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HUMAN CAPITAL AND ECONOMIC GROWTH IN ROMANIA: A VECTOR ERROR CORRECTION MODEL (VECM)

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Abstract

This paper aims to evaluate the human capital on economic growth impact in Romania. Variables have been selected according to an endogenous growth model basing on including the human capital in the Cobb-Douglas production function (Lucas, 1988). As all over usual, here gross domestic product (GDP) will be the endogenous of gross fixed capital formation (GFCF, as physical capital stock), employment (as labour), life expectancy and secondary enrolment rate(as proxies for human capital). We also use expenditure in research and development (R&D) sector (as its percentage in GDP), as control variable. Once our model developed, variables are found as integrated of order one (1) and co-integrated, here allowing a vector error correction model (VECM) for estimation. This will be a system of six equations covering a 25 years (1995-2019) interval for Romania. A long-term relation comes out of our empirical findings, as similarly to Wang (2016), so the GDP growth sees itself determined by: secondary school enrolment, life expectancy(i.e. for human capital), R&D expenditure and labour. Short run causalities have not been found significant for this model

Keywords: human capital; economic growth; Cobb-Douglas production function; vector error correction model (VECM)

1. Introduction

The human capital on economic growth impact in Romania during the 1995-2019 year interval will be searched for in this paper using vector error correction model (VECM) in the *time series* network. Of course, this is for detecting what human capital means for development, at least in the Romania's case. But the real challenge was here the country's human capital's proper evaluation according to theory and available data (WDI). On short, this is about (just) two evaluating parameters as such, i.e. the population's education and healthcare levels.

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But then it isn't to be omitted that Romania didn't too much spend /allow on these two sectors from its GDP in the latest years. Plus, actually such presumable investments even are not here found to have a (good) impact on the short term, but possibly just on the long one. Or such impact evaluation at least might be associated to future decisions on rising investment spending on education and healthcare. And this is our very issue and challenge to be here answered by a short statistical analysis on these two sectors as well as by an empirical study.

Variables here chosen were ordered on the Cobb-Douglas function shape developed the Romer's (1990) & Lucas' (1988) way through the human capital's and R&D's dragging in as equally significant as the classical labour and capital variables. To be equally added that such a way of human capital considering for economic growth dates from the early sixties, when other scholars like Schultz (1961) & Denison (1962) had the first line of empirical results on the same type of modelling on economic growth with just physical capital and labour inputs and so they couldn't fully explain the growth of output. Then, Mankiw & Phelps & Romer (1995), and Lucas (1998) had similar studies either on individual countries, or on panel data cross sections.

Then, Romer & Weil (1992) develop a Solow growth type model (Solow, 1956) with human capital measured by investment in the secondary school enrolled labour, in which investment in education appears decisive at least for the capital income growth. Similarly for Barro (1991), that also uses school enrolment rates as human capital in a study on a number of 98 countries and concludes for a very positively related GDP to initial human capital proxy of 1960 this way assessed. Nevertheless, there are also studies concluding for rather negative and even significant as such relationships of human capital with investment in education, i.e. Banhabib & Spiegel (1992, p.25) that here attach a negative coefficient of years of schooling. Zaman et al. (2017, p.1) study health expenditure associated with both GDP and life expectancy in developing countries like Bangladesh. Other studies see only GDP related to the health expenditure, not the same for life expectancy.

Another example might be the one of Wößmann (20030), that sees human capital as poorly *proxied* when measured alternatively by adult literacy rates, school enrolment ratios, and average years of schooling of the working-age population. Or, inappropriate measures for human capital might lead at least to severe underestimation of its effects to economic development, argues the author.

2. Literature review. Neoclassic and endogenous growth theories

Mensah (2019) finds the neoclassical Solow model shaped by the Cobb-Douglas production function as appropriate for all relationships of the economic growth with physical capital, labour and human capital. See:

$$Y_t = A_t K^{\alpha}_t L^{\beta}_t \tag{1}$$

where Y_t denotes the aggregate production of the economy (i.e.real per capita GDP) at time t, A_t is the technical change and K_t represents capital stock which has been specified as the physical capital stock, L_t is the labour force and α and β measure the *elasticities* of output with respect to labour and physical capital stocks. Schultz(1961) & Denison (1962, pp. 124-128) argue that such a model indicates that there might be about something more than physical capital and labour since effective output comes higher than previously revealed by the Cobb-Douglas calculation formula. Or, the human capital here comes as both available and major explanation as in the view of Tallman (1994).

