A causality analysis between human capital and technology change in Albania

MBA. Lorena Alikaj
Ismail Qemali University, Vlora, Albania

Assoc. Prof. Arsena Gjipali
University of Tirana, Tirana, Albania

Abstract

Following a long period of high economic growth, in the last quarter of 2008 the Albanian economy slowed down – and this trend has continued up to now. To achieve the previous performance Albania needs a new economic model – investing heavily in technology adoption, innovation and human capital (Fullani, 2012). Economists have suggested various channels through which human capital can affect economic growth. The first channel is when human capital is a direct input in the production function and the second channel is when the human capital affects the technology change parameter. So, it is clear that a lack of educated people may reduce economic growth, but it is unclear whether a more educated workforce will cause economic growth in Albania. In this paper, we have investigated a causality relationship between human capital and technological change in Albania for a period of 32 years from 1983 up to 2014, through the application of Engle and Granger (1987) co-integration technique and by using the Vector Error Correction Method. The results of the Engle and Granger (1987) co-integration test indicate that a long run relationship exists between gross enrolment rates in higher education (a proxy for human capital) and TFP (a proxy for technological change) in Albania. Policy implications arise as to the importance of human capital deriving from the role of gross enrolments rates in higher education to TFP in the long run equilibrium.

Keywords: economic growth, higher education, TFP, Granger causality, VECM.

Introduction

Throughout the 20th century, extensive literature has been produced about the role of human capital and technological developments in determining economic growth. Most of the latest studies deal with the empirical testing of this relationship, and most of these empirical works are based on cross-data of developed and developing countries, while limited literature is found for a single country (Oladoyin 2010). Most of the studies confirm that only a limited part of economic growth can be explained by the accumulation of production factors, such as physical capital and working hours of the labor factor. The unexplained part of economic growth, such as Total Factor Productivity (TFP), is widely accepted as a key factor of the economic growth (Easterly and Levine, 2001; Bosworth and Collins, 2003).
The traditional measure which is widely used in the literature to measure the contribution of technological change to economic growth is represented by Total Factor Productivity (TFP) (Kahn and Lim, 1998). The empirical literature points out that the high growth in Asian Tiger countries, such as the People's Republic of China and India, can be explained by the steady growth of TFP. Bulman et al. (2014) and Jitsuchon (2012) argue that countries that managed to successfully overcome middle

income levels had relatively high TFP growth. Tran (2013) argues that middle-income countries should complete "orientation or direction from increasing output factors toward TFP growth orientation". Benavot (1989) also argues that the main contribution of human capital, which is generally often measured in terms of the rate of enrollment at school to the incremental process, is to increase the level of cognitive skills owned by the workforce, and as a consequence, improves productivity in general and should therefore be attributed to TFP. Hence, we sum up that the human capital measured by education is an important factor of economic growth.
Over the last 25 years the Albanian economy has undergone significant structural changes, which have strengthened economic incentives and fuelled economic growth. Growth accounting analysis by Kota (2009) suggests that capital stock has played an important role in economic growth only after 2000, with TFP continuing to be an important determinant of economic growth. Following a long period of high economic growth, in the last quarter of 2008 the Albanian economy slowed down – and this trend has continued up to now. Therefore, in order to gain a better understanding of economic growth in the long run, we will focus on TFP behavior, as being argued to be a crucial determinant of long-run economic growth. To achieve the previous performance Albania needs a new economic model – investing heavily in technology adoption, innovation and human capital (Fullani, 2012). While it is evident that a lack of educated people may slow down the economic growth, it is unclear whether a more educated workforce will trigger the economic growth. Questions such as: does higher education increase productivity, is it important and in what ways it is important, are some of the issues that do not have a clear and accurate answers and have not been previously evaluated for Albania. This paper is organized as follows. Next section lays down the main research hypothesis to be explored in this research work. Methodology is explained in details in Section three. Section four brings the results of the empirical analysis. Section five concludes.

