Education index	Education index is an average of mean years of schooling (of adults) and expected years of schooling (of children). HDRO calculations based on expected years of schooling and mean years of schooling from UNESCO Institute for Statistics.	30	0.39
Gross enrollment ratio, secondary	Total enrollment in secondary education, regardless of age, expressed as a percentage of the population of official secondary education age; UNESCO Institute for Statistics.	30	3.93
Gross enrollment ratio, tertiary	Expressed as a percentage of the total population of the five-year age group following on from secondary school leaving; UNESCO Institute for Statistics.	30	2.68
Gross enrollment ratio, primary	Total enrollment in primary education, regardless of age, expressed as a percentage of the population of official primary education age; UNESCO Institute for Statistics.	30	4.54

Source: Authors

4. Empirical results

4.1. Unit root tests

The autoregressive distributed lag method for cointegration and Toda-Yamamoto Augmented Granger Causality (TYAGC) test are used to test the cointegration and causality between education and economic growth. Stata 17.0 was used to generate all results. The first step in the Bounds Testing methodology of Pesaran et al., (2001) and (Pesaran & Shin, 1995) is to make sure that none of the variables is integrated of order 2 or $> I(2)$.

This study uses two-unit root tests such as Augmented Dickey-Fuller Test (ADF), Phillips-Perron Test (PP) to ensure that none of the variables is of $I(2)$ or higher order. The descriptive statistics of unit root tests regarding the order of integration are presented in Table 2. According to the given estimations results in Table (1), GDP_t , RPC_t , edu_{1t} , edu_{2t} , edu_{3t} and edu_{4t} , all these variables are $I(1)$ with constant under the ADF and PP, while LF_t is of $I(0)$ with constant under ADF and PP. While the order of integration for all variables is $I(1)$ with intercept and trend according to the PP. According to all criteria, none of the variables are $I(2)$, then the ARDL model to cointegration is indeed the appropriate technique for cointegration.

Table 2: Unit root tests

Variables	ADF		PP		Decision
	Intercept	Intercept and trend	Intercept	Intercept and trend	
GDP	-0.144 (0.9449)	-3.126 (0.1001)	0.113 (0.9669)	-3.049 (0.1190)	I (1)
ΔGDP: 1st difference	-10.790 (0.0000) *	-10.885 (0.0000) *	-9.529 (0.0000) *	-9.615 (0.0000) *	
RPC	-0.496 (0.8927)	-1.319 (0.8833)	-0.553 (0.8812)	-1.632 (0.7796)	I (1)
ΔRPC: 1st difference	-3.835 (0.0026) *	-3.765 (0.0184) **	-3.758 (0.0034) *	-3.679 (0.0238) **	
LF	-6.316 (0.0000) *	0.294 (0.9962)	-4.705 (0.0001) *	0.135 (0.9954)	I (0)
ΔLF: 1st difference		-3.692 (0.0229) **		-3.681 (0.0236) **	
edu_{1t}	0.010 (0.9594)	-2.185 (0.4982)	-0.063 (0.9530)	-2.578 (0.2903)	I (1)
Δedu_{1t}: 1st difference	-3.017 (0.0334) **		-3.062 (0.0295) **		
edu_{2t}	1.068 (0.9949)	-2.791 (0.2001)	0.514 (0.9853)	-2.554 (0.3013)	I (1)
Δedu_{2t}: 1st difference	-3.453 (0.0093) *		-3.513 (0.0077) *	-3.134 (0.0984) ***	
edu_{3t}	2.173 (0.9989)	-0.616 (0.9781)	1.788 (0.9983)	-0.688 (0.9739)	I (1)
Δedu_{3t}: 1st difference	-3.644 (0.0050) *		-3.688 (0.0043) *	-4.530 (0.0013) *	
edu_{4t}	-1.869 (0.3467)	-0.274 (0.9901)	-1.557 (0.5050)	-0.696 (0.9734)	I (1)
Δedu_{4t}: 1st difference	-3.621 (0.0054) *		-3.683 (0.0044) *	-5.109 (0.0001) *	

Figures in parentheses are p-values; *, **, *** indicates significance at 1%, 5% and 10% respectively.