As from the *endogenous growth theory*, in its turn, Romer (1990) and Lucas (1988) state that growth is influenced not only by labour and capital – e.g. research and development and its spillovers obviously determine the economic growth (see also Sulaiman at al. 2015, p.1). It is this way that the model used in this study of ours could become an extended version of Solow's(1956) *neoclassical growth model,* where human capital joins the physical capital and labour, as production factor (see also Mankiw & Phelps & Romer 1995):

$$Y= f (K, L, H, R) \quad (2)$$

where H is human capital and R is research and development(R&D) expenditure added to equation (1). To which Lucas (1988) adds that knowledge and learning make human capital accumulation continuous and through it both labour and physical capital productivities are having direct impacts on GDP.

For Harbison & Myers (1964) pretty all levels of formal education -- i.e. initial, primary and post-primary, secondary and post-secondary -- matter as human capital appreciation methodology. Barro (1991) and Grossman (1972, pp. 223) consider that human capital has its proper representation in education, health, migration and other investment objectives this way contributing to the increase in productivity of individuals. Becker (1994, p.17) finds in the whole range of investments in human capital the top ones in education and training. In a word, there is to be found a whole literature considering health and education the top contributors to economic growth. Their approach will be followed in our study by representation of human capital, through education, healthcare and life expectancy (see below).

2.1 Education - as a representation of human capital

Barro (1991) strengthens the idea of economic growth determined by human capital and other variables in a study made on 98 countries and using a cross-country regression model [2]. This study uses *enrolment ratios*[3] as proxy for human capital, the same as Mankiw et al. (1992.

[2] Actually, he uses as proxy of human capital the primary school enrolment ratio.
[3] i.e. number of students enrolled at a grade level over total population of their age group.

Abas(2000), in the same determination context, uses the enrolment ratios for primary and secondary schools as proxies for the country cases of India and Pakistan and so obtains positive and significant effects on economic growth. Khan(2005) makes a cross country analysis and concludes that accumulation of physical capital, improvements of the quality of institutions, a better education and healthcare have significant impacts on growth. In the country case of Nigeria (Sulaiman at al., 2015, p. 7) human capital, as secondary and tertiary school enrolments, is also found as positively and significantly impacting on economic growth. Pretty the same for Haffez et al.(2019) using an ARDL model applied for Pakistan, again, using as proxies for human capital the public spending on education as percentage in GDP and also primary, secondary and tertiary education enrolment rates, together with physical capital's and labour force's participation to GDP. The same analysis for Malaysia was a VECM developed by Khan et al. (2016).

In context, the trend of per capita GDP may capture the one of the overall economy (Miladinov, 2020, p. 6). Following Romer(1990), Barro(1993) and Mankiw et al.(1992) the secondary school enrolment will be employed as a measure of education, as human capital.

2.2 Health, as a component of human capital,

It was proxied in the literature through *life expectancy at birth* for a country population and/or through health public expenditure. According to Girosi & King (2007) all countries seek to increase the health of their population, if not at the same rates anyway with the same purpose to reduce mortality and increase health .

Life expectancy at birth (LEB) reflects the population longevity level and a also a pattern of mortality across all age groups(World Health Organization, 2014). LEB is also used as measuring indicator for population health and longevity (Rabbi, 2013). It is also often used as indicator of population health (Sharma, 2018, Miladinov 2020). As measure of mortality According to Miladinov (2020, p.8), LEB is an valuable indicator of population's health . Moreover, LEB means an expectation of longevity, expected years for a person to survive" (Zaman et al. 2017, p.8).

3. Methodology

As in the above order, the human capital's influence on economic growth will be found and measured in our approach for the Romanian case through the Cobb-Douglas production function using the neoclassic growth and endogenous growth theories. Actually, the secondary enrolment rate and life expectancy at birth, as a double representation through education and health of human capital, have been chosen for our reference model. It is here assumed that the higher level of productivity is done by healthy and educated people through better absorbing new technology as well.

Thus it is considered that our model variables have so far reached that strong theoretical basis to develop onwards. Economic growth in our model is a function of five variables:

real gross domestic product(Y), physical capital (K), labour(L), human capita(H) and research and development(R&D)[4].