Research Hypothesis

The purpose of this research work is to examine the dynamic relationship between human capital and technological change in Albania. To achieve this goal we have formulated two hypotheses. These hypotheses reveal the relationship between gross enrollment rates in higher education and TFP in Albania. Based on our current knowledge, there is no genuine study in the literature that has examined the dynamic relationship between gross enrollment rates in higher education and TFP in Albania. According to the empirical framework and based on implications of endogenous growth theory, Granger's causality relationship may exist between human capital and technological change and the causality-effect can be derived either from human capital to technological change or from technological changes to human capital. From the theoretical point of view there is no consensus about the relationship between human capital and technological changes. Therefore, the underlying hypotheses that we are going to test in this study are:
H_1: *There is a significant long-run relationship between the gross enrolment rates in higher education and TFP in Albania.*
H_2: *There is an important causality relationship between the gross enrolment rates in higher education and TFP in Albania.*

Methodology

1.1 Theoretical model

The models of the ***endogenous growth theory*** are important since they consider human capital accumulation as the main input in the creation of new ideas. Besides, it provides reasonable justification for taking education as a fundamental determinant of economic growth. To build our model, this paper relies on the endogenous growth theory as a function of accumulation of physical and human capital. Considering human capital as an independent production factor, the production function is assumed to be Cobb-Douglas one, which takes the form of:

(1) $$Y = AK^{\alpha}H^{\beta}L^{(1-\alpha-\beta)}$$

Where Y is total output, K is physical capital, H is human capital, L is labour or employment,
and A is total factor productivity. By dividing both sides of equation (1) by L and after some
mathematical computations we will have:

(2) $$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha}\left(\frac{H}{L}\right)^{\beta}$$ or

(3) $$y = Ak^{\alpha}h^{\beta}$$

Where $\frac{Y}{L}$, output per worker or economy wide labour productivity; $\frac{K}{L}$ is capital per worker;
$\frac{H}{L}$ is average human capital. Finally, by taking the natural logarithm of equation (3) above yields the structural form of the production function as:

(4) $$ln(y) = ln(A) + \alpha\, ln(k) + \beta ln(h)$$

From this we count $ln(A)$ or TFP per worker as a residual part of the equation (4) above:

(5) $$ln(A) = ln(y) - \alpha\, ln(k) - \beta ln(h)$$

Another assumption is made to evaluate TFP through the elasticity of production related to physical capital and labor is respectively $\alpha = 0.3$ dhe $\beta = 0.7$[1]. Below we give a full description of the data and variables we have used in our econometric model.

1.2 Data sources and Variables' measures

To test the hypotheses laid above, we have used secondary data of official institutions which are competent for issuing these informations. These are time series macroeconomic data for Albania. All the time series data are transformed into logarithmic form in order to have better estimates (Kruschke, 2010). For measuring human capital, we rely on the standard explanation that Kwon (2009) gives to human capital measurements. According to him, human capital can be measured through the output, costs or income approach. In this paper, we have measured human capital based on the output method, firstly because of the availability of these data in our country, and secondly to make comparisons on the findings. We choose as a proxy for human capital in Albania, *the gross enrolment rates in higher education*. This indicator is derived from the database of World Development Indicators (WDI)[2] of the World Bank. The data was collected for a time period of 32 years, from year 1983 to 2014We employ the newest version of the so-called Penn World Table, version 9.0 developed by the joint efforts of Robert Feenstra from the University of California at Davis, and Robert Inklaar and Marcel Timmer from the Groningen Growth and Development Centre at the University of Groningen (see Feenstra et al. 2013)[3]. In the database of the Penn World Table (PWT 9), we noticed that the authors have calculated the *TFP* variable for all other countries but this variable is missing for Albania. Since PWT 9 contains data on production, capital stock, labor and human capital for a group of 70 countries during the period 1970s to 2014, we used these data to calculate the TFP variable in Albania for the period form 1970s to 2014.

cgdpo – Real GDP calculated by production method - report the Gross Domestic Product (GDP) based on PPPs in millions of US dollars. This indicator allows comparison of production capacity between countries and over time.

emp - Number of Employees - Based on the Penn World Table (PWT) in which all persons aged 15 years and over , who during the reference week performed a job, even for one hour per week or were not in work but had a job or business from which they were temporarily absent are included.

ck – Reports the levels of physical capital in terms of price at that time (eg, current

---

[1] The similar assumption was made by Loukianova and Unigovskaja (2004), in their empirical work related to recent growth in low income and CIS countries.