Source: Authors

To analyze our questions, this study use the error-correction version of the ARDL method of equation (1) and (2) to investigate the long run (LR) relationship between GDP_t , RPC_t , LF_t and edu_{it} by following Pesaran & Pesaran, (1997) and Pesaran & Shin, (1995), as:

$$\begin{aligned} \Delta \ln GDP_t = & \alpha_{0GDP_t} + \sum_{i=1}^n \beta_{iGDP_t} \Delta \ln GDP_{t-i} + \sum_{i=1}^n \gamma_{iGDP_t} \Delta \ln RPC_{t-i} + \sum_{i=1}^n \theta_{iGDP_t} \Delta \ln LF_{t-i} \\ & + \sum_{i=1}^n \vartheta_{iGDP_t} \Delta \ln Edu_{it-i} + \delta_{1GDP_t} \ln GDP_{t-1} + \delta_{2GDP_t} \ln RPC_{t-1} + \delta_{3GDP_t} \ln LF_{t-1} \\ & + \delta_{4GDP_t} \ln Edu_{it-1} \end{aligned} \quad (3)$$

Equation if education serves as dependent variable is:

$$\begin{aligned} \Delta \ln Edu_{it} = & \alpha_{0Edu_{it}} + \sum_{i=1}^n \beta_{iEdu_{it}} \Delta \ln Edu_{it-i} + \sum_{i=1}^n \gamma_{iEdu_{it}} \Delta \ln RPC_{t-i} \\ & + \sum_{i=1}^n \theta_{iEdu_{it}} \Delta \ln GDP_{t-i} + \sum_{i=1}^n \vartheta_{iEdu_{it}} \Delta \ln LF_{t-i} \\ & + \delta_{1Edu_{it}} \ln Edu_{it-1} + \delta_{2Edu_{it}} \ln RPC_{t-1} + \delta_{3Edu_{it}} \ln GDP_{t-1} + \delta_{4Edu_{it}} \ln LF_{t-1} \end{aligned} \quad (4)$$

The four terms (β , γ , θ , and θ) with summation signs in equations 3 and 4 reflect the error correction dynamics, whereas the second part (terms with δ_i) represents the long-run relationship. Δ is the first difference operator.

To investigate the long-run relationship between the variables of interest, the first step in the ARDL model was to compute the well-known F -statistic on the differenced variables components of the error correction mechanism (ECM) model for the joint significance of the variables lagged level coefficients. In this first step, the ARDL equation when edu_{it} serves as dependent variable is modeled as follows:

$$\begin{aligned} \Delta \ln Edu_{it} = & a_{0Edu_{it}} + \sum_{i=1}^n b_{iEdu_{it}} \Delta \ln Edu_{it-i} + \sum_{i=1}^n c_{iEdu_{it}} \Delta \ln RPC_{t-i} \\ & + \sum_{i=1}^n d_{iEdu_{it}} \Delta \ln RGDP_{t-i} + \sum_{i=1}^n e_{iEdu_{it}} \Delta \ln LF_{t-i} \\ & + \varepsilon_{1t} \end{aligned} \quad (5)$$

To establish an error correction mechanism in this equation, we add the first lag of the level of each variable. The ECM is expected to have a negative sign, which implies that the model is converging toward the equilibrium after a certain threshold level. The ECM of ARDL model (5) can be written as follows:

$$\begin{aligned} \Delta \ln Edu_{it} = & a_{0Edu_{it}} + \sum_{i=1}^n b_{iEdu_{it}} \Delta \ln Edu_{it-i} + \sum_{i=1}^n c_{iEdu_{it}} \Delta \ln RPC_{t-i} \\ & + \sum_{i=1}^n d_{iEdu_{it}} \Delta \ln RGDP_{t-i} + \sum_{i=1}^n e_{iEdu_{it}} \Delta \ln LF_{t-i} \\ & + \delta_{1Edu_{it}} \ln Edu_{it-1} + \delta_{2Edu_{it}} \ln RPC_{t-1} + \delta_{3Edu_{it}} \ln RGDP_{t-1} \\ & + \delta_{4Edu_{it}} \ln LF_{t-1} + \varepsilon_{1t} \end{aligned} \quad (6)$$

To test the cointegration among variables. The F -test was used to examine whether or not long-run correlations exist. The null hypothesis for no cointegration among the variables is given as:

$H_0 : \delta_{1Edu_{it}} = \delta_{2Edu_{it}} = \delta_{3Edu_{it}} = \delta_{4Edu_{it}} = 0$ against the alternative hypothesis

$H_1 : \delta_{1Edu_{it}} \neq \delta_{2Edu_{it}} \neq \delta_{3Edu_{it}} \neq \delta_{4Edu_{it}} \neq 0$

The test can be denoted as: $F_{edu_{it}}(edu_{it}/GDP_t, RPC_t, LF_t)$.