The endogenous variable:

(1)*growth,* as GDP per capita, PPP (constant 2017 international thousand $)

and exogenous :

(2)*physical capital* proxy through Gross fixed capital formation(GFCF), as percentage of GDP;

(3)*employment* to population ratio;

(4) life expectancy at birth, total (years), as a proxy for population's *health;*

(5) school enrolment, secondary (% age group), as a proxy for *education;*

(6) research and development expenditure (R&D as % of GDP), a *control variable* included in the model as by Romer (1990). Natural logarithms here apply for transforming variables in order to avoid *heteroskedasticity* (see Gujarati 1995, 387).

A vector error correction model (VECM) is here shaped following the basic steps required to estimating such a model: (a)series must be stationary (integrated of same order); (b) the optimal model lag length must be determined; (c)the Johansen co-integration test must be performed; (d) if there is no co-integration, do estimate the unrestricted VAR model; (e)but if there is co-integration, then specify the restricted VAR model.

This model is intended to examine whether there is a long and/or a short run relationship of human capital with economic growth in Romania, as in Bane (2018). From equation (2), an explicit estimable function is specified as follows:

$$\text{Log } Y_t = a_t + \alpha \log K_t + \beta \log L_t + \gamma \log H_t + w \log R_t + \varepsilon \quad (3)$$

where Y_t denotes the aggregate production of the economy (real per capita GDP) at time t, a_t is a constant, K_t is physical capital stock, L_t is labour, H_t is human capital, R_t is R&D expenditure, t is time expressed in years, log is natural logarithm and ε is error term, all these as for Mensah (2019).

4. Findings: model estimating

4.1 Descriptive statistics of variables

Normal distribution, outliers in data, central tendency (i.e. mean, median, maximum, minimum), dispersion (standard deviation), skewness (i.e. degree of symmetry) and kurtosis (i.e. degree of sharpness) come out of descriptive statistics developed

[4] Data were collected as variables from World Development Indicators (WDI) online database, World Bank for a period of 25 years, during the 1995-2019 years interval, for Romania.

previously to the regression analysis. Normality of assumptions determines results of tests on intervals. In context, skewness and kurtosis show, in their turn, that data are not normal and here Jarque-Bera statistic measures the difference of the skewness and kurtosis of the series with those from the normal distributions. Our data sample regards the 1995-2019 period for Romania, data that were *linearised* by natural logarithms.

Table 1 Descriptive statistic of variables

	L_GDP	L_GFCF	L_EMPLOYMENT	L_LIFE	L_RESEARCH	L_SECONDARY
Mean	2.888445	3.168172	3.987009	4.284594	-0.765159	4.458866
Median	2.987196	3.133318	3.938665	4.284552	-0.733969	4.469350
Max.	3.396855	3.618725	4.133084	4.323603	-0.400478	4.587617
Min.	2.468100	2.893146	3.913422	4.234107	-0.994252	4.306090
SD	0.307899	0.168897	0.081746	0.029801	0.165778	0.090097
Skw	-0.048238	0.984153	0.923844	-0.165565	0.497921	-0.089253
Kurt.	1.643989	4.207808	2.048590	1.736577	2.626382	1.677497
Jarque-Bera	1.925077	5.555235	4.499092	1.776963	1.178431	1.855081
Probability	0.381922	0.062186	0.105447	0.411280	0.554762	0.395525
Sum	72.21112	79.20429	99.67524	107.1149	-19.12898	111.4717
Sum Sq. Dev.	2.275239	0.684633	0.160376	0.021314	0.659579	0.194819
Obs.	25	25	25	25	25	25

Source : Author's calculations in Eviews,2021

4.2 Stationarity and co-integration

The second step in the above order is investigating the *stationarity* and *co-integration*, applying specific tests assigned to data series. Dickey-Fuller unit root test (Aug. DF test) was applied on each time series data and *Schwartz Info*-criterion was here applied for lag length of the series. This test has null hypothesis and alternative hypothesis:

(a). H_0: The individual series has a unit root (b). H_1: series are stationary for a significance level $\alpha = 0.05$ (or 5%)

Table 2 Unit root Aug. DF test

Variables	Level data t-stat.	Prob.	First diff. t-stat.	Prob.
(1)	(2)	(3)	(4)	(5)
GDP per capita	0.52	0.98	-3.03	0.04
GFCF as % GDP	-1.78	0.37	-4.38	0.002
Employment rate(%)	-1.79	0.37	-3.72	0.01
Life Expectancy - Year	-0.69	0.82	-5.47	0.0002
Secondary enrolment rate(%)	-1.83	0.35	-1.95	0.03
R&D % GDP	-2.55	0.11	-3.54	0.01

Source : Author's calculations in Eviews,2021

All series in Table 2 have unit root at level and become stationary at the first difference.