[2] World Development Indicators. https://data.worldbank.org/data-catalog/world-development-indicators

[3] The data are accessible from www.ggdc.net/pwt.

prices). Capital stock is estimated based on accumulation and depreciation of past investments using the permanent inventory method (PIM).

hc – Provides an index of human capital per person, which is related to the average years of schooling and returns to education. In PWT 8, an index of human capital was estimated using data on the average years of education by Barro and Lee (2013) and rates of return to education by Psacharopoulos (1994).

Yt_worker - in order to obtain real GDP per workers, we have divided real GDP calculated with the current PPP, by the number of engaged persons (in millions).

K_worker - to obtain the stock of physical capital per worker, we have divided the stock of physical capital, by the number of engaged persons (in millions).

tert_enrol_ratio - Gross enrollment rate in higher education.

ln_AD1 - is the first difference of the time series ln_A_t ($ln\_A_t - ln\_A_{t-1}$).

lntert_enrol_D1 - is the first difference of the time series lntert_enrol_ratio ($lntert\_enrol\_ratio_t - lntert\_enrol\_ratio_{t-1}$).

1.3 Regression Equations

The study relies on the observation of the above variables over a long period of time, which requires the use of time series techniques. This study uses only two variables for Albania. Initially, we regress the TFP on gross enrollment rates in higher education in order to determine the causality and the relationship between these two variables. Regression is explained in the following equation:

$$\textbf{(6)} \qquad ln\_A_{t-1} = \quad + \quad lntert\_enrol\_ratio_{t-1} + \quad _{t-1}$$

where, **ln_A** is the logarithm of TFP; **lntert_enrol_ratio** is the logarithm of gross enrollment rates in higer education; is the constate; β_1 is the coeficient of indipendet variable and e_{t-1} is the standart error of indipendet variable.

Through simple regression analysis we can measure the degree of linear relationship of one variable depending on other variables, but we cannot get information about their causality. If we want to determine if human capital causes TFP; or if TFP causes human capital, we must consider this relationship under the concept of Granger's causality. According to the Granger concept (1969), the causality from human capital to TFP means that by using the past values of human capital along with the past values in TFP this will lead to better predictions of TFP, compared to the use of only the remaining values of the TFP.

1.4 The Granger Causality Test under Vector Error Correction Model (VECM)

Engle and Granger (1987) argue that if the variables are integrated and the Granger test is specified then we can get a false causality among the variables. To overcome this weakness of Granger's test, Engle and Granger proposed a method by incorporating the error term into the equations (7) and (8), which capture long-term and short-term relationships between variables when they are integrated in level. In our case, if two variables (ln_TFP_t) and (ln_Hum_t) are integrated in the first order or ~ (1) then the VECM model would be written:

(7) $$\Delta ln\_Hum_t = \delta_i + \sum_{i=1}^{p} \alpha_i \Delta ln\_Hum_{t-1} + \sum_{i=1}^{p} \beta_i \Delta ln\_TFP_{t-1} + \gamma_1 \hat{\varepsilon}_{1t-1} + \;_1$$

(8) $$\Delta ln\_TFP_t = \lambda_i + \sum_{i=1}^{p} d_i \Delta ln\_Hum_{t-1} + \sum_{i=1}^{p} c_i \Delta ln\_TFP_{t-1} + \gamma_2 \hat{\varepsilon}_{2t-1} + \;_2$$

where ($\hat{\varepsilon}_{1t-1}$ $\hat{\varepsilon}_{2t-1}$), refer to error correction terms obtained from the first long-run model, which can be explained as the deviation of (ln_Hum_t) and (ln_TFP_t) from their long-term equilibrium values.