A similar test was conducted for the equation when GDP_t serves as a dependent variable, this can also be denoted as follows: $F_{edu_{it}}(GDP_t/edu_{it}, RPC_t, LF_t)$. If the computed value of the F -statistic is larger than the upper critical value (upper critical bound), given by Pesaran et al. (2001) and Narayan (2005) the variables are cointegrated. Then the null hypothesis of no cointegration is rejected, indicating that there is a long-run relationship among the variables when edu_{it} serves as a dependent variable. If the calculated value of the F -statistic is less than the lower bounds critical value, then the variables are not cointegrated in the long term, and the hypothesis of no cointegration cannot be rejected. Finally, if the calculated value falls between lower and upper bounds critical values, then the cointegration test becomes inconclusive.

4.2. Co Integration Tests

First, we estimate the equations (3) and (4) to examine the existence of a long-run relationship between our variables in the model. In this case, we are using the ARDL approach to cointegration, by using the F -statistic. We choose the different lag lengths, 1,2,3, and 4 as the maximum order of lags in the ARDL and estimate for the period 1990-2019. Tables 3 and 4 shows the cointegration results, when GDP_t serves as a dependent variable, and when edu_{it} serves as a dependent variable respectively. (Pesaran et al., 2001), lower and upper critical values for bounds testing ARDL for 1%, 5%, and 10% significance levels are [4.29-5.61], [3.23-

4.35], and [2.72-3.77] respectively. Narayan, (2005), lower and upper critical values for bounds testing ARDL for 1%, 5%, and 10% significance levels are [4.61-5.96], [3.27-4.30] and [2.67-3.58] respectively.

All the value of the calculated F -statistic exceeds the upper bound even at the 1%, 5%, and 10% significance level in both the (Narayan, 2005; Pesaran et al., 2001), we can conclude that there is evidence of a long-run relationship between our variables in the model.

When GDP_t serves as a dependent variable, all the indicators of education, indicate that there exists a cointegration relationship among GDP_t , RPC_t , LF_t and edu_{it} according to both (Narayan, 2005; Pesaran et al., 2001). This implies that the null hypothesis of no cointegration cannot be accepted.

Table 3: Cointegration: When GDP_t is a dependent variable

Cointegration	Lag length (1,2,3,4)				Decision results	
	1	2	3	4	Pesaran et al. (2001)	Narayan (2005)
$\Delta GDP_t [F_{GDP_t}(GDP_t/RPC_t, edu_{1t}, LF_t)]$	9.14	22.65	25.66	11.42	Cointegration	Cointegration
$\Delta GDP_t [F_{GDP_t}(GDP_t/RPC_t, LF_t, edu_{2t})]$	9.78	13.20	26.10	22.69	Cointegration	Cointegration
$\Delta GDP_t [F_{GDP_t}(GDP_t/RPC_t, LF_t, edu_{3t})]$	4.83	7.91	32.83	28.92	Cointegration	Cointegration
$\Delta GDP_t [F_{GDP_t}(GDP_t/RPC_t, LF_t, edu_{4t})]$	3.17	6.54	10.31	12.90	Cointegration	Cointegration

Source: Author's calculations

Similarly, the Table 4 show that there exists a long-run relationship between education and all variables (GDP_t , RPC_t , and LF_t) when education is a dependent variable. As we described our variable education edu_{it} is presented by four separate variables (edu_{1t} , edu_{2t} , edu_{3t} , edu_{4t}). According to both Narayan, 2005 and Pesaran and all, 2001 critical values, we reject the null hypothesis of no cointegration between education and economic growth and we confirmed that there is a cointegration between our variables.

Table 4: Cointegration: When edu_{it} is a dependent variable?

Cointegration	Lag length (1,2,3,4)				Decision results	
	1	2	3	4	Pesaran et al. (2001)	Narayan (2005)
$\Delta edu_{1t} [F_{edu_{1t}}(edu_{1t}GDP_t, RPC_t, LF_t)]$	6.21	6.48	9.41	9.41	Cointegration	Cointegration
$\Delta edu_{2t} [F_{edu_{2t}}(edu_{2t}GDP_t, RPC_t, LF_t)]$	6.57	5.67	6.02	10.58	Cointegration	Cointegration
$\Delta edu_{3t} [F_{edu_{3t}}(edu_{3t}GDP_t, RPC_t, LF_t)]$	3.74	3.74	7.23	7.23	Cointegration	Cointegration
$\Delta edu_{4t} [F_{edu_{4t}}(edu_{4t}GDP_t, RPC_t, LF_t)]$	22.55	8.07	8.07	8.07	Cointegration	Cointegration

Source: Author's calculations

In conclusion, the results at this stage confirm that the cointegration between education and economic growth exists. We can then go ahead to estimate the ARDL for both models. In our case, we limit our analysis in the cointegration test.