Also, no variable is found to be second difference stationary. As a result of unit root test for data in levels, all p-values were found higher than 0.05 significance level(col. 3), so we accept the H0 and reject the H1, i.e. series have unit root, are not stationary and become stationary at first difference (col. 5) $p < 0.05$ significance level. First difference stationary data are represented in Fig. 2.

Figure 1 First difference data

Source : Author's calculations in Eviews,2021

Recall that the co-integration to be tested procedure goes back to original series regardless their yes or no stationarity (Aljandali, 2018, p.61).All variables are found to be integrated of order one I(1) (see Table 2). The Johansen co-integration test with null hypothesis H_0 that series are not co-integrated and H_1 alternative hypothesis of co-integration is then applied. The residuals series of level data was also estimated and it proves *stationary, so* confirming the co-integration and also a long-term relationship between variables. Then for testing this co-integration two types of Johansen test were needed either. Both the Trace and Maximum Eigen Value (Unrestricted Co-Integration Rank) tests do suggest two cointegrating equations at 0.05 level .

VECM (Vector Error Correction Model) proves as a suitable estimation technique for a set of variables with one or more co-integration vectors, once able to adjust to both short run changes in variables and deviations from equilibrium (Andrei, 2015, p.572).

The other lag length Schwartz Info criterion also suggests an estimating VECM with one lag. The rule is that VECM's specific lag is the VAR's corresponding lag minus one (the unit value).

Table 3 Lag Selection

Lag	LogL	LR test	Final prediction error	Akaike	Schwarz	Hannan-Quinn
0	202.0633	NA	1.59e-15	-17.04898	-16.75277	-16.97449
1	353.9738	211.3538	7.51e-20	-27.12816	-25.05465	-26.60668
2	413.7925	52.01623*	2.07e-20*	-29.19935*	-25.34854*	-28.23088*

* That indicates lag order selected.

Source: author's calculations , Eviews,2021

The VECM (Vector error correction model) with one lag, was estimated by OLS (ordinary least squares regression) as a system with six variables:

(a) the aggregate level of per capita GDP as basing per capita growth;

(b) Gross fixed capital formation (GFCF) as the proxy for physical capital;

(c) employment rate, as a representation of labour;

(d) enrolment in secondary and tertiary education enrolment, in numbers of students as a % of age group;

(e)R&D expenditure, as its percentage in GDP (as a measure of technology);

(f) life expectancy in years, as a measure of population's health and also a component of human capital (Khan 2015).

Our VECM will be a six equations system with all variables getting in turn dependent and independent in order to find the long and short run associations between. Then, the VECM gets the following form (Andrei 2015, p. 572):

$$\Delta Y_t = \alpha_1 + \alpha_2 * Ect_{(-1)} + \alpha_3 * \Delta Y_{t-1} + \alpha_4 \Delta X_{1,\, t-1} \ldots \Delta X_{5,\, t-1} + \epsilon_t \quad (4)$$

The error correction term $Ect_{(-1)}$ measures the speed of adjustment of economic growth towards equilibrium level and Y, X1...X5 are the variables of the model. The coefficient of the error correction term and its statistical significance measures the return to equilibrium trend of each variable. Significant resulted coefficient means the role of past equilibrium errors in capturing the long-run impact by their current outcomes (Andrei, 2015, pp. 572-573). Otherwise, Ect represents the residuals after estimating the co-integration regression(eq.3) and is stationary in levels which confirm the variables' co-integration (this is called the Engle-Granger test). VECM short run effects see themselves captured in their turn through individual coefficients of the differentiated terms of equation (4), like in Jain (2019).