When the equations include error correction terms, short-term dynamics are needed to achieve long-term equilibrium and to provide us with an opportunity to detect Granger's causality (Granger, 1988). ( ) captures the negative causal relationships between variables in the long run and is likely to be in absolute value less than one. When the value of ( ) is less than five percent, (γ) is not statistically significant. In this case, the system of equations suggests that in the context of forecast, the variables of the system are independent. On the other hand, when ($_1$) is statistically important, but ($_2$) is not, the equation system suggests a single causality in one direction from (ln_TFP_t) to (ln_Hum_t) meaning that (ln_TFP_t) directs (ln_Hum_t) towards long-term equilibrium, but not vice versa. However, the opposite will occur when ($_2$) is important and ($_1$) is not important. This is logical, because if both coefficients ($_1$, $_2$) are important, then there is a bivariate relationship of Granger's causality. (β_i) measures the short-term impact of changes in (ln_Hum_t) as a result of changes in (ln_TFP_t). ($_i$) measures the short-term effect of changes in (ln_TFP_t) as a result of changes in (ln_Hum_t) while ( ) refers to the standard error term. All models discussed above will be used in our study if the variables involved are stationary in the first difference, which means that the time series on gross enrollment rates in higher education and TFP series are integrated in the first order ~ (1).

2. Empirical results

To achieve the overall goal, the first objective is to discover the existence of short-term and long-term relationships between the proxy of human capital and technological change. The second objective is to determine the direction of causality between them and this is achieved through Granger's causality method. In essence, we have followed a four-step procedure to prove the causality. Firstly, the nature of time series has been examined by using unit root tests. Secondly, a co-integrating test on non-stationary variables was carried out to determine whether we have short-term or long-term relationships between variables in the study. Thirdly, depending on the relationship between them, we estimate the VAR or VECM model. Finally, we apply the Granger Causality Test under each model.

2.1 Unit root testing procedure

The unit root test results often depend critically on the number of lagged differences contained in the regression equation. The reason for adding lags is to make sure that the mistakes are uncorrelated. To address this problem, we used the Akaike (1973) (AIC), (LR), (FPE), (SIC) and (HQ) information criteria to determine the appropriate lag length of the variables in the study. All these are reported by the "varsoc" command in Stata. After we have specified the proper lag length, we have tested the stationarity of all variables at levels using Augmented Dickey-Fuller (ADF) Tests, Phillip-Perron Tests, and KPSS Tests. After performing the tests, if the statistical value of the test, in absolute value, is greater than the critical value (the critical value of 5%) then the null hypothesis H_0 is rejected and we accept that the variables are stationary. All tests were developed at the 5% significance level. The Table 1 below shows the test results for all the variables in levels. All the performed unit tests ***failed to reject*** the null hypothesis for gross enrollment rates in higher education and TFP, which implies for the existence of a unit root in their levels.

Table 1: Results of unit root tests of variables at levels

Unit Root Tests					
Variables	**Augmented Dickey Fuller (ADF)**			**Phillips Perron (PP)**	**Newey-West Bandwidth (KPSS)**
	With constant and trend	With constant but without trend	Without constant and trend	With constant and trend	With trend
ln_AD1	-1.847	-0.795	0.75	-1.896	t > 0.146
lntert_enrol_ratioD1	-1.367	1.353	6.35	-1.093	t > 0.146

Source: Authors' calculations

The test results in Table 1 reveal that all variables are non-stationary in levels. To determine the order of integration of variables, we created the new variables based on their first differences as follows:

ln_AD1 = $ln\_A_t - ln\_A_{t-1}$

lntert_enrol_D1 = $lntert\_enrol\_ratio_t - lntert\_enrol\_ratio_{t-1}$

Table 2: Results of unit root tests of variables at first difference

Unit Root Tests					
Variables	**Augmented Dickey Fuller (ADF)**			**Phillips Perron (PP)**	**Newey-West Band width (KPSS)**
	With constant and trend	**With constant but without trend**	**Without constant and trend**	**With constant and trend**	**With trend**
ln_AD1	-6.72	-6.587	-6.574	-6.72	t < 0.146
lntert_enrol_ratioD1	-4.944	-4.462	-2.75	-4.944	t < 0.146

Source: Author's calculations

The results show that ADF, PP and KPSS tests ***reject*** the null hypothesis H_0 of the unit root on the first difference of the variables, meaning that these variables are integrated in the first order, I (1). This finding implies that there may be one or more interaction vectors between these variables, so the next step in our analysis is to identify the existence of short or long- run relationships between them.