4.3. Toda-Yamamoto Augmented Granger Causality (TYAGC) test

Granger Causality is the traditional method for testing causality between variables as proposed by Granger, (1969). The Granger causality test without considering other variables because of their effect was considered a possibility of specification bias. It has been shown in the literature that the Granger causality test is extremely sensitive to model specification and lags. In dealing with these problems, TYAGC overcoming the problem of asymptotic critical values when causality is done in the presence and absence of stationarity and cointegration (Ziramba, 2008). To use the Tada Yamamoto causality approach, we must first identify the lag length p and the maximal order of integration of a series, denoted by d_{max} , and estimate $(p + d_{max})^{th}$ order of VAR model using Seemingly Unrelated Regression. Secondly, the hypothesis is tested by

conducting a standard Wald statistic test which has an asymptotic Chi-square distribution with m degrees of freedom. According to Toda and Yamamoto (1995), the modified Wald test is valid for integrated and co-integrated variables, for series I (0), I(1), or I(2). Let consider the bivariate model with p lag. In this case, the relevant VAR model is based on the following equations:

$$\ln GDP_t = \mu + \sum_{i=1}^{p+m} \alpha_i \ln GDP_{t-i} + \sum_{i=1}^{p+m} \beta_i \ln edu_{it-i} + \mu_{1t} \quad (7)$$

$$\ln edu_{it} = \mu + \sum_{i=1}^{p+m} \gamma_i \ln edu_{it-i} + \sum_{i=1}^{p+m} \delta_i \ln GDP_{t-i} + \mu_{2t} \quad (8)$$

Where m is the maximal order of integration, p is the optimal lag length of $\ln GDP_t$ and $\ln edu_{it}$, and μ_{it} are the error terms are assumed to be white noise, $\sim (0, \sigma^2)$.

The null hypothesis of non-causality between variables, against the alternative hypothesis, is given by:

$$H_0: \ln edu_{it} \text{ does not Granger cause } \ln GDP_t, \text{ if } \beta_i = 0$$

$$H_1: \ln edu_{it} \text{ does not Granger cause } \ln GDP_t, \text{ if } \beta_i \neq 0$$

Before employing the TYAGC test, it is necessary to determine the optimal lag length p and the maximum order of integration m . In our case, the order of integration is determined using the PP and ADF unit root test. The maximum integration for our VAR model is shown as, $m = 1$, we specify the model by determining the lag length based on the Akaike Information Criterion. The optimal lag length selected by AIC for our study is shown as 3. The TYAGC test can be performed by constructing the Vector Autoregressive (VAR) model of ($m + p = 4$).

4.3.1. Bivariate TYAGC Framework

In this section, the study investigates the bivariate Toda Yamamoto Granger Causality. Between economic growth and education model (1) and (2), between GDP_t and RPC_t model (3) and (4), between GDP_t and LF_t model (5) and (6), between education and RPC_t model (7) and (8), between education and LF_t Model (9) and (10). We estimate all equations, the results are reported in summary in table 5. Throughout, results that are mentioned but not presented in detail are available from the authors. All equations are reported in appendix 1.

$$\ln GDP_t = \alpha_1 + \sum_{i=1}^4 \beta_{1i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{1i} \ln Edu_{it-i} + u_{1t} \quad (1)$$

$$\ln edu_{it} = \alpha_2 + \sum_{i=1}^4 \beta_{2i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{2i} \ln Edu_{it-i} + u_{2t} \quad (2)$$

The main results of the bivariate analysis. As indicated in detail, the null hypothesis of non-causality between all measures of education and economic growth was tested using the modified Wald test. The results of bivariate TYAGC reveal that the null hypothesis was rejected. At the same moment, the null hypothesis that the economic growth does not Granger cause education was rejected except gross enrollment ratio, in primary. Therefore, we can conclude that there is bidirectional causality (feedback) between education and economic growth which validates the theory as well as with the past empirical research. The hypothesis that economic growth does not Granger cause gross enrollment ratio, in primary, indicate that economic growth fails to cause significantly gross enrollment ratio, primary.