Table 4 Results of cointegration equations

Cointegrating Eq:	**CointEq1**	**CointEq2**
Col.	(1)	(2)
L_GDP(-1)	1.000000	0.000000
L_GFCF(-1)	0.000000	1.000000
L_EMPLOYMENT(-1)	2.863574	2.099725
L_LIFE(-1)	-18.59885	-2.298564
L_RESEARCH(-1)	-0.333456	0.469694
L_SECONDARY(-1)	3.976052	0.421417
C	47.39594	-3.198294

Source : author's calculations in Eviews,2021

We can write the two co-integrated equations as follows :

Coint_eq1:

L_gdp(-1)=-2.863574*L_EMPLOYMENT(-1)+18.59885*L_LIFE(1)+0.333456*L_RESEARCH(-1)-3.976052*L_SECONDARY(-1)-47.39594 (5)

Coint_eq2:

L_GFCF(-1)=-2.099725*L_EMPLOYMENT(-1)+2.298564*L_LIFE(-1)-0.469694*L_RESEARCH(-1)-0.421417*L_SECONDARY(-1)+3.198294 (6)

5. Further interpretation and results

VECM, as a system of six equations by OLS, under Eviews environment (Table 5) was estimated, each variable coming to be considered as endogenous. The coefficients can be interpreted as long-term (co-integration) and short-term (causality) relationships. For a long term relation between variables, the coefficient of co-integrated equations must be negative and significant. Its negative sign indicates that the adjustment is in the right direction in order to restore the long-term relationship (i.e. the speed of adjustment to equilibrium).

Table 5 VECM estimation results and test

Variables	**D(L_GDP)**	**D(L_GFCF)**	**D(L_EMPLOYMENT)**	**D(L_LIFE)**	**D(L_RESEARCH)**	**D(L_SECONDARY)**
Col.	(1)	(2)	(3)	(4)	(5)	(6)
Coint_eq1	-0.18*	-0.22	-0.24*	0.004	-0.22	-0.08
Coint_eq2	-0.07***	-0.29	0.13	-0.008	-0.48**	0.05
D(L_GDP(-1))	-0.39**	-1.09	-0.30	-0.04	-0.99	-0.10
D(L_GFCF(-1))	0.29*	0.64**	-0.09	-0.0009	0.38	0.03
D(L_EMPLOYENT(-1))	0.17	0.077	0.04	0.02	0.82	-0.009
D(L_LIFE(-1))	0.17	1.62	-0.35	-0.26	-7.22	0.008
D(L_RESEARCH(-1))	-0.09	-0.25	-0.07	0.004	-0.10	-0.05
D(L_SECONDARY(-1))	0.52	1.11	0.43	0.13	3.16	0.75**
C	0.04	0.02	0.001	0.005**	0.029	0.004
R^2	0.89	0.48	0.54	0.38	0.54	0.60
Adj. R^2	0.82	0.18	0.28	0.040	0.28	0.38

Note: *, ** and *** indicate significance levels at 1%, 5% and 10%

Source : Author's calculations in Eviews,2021

5.1 VAR Model - Substituted Coefficients for equation of interest (col.1) :

D(L_GDP)=-0.18*Cointeqeq1-0.073*Cointeqeq2-0.39*D(L_GDP(-1))+0.29*D(L_GFCF(-1))+0.17*D(L_EMPLOYMENT(-1))+0.17*D(L_LIFE(-1))-0.09*D(L_RESEARCH(-1))+0.52*D(L_SECONDARY(-1)) + 0.04 (7)

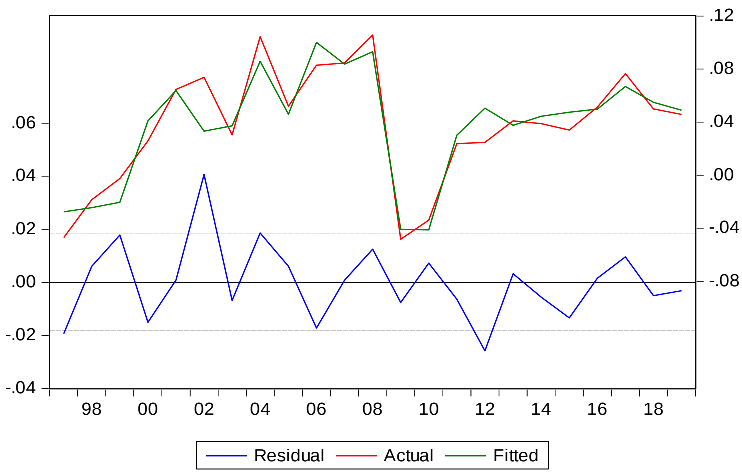
The normalized co-integrating equation for per capita GDP - *CointEq1*- is shown in Table 6. The equation shows that in *the long run* , employment rate, life expectancy, R&D expenditure and secondary enrolment rate impact positively on the level of per capita GDP in Romania and the impact is also significant as above expected, at the beginning of our study (see also Table 6 col.1). In other words, human capital rising (see, through secondary enrolment and life expectancy) will claim long term impact either on GDP growth, or on employment and the R&D sector (-0,24 and -0.48 long run coefficients significant for 99-95% respectively).