2.2 The co-integrated test results

To test the existence of a co-integrating relationship between human capital and technological change, we used the two-step of Engle and Granger's (1987) cointegration test. The results of this test are given in Tables 3 and 4 below:

Table 3: OLS model of TFP and gross enrollment rates in higer education

```
. reg ln_A lntert_enrol_ratio
```

Source	SS	df	MS
Model	.578958758	1	.578958758
Residual	.182466981	30	.006082233
Total	.761425739	31	.024562121

Number of obs =	32
F(1, 30) =	95.19
Prob > F =	0.0000
R-squared =	0.7604
Adj R-squared =	0.7524
Root MSE =	.07799

ln_A	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lntert_enrol_ratio	.1895614	.0194293	9.76	0.000	.1498814	.2292413
_cons	5.300187	.0555462	95.42	0.000	5.186746	5.413627

Table 4: ADF test on residual of the OLS regression (ln_A and lntert_enrol_ratio)

```
. dfuller uhat1,nocons
```

Dickey-Fuller test for unit root   Number of obs = 31

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.483	-2.650	-1.950	-1.602

Summing up the results of the Tables above we observe that: under the Engle and Granger (1987) method, the value of the z (t) test in absolute value is (3,483), which is greater than the critical value of 5% (1,950), so we reject the null hypothesis H_0 of a unit root, and conclude that there is a long-run relationship between them which indicates that the variables are co-integrated. This means that both variables move together in the long run.

2.3 Vector Error Correction Model (VECM)

Based on this result we have applied the standard model of Granger's causality under the Vector Error Correction Model (VECM) to determine the causality of this relationship. Through this test we will show that if changes in gross enrollment rates in higher education can cause changes in TFP, or whether TFP changes can cause changes in gross enrollment rates in higher education or if exist a dual causality in the short and long run.

To apply the VECM model, firstly, we ensured that we have correctly determined the right length of the lag based on information criteria tests. From the results of Table 5, the FPE and AIC criteria reach their minimum value for lag (p = 2).

Table 5: The lag length in the VECM model

Selection-order criteria
Sample: 1987 - 2014 Number of obs = 28

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	4.70309				.002826	-.193078	-.163987	-.097921
1	72.0855	134.76*	4	0.000	.000031	-4.72039	-4.63312*	-4.43492*
2	76.2105	8.2499	4	0.083	.000031*	-4.72932*	-4.58387	-4.25353
3	78.1899	3.9589	4	0.412	.000036	-4.58499	-4.38136	-3.91889
4	80.7204	5.0609	4	0.281	.000041	-4.48003	-4.21821	-3.62361

Endogenous: ln_A lntert_enrol_ratio
Exogenous: _cons

Secondly, we only use a co-integration equation of the results of the above-performed integration tests, with a 5% significance level. Thirdly, we use the time series data in their level instead of their first difference, because the STATA program, to estimate VECM, makes the changes by itself by turning the time series in their first differences. The first part of the VECM model is shown in the following Table 6. From Table 7 we can write the long-term co-integration equation between the gross enrollment rates in higher education and TFP as:

Co-integration equation = ln_A – 0.2338 lntert_enrol_ratio

where: ln_A measures TFP and lntert_enrol_ratio is the the proxy for human capital. This means that in the long run equilibrium (when the co-integration equations are equal to 0) we will have: **ln_A = 0.2338 lntert_enrol_ratio**

From the integration equation we note that there is an important long-run relationship between gross enrollment rates in higher education and TFP. This means that gross enrollment rates in higher education affect positively TFP rates, thus by increasing with 1% the gross enrollment rates in higher education this will lead to an increase of TFP growth rates by 0.23%.