The bivariate TYAGC result also indicates from model (5) and (6) that there is bidirectional causality between economic growth and labor force. From model (3) and (4) the result shows that there is only one-way causality between economic growth and real physical capital, run from economic growth to real physical capital. According to model (7) and (8) in table 4, education index proxy for education development and gross enrollment ratio, secondary does not Granger cause real physical capital. Also, the result indicates that real physical capital does not granger cause gross enrollment ratio, primary. At the same time, we can conclude that gross

enrollment ratio, secondary and gross enrollment ratio, in primary Granger cause real physical capital, and there is causality from real physical capital to education index, gross enrollment ratio, secondary and gross enrollment ratio, tertiary. From model (9) and (10), the result indicates that there is bidirectional causal nexus between gross enrollment ratio, tertiary and labor force. At the same time, there is unidirectional causality between education index, gross enrollment ratio, secondary and gross enrollment ratio, in primary and labor force.

To summarize, the bivariate TYAGC shows that there is a feedback causality between education and economic growth.

4.3.2 Multivariate TYAGC with three variables

After estimating bivariate TYAGC, in this section, we proceed to estimate a multivariate test using three variables in our model. We estimate equations (11), (12), and (13) to capture the causality between economic growth, real physical capital and education and among economic growth, LF_t and Edu_{it} Eqs. (14), (15), and (16). The following equations are estimated, considering each of the variables as the dependent variable. All equations are reported in appendix 2.

$$\ln GDP_t = \alpha_{11} + \sum_{i=1}^4 \beta_{11i} \ln GDP_{t-i} + \sum_{i=1}^4 \lambda_{11i} \ln RPC_{t-i} + \sum_{i=1}^4 \gamma_{11i} \ln Edu_{it-i} + u_{11t} \quad (11)$$

$$\ln Edu_{it} = \alpha_{12} + \sum_{i=1}^4 \beta_{12i} \ln GDP_{t-i} + \sum_{i=1}^4 \lambda_{12i} \ln RPC_{t-i} + \sum_{i=1}^4 \gamma_{12i} \ln Edu_{it-i} + u_{12t} \quad (12)$$

The causality between economic growth and all indicators of education is tested and the results are summarized in detail available from the authors. The result shows that the null hypothesis of no Granger causality between education and economic growth except gross enrollment ratio, primary is rejected. Overall, the result supports our previous bivariate argument confirming that there is bidirectional causality between education and economic growth. Our results also show a feedback relationship (two-way Granger causality) between RPC_t and economic growth, and between education and RPC_t .

The TYAGC in detail indicates that there is two-way causality between education and economic growth when RPC_t and LF_t as 3rd variable except gross enrollment ratio, primary. There is one-way causality between economic growth and gross enrollment ratio, primary running from GDP_t to gross enrollment ratio, primary. The results also indicate that there is one-way causality between LF_t and education flowing from education to LF_t . At the same moment, the null hypothesis that GDP_t does not granger cause LF_t when education serves as 3rd variable is rejected. We can conclude that there is bidirectional causality between economic growth and the labor force. So, it is clear that LF_t appears to be a very important variable that influences two main variables education and economic growth.

In general, the result of multivariate TYAGC supports our previous bivariate causality that there is two-way causality between education and economic growth.

4.3.3 Multivariate TYAGC with all variables

Now we investigate the multivariate TYAGC with all variables. Considering each variable as a dependent variable. The causality between GDP_t , RPC_t , LF_t and Edu_{it} was tested using TYAGC. The main results detail is available from the authors. All equations are reported in appendix 3.

$$\begin{aligned} \ln GDP_t = & \alpha_{17} + \sum_{i=1}^4 \beta_{17i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{17i} \ln RPC_{t-i} \\ & + \sum_{i=1}^4 \lambda_{17i} \ln LF_{t-i} + \sum_{i=1}^4 \delta_{17i} \ln Edu_{it-i} + u_{17t} \end{aligned} \quad (17)$$

$$\ln Edu_{it} = \alpha_{18} + \sum_{i=1}^4 \beta_{18i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{18i} \ln RPC_{t-i} + \sum_{i=1}^4 \lambda_{18i} \ln LF_{t-i} + \sum_{i=1}^4 \delta_{18i} \ln Edu_{it-i} + u_{18t} \tag{18}$$

The results presented support our previous bivariate causality and multivariate causality (with only three variables in the equation) that there is causality between education and economic growth. Thus, we can conclude that there exists two-way causality between education and economic growth. While economic growth does not granger cause edu_{4t} (Gross enrollment ratio, primary).