The coefficient of long run was found to be negative (-0,18) and significant at 99% (P<0,01), as suggested in the literature. Our results are similar to those reported in studies of Abbas(2000, p. 465) and Sulaiman at al.(2015, p.6). A similar long term impact was obtained from all variables on *employment rate* and on *R&D expenditure,* each of them as endogenous (col. 3 and col. 5 table 5). No other significant impact on the GDP growth in the short run, i.e. none from education, life expectancy, R&D expenditure or employment rate.

The R^2 determination coefficient value of 0.89 for equation of interest (col.1) means that 89% of the GDP growth's evolving could be explained by: physical capital, employment, life expectancy at birth, secondary school enrollment and research and development(R&D) expenditure. The higher the R-squared values, the smaller the differences between observed data and fitted values.

Correlation coefficients R^2 for the rest of five equations of VECM are shown in table 5 (they are varying between 0,38 and 0.60).

Figure 2 Actual , fitted, residual graph - endogenous GDP growth



Source : Author's calculations in Eviews,2021

6. Residuals diagnostics

The model was tested for normality, *heteroskedasticity* and serial correlation of residuals. First, VECM requires that the errors between observed and predicted values should be normally distributed. Histogram of normality test is applied with H_0 representing the null hypothesis of the Jarque-Bera (JB) test for normal distribution of errors ; the probability of 0.4846 > 0.05 significance level attached to the Jarque-Bera test statistic leads to accepting null hypothesis and accept that errors are normally distributed.

Table 6 System Residual Normality Tests[5]

Component	Skew.	Chi^2	df	P.value
1	0.700833	1.882805	1	0.1700
2	0.738096	2.088346	1	0.1484
3	-0.458272	0.805050	1	0.3696
4	0.035538	0.004841	1	0.9445
5	0.663912	1.689654	1	0.1936
6	-0.495133	0.939768	1	0.3323
Joint		7.410465	6	0.2845
Component	Kurtosis	Chi-sq	df	Prob.
1	3.978803	0.918137	1	0.3380
2	3.851637	0.695065	1	0.4044
3	2.758581	0.055855	1	0.8132
4	1.633791	1.788754	1	0.1811
5	3.186797	0.033439	1	0.8549
6	2.193869	0.622770	1	0.4300
Joint		4.114019	6	0.6612
Component	Jarque-Bera	df	Prob.	
1	2.800942	2	0.2465	
2	2.783410	2	0.2487	
3	0.860905	2	0.6502	
4	1.793595	2	0.4079	
5	1.723094	2	0.4225	
6	1.562538	2	0.4578	
Joint	11.52448	12	0.4846	

Source:Author's calculations in Eviews,2021

Secondly, applying the test for serial autocorrelation in the residuals the null of Portmanteau tests for Autocorrelations (H_0) comes up for no serial correlation exhibited by residuals. Both the Q-statistics and the adjusted Q-statistics are reported. The p-value keeps significance up to lag 9. The null hypothesis is then accepted and so concluding that the VECM system estimation does not exhibit residual autocorrelation.

[5] H_0:residuals are multivariate normal; Interval: 1997-2019; Orthogonalization:Cholesky (Lutkepohl); Obs. 23

Table 7 Tests for Autocorrelations (System Residual Portmanteau)[6]

Lag	Q-Stat	P. value	Adj. Q-Stat	P.value	df
1	25.70634	0.8984	26.87481	0.8648	36
2	50.82291	0.9725	54.38344	0.9396	72
3	97.82829	0.7484	108.4396	0.4700	108
4	128.7778	0.8135	145.9048	0.4400	144
5	156.8297	0.8929	181.7490	0.4495	180
6	197.7610	0.8082	237.1266	0.1546	216
7	231.4200	0.8194	285.5113	0.0721	252
8	250.0348	0.9484	314.0541	0.1396	288
9	275.1261	0.9772	355.2755	0.1118	324
10	303.4242	0.9863	405.3413	0.0497	360
11	326.4531	0.9955	449.4801	0.0326	396
12	348.6677	0.9987	495.9289	0.0179	432

Source:Author's calculations in Eviews,2021

Lastly, VEC Residual Heteroskedasticity tests are applied for the regression residuals.The null hypothesis H_0 is that the residuals are *homoscedastic*.The joint test has a significance of p=0.2017. We accept the null (since p 0.05 < 0.2017, the residuals are homoscedastic.