So, we accept the first research hypothesis that: raising TFP rates depends significantly and positively on increasing gross enrollment rates in higher education. But what will happen to our variables if the equilibrium in the long run is not achieved? From the VECM autopu we find that there is an error term in the co-integration equation that is statistically significant and has negative values. This tells us that: the co-integrating equation is not equal to 0, but is less than 0; so we will have: **ln_A – 0.2338 lntert_enrol_ratio < 0**

Table 6: VECM Model

Vector error-correction model

Sample:	1985 - 2014	No. of obs	= 30
		AIC	= -4.763636
Log likelihood =	80.45454	HQIC	= -4.629159
Det(Sigma_ml) =	.0000161	SBIC	= -4.343277

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_ln_A	4	.061852	0.4397	20.40778	0.0004
D_lntert_enrol~o	4	.074801	0.5469	31.385	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_ln_A						
_ce1 L1.	-.716019	.1644081	-4.36	0.000	-1.038253	-.3937851
ln_A LD.	.2273774	.1604151	1.42	0.156	-.0870305	.5417852
lntert_enrol_ratio LD.	-.3023324	.1723347	-1.75	0.079	-.6401022	.0354373
_cons	-.0000777	.0175783	-0.00	0.996	-.0345305	.0343752
D_lntert_enrol_ratio						
_ce1 L1.	-.0008554	.1988295	-0.00	0.997	-.3905541	.3888432
ln_A LD.	-.1155191	.1940006	-0.60	0.552	-.4957532	.264715
lntert_enrol_ratio LD.	.1470455	.2084157	0.71	0.480	-.2614417	.5555327
_cons	.0650291	.0212586	3.06	0.002	.023363	.1066952

Table 7: The equations of co-integration in the long-run

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	1	72.98848	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_ce1						
ln_A	1	.	.	.	.	.
lntert_enrol_ratio	-.2337984	.0273662	-8.54	0.000	-.2874352	-.1801617
_cons	-5.220881	.	.	.	.	.

To interpret the state of disequilibrium, we consider the error correction values (ce1) in Table 6. From this table we can rewrite the integration equation which also contains the long- and short - run components such as:

Δln_A = –5.220 – 0.3023 Δlntert_enrol_ratio – 0.716 ce1

We can see that error correction for **ln_A** is statistically significant at 1% and it is -0.716, this means that TFP per worker is an endogenous variable. This also shows that the dynamic model is stable because the deviations from long-run equilibrium are adjusted by increasing TFP per worker. It represents the negative annual adjustment of **ln_A**$_t$, which will be 0.716% from its co-integrative value **ln_A**$_{t-1}$. Also, for the second equation, where **lntert_enrol_ratio** is a dependent variable, the error correction is **ce2** = 0.0008 but is not statistically significant. So if we believe that long-term relationships will break down for different reasons, we will see that TFP will react to the mistakes by adjusting itself and by trying to maintain a *steady state*. In order to discuss on what happens in the short-term perspective, we will focus on the values of the first differences of the variables in the columns in Table 6.

We can say that D_ln A is significantly dependent on the growth rate of the previous period's **lntert_enrol_ratio**. The coefficient of **lntert_enrol_ratio** is 0.3023 and is statistically significant, indicating that exist a short-run causality which derive from gross enrollment rates in higher education to TFP. Whereas, with regard to the second equation where **lntert_enrol_ratio** appears as a dependent variable, it is noticed that the model is not statistically significant and it does not depend on its own lags or TFP values either. All the coefficients before the variables are all insignificant and we can say that: TFP does not cause changes to high education enrollment rates.

2.4 Diagnostics check

After evaluating the VECM model, the next step is to determine whether the selected model produce efficient estimates from the data and whether the model is well-specified. Various post estimation tests are conducted to check for the problems of misspecification and stability.