The TYAGC results also indicate that we cannot reject the null hypothesis that economic growth does not granger cause LF_t . Our results also show that we cannot reject the null hypothesis that economic growth does not granger cause RPC_t . This implies that there exists a feedback relationship (two-way Granger causality) between LF_t , RPC_t and GDP_t in the presence of all indicators of education.

The null hypothesis of no Granger causality between LF_t and all indicators of education is rejected, concluding that there is feedback between LF_t and education. In case of testing causality between RPC_t and education, the result reveals that RPC_t only Granger cause education index and gross enrollment ratio, secondary and does not Granger cause gross enrollment ratio, tertiary and gross enrollment ratio, primary. However, all indicators of education Granger cause RPC_t .

The causality between education and economic growth is tested and results from bivariate, multivariate (with three and all variables) are summarized in Table 5.

Table 5: Summary causal nexus between education and growth

Hypothesis testing	Summary of TYAGC tests			
	Bivariate	Multivariate with three variables		Multivariate with all variables
	GDP_t and edu_{it}	GDP_t, RPC_t and edu_{it}	GDP_t, LF_t and edu_{it}	GDP_t, RPC_t, LF_t and edu_{it}
Education (edu_{1t}) does granger cause GDP_t	(0.094)	(0.018)	(0.430)	(0.018)
GDP_t does Granger cause education (edu_{1t})	(0.033)	(0.003)	(0.003)	(0.000)
Education (edu_{2t}) does granger cause GDP_t	(0.000)	(0.000)	(0.000)	(0.000)
GDP_t does Granger cause education (edu_{2t})	(0.000)	(0.000)	(0.000)	(0.000)
Education (edu_{3t}) does granger cause GDP_t	(0.000)	(0.001)	(0.016)	(0.006)
GDP_t does Granger cause education edu_{3t}	(0.000)	(0.006)	(0.018)	(0.034)
Education (edu_{4t}) does granger cause GDP_t	(0.000)	(0.000)	(0.005)	(0.000)
GDP_t does Granger cause education (edu_{4t})	(0.828)	(0.733)	(0.122)	(0.550)

Figures in brackets are p-value. *, **, *** indicates significance at 1%, 5% and 10% respectively.

Source: Author's calculations

From Table 5, it can be observed that the null hypothesis of no Granger causality between all indicators of education and economic growth was rejected. There is bidirectional causality between education and economic growth. all indicators of education Granger cause economic growth in the case of bivariate and multivariate TYAGC. Economic growth does Granger cause education in all causality cases except gross enrollment ratio, primary. Economic growth fails to cause gross enrollment ratio, primary in all causality cases.

In general, our results confirm the importance of education and its contribution to economic growth. it is documented in the literature that economic growth and education have a long-run relationship and both have the causal link either one or two-way. Our results are consistent with. (Afzal et al., 2011), investigate the cointegration and causality between education and economic growth in the case of Pakistan, they showed that there is a cointegration among education and

growth, and they suggest more investments in university education in order to promote economic growth. The government should focus more on education because it acts as input for higher education and to stimulate economic growth.

5. Conclusions

In this paper we investigate the cointegration and causal link between education and economic growth in Morocco. Education, in all of its forms, is one of the fundamental factors of development. Hence, a country needs to invest more in education. Without significant investments in human capital, no country can achieve sustainable economic development.

Based on the results of unit root tests (ADF, PP), we found that none of the variables are integrated of order 2, the variables are a mix of I (0) and I (1). According to unit root tests, the ARDL bounds test approach was examined followed by Toda Yamamoto Granger Causality. Education and economic growth cointegration were examined using the ARDL approach and the causal relationship between education (measured by four indicators) and economic growth was investigated in bivariate, multivariate (with three variables) in the presence and absence of the labor force, and real physical capital as a third and fourth variable and multivariate (with all variables). Several indicators were used to demonstrate the robustness of the empirical results. Our results indicate that there exists two-way causality between economic growth and education except for the gross enrollment ratio in the primary. Education and all levels of education cause economic growth in the presence of real physical capital in bivariate, multivariate (with all variables), and multivariate (with three variables), whereas education and levels of education cause economic growth in the presence of labor force, except education index proxy for education development. While economic growth granger causes all metrics of education except the gross enrollment ratio, primary. As a result, we can conclude that there is a two-way causality between education and economic growth. While GDP_t does not granger cause Edu_{4t} (Gross enrollment ratio, primary) in all cases of bivariate, multivariate (with three variables), and multivariate (with all variables). The results from bounds test cointegration confirm the long-run relationship between education and economic growth, when GDP_t serves as a dependent variable, and when edu_{it} serves as a dependent variable respectively.