Table 8 VEC Residual Heteroskedasticity Test[7]

Joint test:		
Chi-sq	df	Prob.
357.4331	336	0.2017

Source: Author's calculations in Eviews,2021

Diagnostic tests also indicate that the residuals are normally distributed, *homoskedastic* and serially uncorrelated.

7. Discussion and conclusions

Regarding the human capital's central role on GDP producing and development both neoclassical growth and endogenous growth models do confirm it (Wößmann 2000).

A significantly long term impact on development in Romania comes out of our above study as determined by human capital, here identified with education and health sectors.

VECM with one lag and Granger causality does make clear both the short term causality (joint Granger causality) between selected variables, and these variables' long term impact on GDP growth. These variables come on the Cobb-Douglas production function structure and scholars -- e.g. Romer (1990) and Lucas (1988) -- argue for here including

[6] Null Hypothesis H_0 : no serial correlation of residuals up to lag h; Interval: 1997-2019; obs.: 23; df- degrees of freedom .

[7] No Cross Terms (only levels and squares);Interval: 1995 2019; obs.: 23

the human capital -- i.e. education and healthcare levels -- as equally significant. Stationarity and cointegration specific tests had done make room to choosing an autoregressive type VECM as an equations system with all variables not only exogenous, but also potentially endogenous. Similar long term effects are found in this study for employment rate and R&D expenditure, as endogenous in their turn, while corresponding short term effects are missing as well as for GDP endogenous. Once more to be underlined that this same health's and education's (i.e. human capital's) impacts on the Romania's development result only on the long term (not equally on the short one).

The specific coefficient of long term was found to be negative (-0.18), as suggested by the literature and at 99% significance (P<0,01). Human capital, by its school enrolment and life expectancy proper variables, keeps its long term impact not only on GDP, but equally on employment rate and R&D expenditure.

As for the short term it seems that only GDP(-1) and GFCF(-1) do influence the economic growth, i.e. GDP endogenous. Lastly as for missing results on the short term impact of human capital on Romania's economic growth, at least one of explanations might consist in having used proxies not quite proper to health and education and this due to (even temporary) absence of long term statistics and/or to skipping lagged impacts. Actually, the current secondary education individuals enrolled will be supposed to compete on the labour market in the following ears (Wößmann, 2003). Those enrolled today in the secondary education system won't be hired tomorrow for possibly including their knowledge in the current human capital. So, such a relationship tends to be a lagged and indirect one (Wößmann, 2000 & 2003)[8].

References

Abbas, Q. (2000). The Role of Human Capital in Economic Growth: A Comparative Study of Pakistan and India. *The Pakistan Development Review ,* 39, no. 4 : 451–473.

Aljandali A. et al. (2018). *Economic and Financial Modelling with EViews ; A Guide for Students and Professionals.* Cham : Springer International Publishing AG, part of Springer Nature

Andrei D.M. & Andrei L.C, (2015). Vector error correction model in explaining the association of some macroeconomic variables in Romania , *Procedia Economics and Finance,* 22:568 – 576.6. https://doi.org/10.1016/ S2212-5671(15)00261-0

Bane, J. (2018). Human Capital and Economic Growth in Developing Countries: Evidences from Low and Middle Income African Countries. In *Determinants of Economic Growth in Africa*:237-258. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-76493-1_8

Barro, R. (1991). Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics*, 106, no.2 : 407-433. https://doi.org/10.2307/2937943

Becker ,G. S.(1994). *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*, Third Edition.The University of Chicago Press

[8] This author sees the secondary enrolment as in the category of „imperfect proxies" for human capital.

Benhabib, J. & Spiegel, M.M., (1992). The Role of Human Capital and Political Instability in Economic Development, *Working Papers 92-24*, New York University:C.V. Starr Center for Applied Economics.