- ✓ **Stability test**

The general rule in this test is that there would be a sustainability problem if some of the remaining calculated modules are very close to one. Eigen values appear in the Table 8 below. Only one of the Eigen values is one, while the other calculated modules are not close to one.

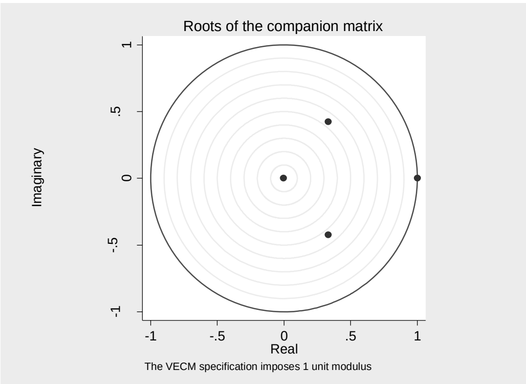
Table 8: Stability test of the VECM

Eigenvalue stability condition

Eigenvalue	Modulus
1	1
.3318699 + .4243132*i*	.538683
.3318699 - .4243132*i*	.538683
-.00513599	.005136

The VECM specification imposes a unit modulus.

Figure 1: Roots of the companion matrix of the VECM



The results show that: there is a real root about 0.33. Although there is no distribution theory to measure how close this root is close to one, but based on other literature discussions about this issue (for example, Johansen (1995, p. 137-138)), we conclude that the root 0.33 supports our previous analysis, in which the predicted co-integration equation is probably stationary. Below, diagnostic checks will be carried out on auto-correlation of residuals, heteroskedasticity and normality.

- ✓ **LM test of autocorrelation**

After evaluating the VECM model we test whether the residuals of this model are a "white noise" or not. If autocorrelation is observed between the residues then it is implied that some information is left out of the model, such as insufficient lags. The Lagrange-Multiplier (LM) test detects the serial correlation of the residues up to the specified order of a lag, which should be the same as that of the corresponding VAR. The results of the Lagrange-Multiplier test are presented in Table 9. We see that the null hypothesis that there is no autocorrelation in the residuals for any of the orders tested cannot be rejected.

Table 9: LM test of the VECM

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	1.7357	4	0.78422
2	1.4081	4	0.84278

H0: no autocorrelation at lag order

- ✓ **Testing for normality of residuals**

To test if the residual of the model have normal distribution we have used the statistics of Jarque-Bera. Jarque-Bera's statistical testing as explained by Mantalos (2010) indicates whether the residues have normal distribution or not. However, the lack of normality of residuals does not cause the co-integration tests and VECM to be invalid. The test results are presented in the Table 10 below.

Table 10: Tests for normality, skewness, and kurtosis of the residuals in the VECM

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_ln_A	4.008	2	0.13477
D_lntert_enrol_ratio	8.540	2	0.01398
ALL	12.548	4	0.01371

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
D_ln_A	-.19863	0.197	1	0.65693
D_lntert_enrol_ratio	1.0898	5.938	1	0.01482
ALL		6.135	2	0.04653

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
D_ln_A	4.7461	3.811	1	0.05091
D_lntert_enrol_ratio	4.4428	2.602	1	0.10673
ALL		6.413	2	0.04050

The single equation and overall Jarque-Bera statistics do not reject the normality value at 5% significance level. The skewness results for ln_AD1 do not suggest non-normality. Kurtosis test statistics, which test the null hypothesis H_0 that the terms of disturbance have kurtosis consistent with normality, do not reject the null hypothesis H_0.