According to the findings of the study, the government should pay attention more on primary education. The primary schooling should be a priority because it acts as an input for all higher education. To stimulate economic growth, more funding is needed for education, especially at the primary and university levels. It is also suggested that the relationship between education and economic growth be investigated and broadened by incorporating other variables than physical capital and labor force, such as education expenditures.

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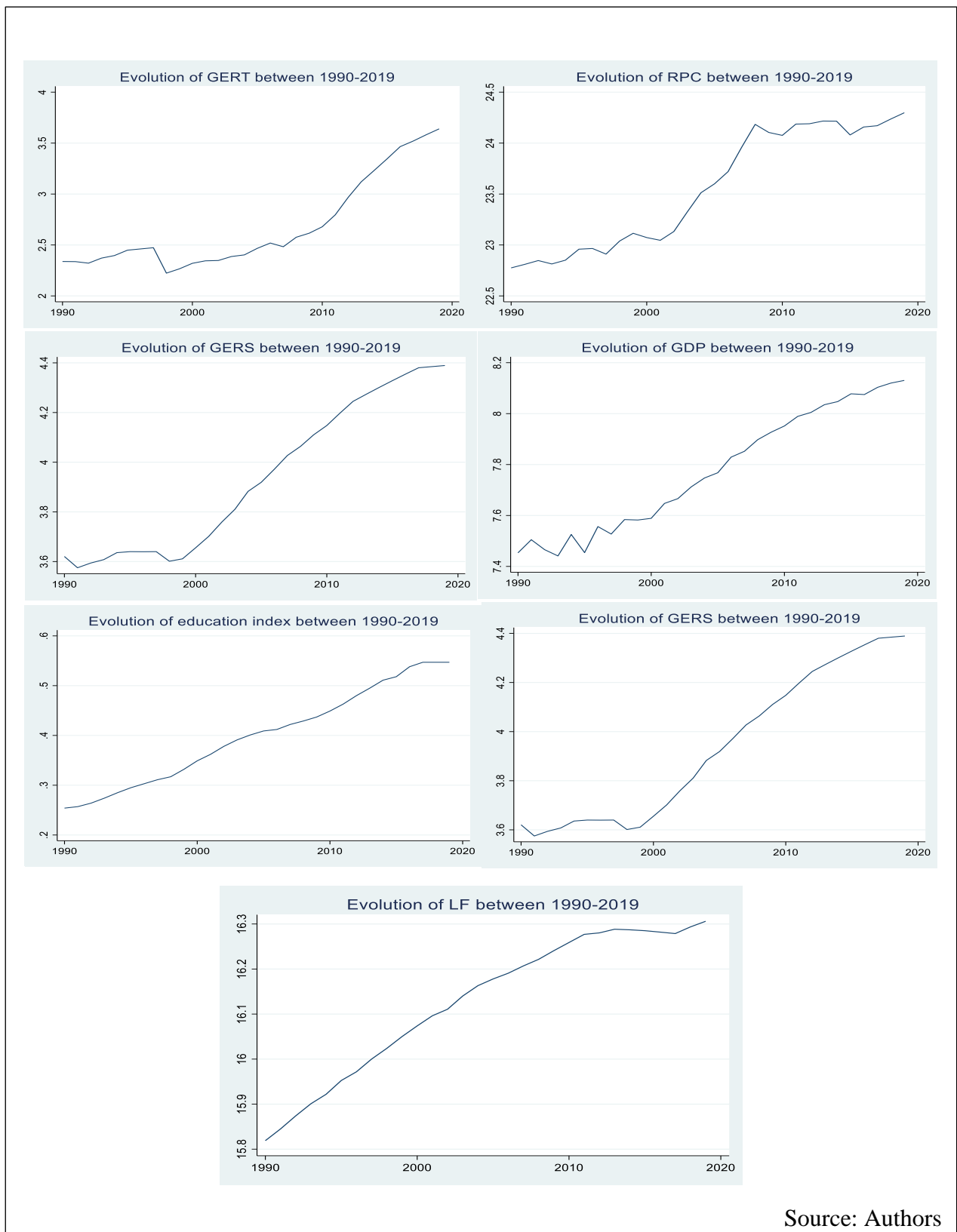
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Appendix Appendix 1

Figure 1. The evolution of our variables between 1990 to 2019.



Source: Authors

Appendix 2. Other bivariate equations

$$\ln GDP_t = \alpha_3 + \sum_{i=1}^4 \beta_{3i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{3i} \ln RPC_{t-i} + u_{3t} \quad (3)$$

$$\ln RPC_t = \alpha_4 + \sum_{i=1}^4 \beta_{4i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{4i} \ln RPC_{t-i} + u_{4t} \quad (4)$$

$$\ln GDP_t = \alpha_5 + \sum_{i=1}^4 \beta_{5i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{5i} \ln LF_{t-i} + u_{5t} \quad (5)$$

$$\ln LF_t = \alpha_6 + \sum_{i=1}^4 \beta_{6i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{6i} \ln LF_{t-i} + u_{6t} \quad (6)$$

$$\ln edu_{it} = \alpha_7 + \sum_{i=1}^4 \beta_{7i} \ln edu_{it-i} + \sum_{i=1}^4 \gamma_{7i} \ln RPC_{t-i} + u_{7t} \quad (7)$$

$$\ln RPC_t = \alpha_8 + \sum_{i=1}^4 \beta_{8i} \ln edu_{it-i} + \sum_{i=1}^4 \gamma_{8i} \ln RPC_{t-i} + u_{8t} \quad (8)$$

$$\ln edu_{it} = \alpha_9 + \sum_{i=1}^4 \beta_{9i} \ln edu_{it-i} + \sum_{i=1}^4 \gamma_{9i} \ln LF_{t-i} + u_{9t} \quad (9)$$

$$\ln LF_t = \alpha_{10} + \sum_{i=1}^4 \beta_{10i} \ln edu_{it-i} + \sum_{i=1}^4 \gamma_{10i} \ln LF_{t-i} + u_{10t} \quad (10)$$

Appendix 2. Other Multivariate TYAGC with three variables

$$\ln RPC_t = \alpha_{13} + \sum_{i=1}^4 \beta_{13i} \ln GDP_{t-i} + \sum_{i=1}^4 \lambda_{13i} \ln RPC_{t-i} + \sum_{i=1}^4 \gamma_{13i} \ln edu_{it-i} + u_{13t} \quad (13)$$

$$\ln GDP_t = \alpha_{14} + \sum_{i=1}^4 \beta_{14i} \ln GDP_{t-i} + \sum_{i=1}^4 \lambda_{14i} \ln LF_{t-i} + \sum_{i=1}^4 \gamma_{14i} \ln edu_{it-i} + u_{14t} \quad (14)$$

$$\ln edu_{it} = \alpha_{15} + \sum_{i=1}^4 \beta_{15i} \ln GDP_{t-i} + \sum_{i=1}^4 \lambda_{15i} \ln LF_{t-i} + \sum_{i=1}^4 \gamma_{15i} \ln edu_{it-i} + u_{15t} \quad (15)$$

$$\ln LF_t = \alpha_{16} + \sum_{i=1}^4 \beta_{16i} \ln GDP_{t-i} + \sum_{i=1}^4 \lambda_{16i} \ln LF_{t-i} + \sum_{i=1}^4 \gamma_{16i} \ln edu_{it-i} + u_{16t} \quad (16)$$

Appendix 3. Other Multivariate TYAGC with all variables

$$\begin{aligned} \ln RPC_t = & \alpha_{19} + \sum_{i=1}^4 \beta_{19i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{19i} \ln RPC_{t-i} \\ & + \sum_{i=1}^4 \lambda_{19i} \ln LF_{t-i} + \sum_{i=1}^4 \delta_{19i} \ln edu_{it-i} + u_{19t} \end{aligned} \quad (19)$$

$$\begin{aligned} \ln LF_t = & \alpha_{20} + \sum_{i=1}^4 \beta_{20i} \ln GDP_{t-i} + \sum_{i=1}^4 \gamma_{20i} \ln RPC_{t-i} \\ & + \sum_{i=1}^4 \lambda_{20i} \ln LF_{t-i} + \sum_{i=1}^4 \delta_{20i} \ln edu_{it-i} + u_{20t} \end{aligned} \quad (20)$$