Conclusions

The purpose of this research was to examine the dynamic relationships between human capital and technological change in Albania. According to the empirical framework and based on implications of endogenous growth theory, Granger's causality relationship may exist between human capital and technological change and the causality-effect can be derived either from human capital to technological change or from technological changes to human capital. From the theoretical point of view there is no consensus about the relationship between human capital and the technological changes. To evaluate whether there has been any causality relationship between human capital and technological changes in Albania, we have used gross enrollment rates in higher education as a proxy for human capital and TFP as a proxy for technological change. Our analysis was based on the use of time series techniques. The Engle and Granger (1987) co-integration test results indicate that *there is a significant long-run relationship between the gross enrolment rates in higher education and TFP in Albania.* If the long run equilibrium will break down the TFP will react to the mistakes by adjusting itself and by trying to maintain a steady state. Also the results of VECM model shows that *an important causality relationship exists derive from gross enrolment rates in higher education to TFP.* A rise in gross enrollment rate in higher education would boost the technological development; therefore, more resources should be put to the education sector, even in the public or private sector.

References

Akaike, H. (1973). "Information theory and an extension of the maximum likelihood principle", in 2nd International Symposium on Information Theory, Petrov, B.N. and Csaki, F. (eds), Akademiai Kiado, 267-281.
Barro, Robert J. and Jong-Wha Lee (2013), "A new data set of educational attainment in the world, 1950-2010" Journal of Development Economics 104: 184–198.
Benavot, A. (1989). "Education, gender and economic development: A cross-national study", Sociology of Education, 62, January, 14-32.
Bosworth, B. and S.M. Collins (2003). "The Empirics of Growth: An Update," Brookings Papers on Economic Activity. 2: 103-206.
Bulman, David, Maya Eden, and Ha Nguyen. 2014. "Transitioning from Low-Income Growth to High- Income Growth–Is There a Middle Income Trap?" World Bank Policy Research Working Paper No. 7104.
Easterly, W., & Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models. The World Bank Economic Review, 15(2), 177-219.
Engle, R., & Granger, C. (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica: Journal of the Econometric Society, 251-276.

Feenstra, Robert C., Hong Ma, J. Peter Neary and D.S. Prasada Rao (2013), "Who Shrunk China? Puzzles in the Measurement of Real GDP" Economic Journal 123(573): 1100– 1129.
Fullani, A. (2012). "Growth in Albania and South East Europe: The way ahead", South East European Studies at Oxford (SEESOX).
Granger, C. (1969). Investigating causal relations by econometric models and cross-spectral methods. Econometrica: Journal of the Econometric Society, 424-438.
Granger C. W. J. (1988). Journal of Econometrics 39: 199-211.
Jitsuchon, S. (2012). Thailand in a middle income trap. TDRI Quarterly Review, 27(2): 13–2.
Johansen, S. (1995), Likelihood-based Inference in Co-integrated Vector Autoregressive Models, Oxford, Oxford University Press.
Khan, A. H. (1998). The Experience of Trade Liberalization in Pakistan.Pak. Dev. Rev., 37(4): 661-685.
Kota, V., (2009), "Alternative methods of estimating potential output in Albania", Bank of Albania, Working Paper Series 2009;
Kruschke, J. (2010). Doing Bayesian Data Analysis: A Tutorial Introduction With R and Bugs: Elsevier Science & Technology.
Kwon, D.B. (2009). Human capital and its measurement. The 3rd OECD World Forum on "Statistics, Knowledge and Policy" Charting Progress, Building Visions, Improving Life Busan, Korea - 27-30 October 2009, from http://www.oecdworldforum2009.org/.
Loukoianova, E. & Unigovskaya, A. (2004). "Analysis of Recent Growth in Low –Income CIS Countries," IMF Working Paper Series, No 152.
Mantalos, P. (2010)."The three different measures of the sample skewness and kurtosis and the effects to the Jarque-Bera test for normality." Discussion paper, Jönköping International Business School.
Oladoyin, D. (2010). "The Role of Human Capital in Economic Development: An Empirical Study of the Nigerian Case," Oxford Business and Economics Conference Program, 2010.
Psacharopoulos, G. (1994). "Returns to investment in education: A global update", World Development, 22, 1325-1343.
Tran, V. T. (2013). "The Middle-Income Trap: Issues for Members of the Association of Southeast Asian Nation." ADBI Working Paper No. 421.
World Development Indicators. https://data.worldbank.org/data-catalog/world-development-indicators, date accessed 30 April 2018