Denison,E.F.(1962). Education, Economic Growth, and Gaps in Information, *Journal of Political Economy*, University of Chicago Press, 70(5):124-128. http://dx.doi.org/10.1086/258729

Eurostat, the statistical office of the European Union (2019). Enlargement countries -population statistics and database. Accessed May 2020. http://ec.europa.eu/eurostat/statistics-explained/index.php/Enlargement_countries_-_population_statistics

Girosi, F., & King, G. , (2007). *Demographic Forecasting.* Princeton: Princeton University Press.

Grossman, M. (1972). On the Concept of Health Capital and the Demand for Health, *Journal of Political Economy,* 80. p. 223-255.https://www.jstor.org/stable/1830580

Gujarati, D.N. (1995) *Basic Econometrics*. 4th Edition. New York:United State Military Academy.

Hafeez A, & Rahim A., (2019) . Human Capital and Economic Growth: Evidences from Pakistan , *Journal of Research in Social Science*s, 7, No.1 (Jan): 128-135.

Harbison, F. & Myers, C.A. (1964). *Education, Manpower, and Economic Growth: Strategies of Human Resource Development* New York: McGraw-Hill.

Jain H. (2019). Wage–Productivity Relationship in Indian Manufacturing Industries: Evidences from State-level Panel Data. *The Journal of Applied Economic Research*. ;13(3):277-305. doi:10.1177/0973801019841258

Khan, M.S. (2005). Human Capital and Economic Growth in Pakistan. *The Pakistan Development Review ,* 44, no.4 , part 1 (Winter) : 455-478.

Khan H.N., et al., (2016). On the relationship between health, education and economic growth: Time series evidence from Malaysia , *American Institute of Physics*, 1787, no.1 :1-7. https://doi.org/10.1063/1.4968146 .

Khan,M.(2016). Contribution of female human capital in economic growth: an empirical analysis of Pakistan (1972 ‑ 2012)," *Quality & Quantity: International Journal of Methodology*, Springer, 50(2), pages 709-728, March.

Kosztowniak, A.(2014). Analysis of the Cobb-Douglas Production Function as a Tool to Investigate the Impact of FDI Net Inflows on Gross Domestic Product Value in Poland in the Period 1994–2012*, Oeconomia Copernicana*, 5(4):169-190, doi:http://dx.doi.org/10. 12775/OeC.2014.032

Lucas, Robert (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics*. 22, no.1: 3–42. doi:10.1016/0304-3932(88)90168-7.

Mankiw,N. G. , Romer,D. & Weil,D.N.(1992). A Contribution to the Empirics of Economic-Growth, *The Quarterly Journal of Economics* 107: 407–437. https://doi.org/10.2307/2118477

Mankiw, N.G, Phelps E. S. & Romer. P. M. (1995). The Growth of Nations, *Brookings Papers on Economic Activity*, 1(25th Anniversary Issue): 275-326. https://doi.org/10.2307/2534576

Mensah I.A et al.(2019). Analysis on the nexus of economic growth, fossil fuel energy consumption, CO2 emissions and oil price in Africa based on a PMG panel ARDL approach , *Journal of Cleaner Production*, 228, no.29 : 161-174. https://doi.org/10.1016/j.jclepro.2019.04.281

Miladinov, G. (2020). Socioeconomic development and life expectancy relationship: evidence from the EU accession candidate countries. *Genus* 76, no. 2: 1-20. ttps://doi.org/10.1186/s41118-019-0071-0

Obradović, J. & Đorđević M.(2020). Monetary Policy Transmission on Real Trends in Serbia – VAR Analysis *, Economic Themes,*Sciendo, vol. 58(1), pages 53-73

Rabbi A. M. F., (2013). Imbalance in life table: Effect of infant mortality on lower life expectancy at birth, *Journal of Scientific Research* 5, no.3 : 479–488. https://doi.org/10.3329/jsr.v5i3.14105.

Romer,P.M.(1990). Human capital and growth: Theory and evidence, *Carnegie-Rochester Conference Series on Public Policy*, 32 : 251-286.https://doi.org/10.1016/0167-2231(90)90028-J

Schultz, T. W. (1961). Investment in human capital. *The American Economic Review*, 51, no.1 : 1-17.https://www.jstor.org/stable/1818907

Sharma, R. (2018). Health and economic growth: Evidence from dynamic panel data of 143 years. *PLoS ONE*, 13, no.10: e0204940. https://doi.org/10.1371/journal.pone.0204940

Solow, R.M. (1956). A contribution to theory of economic growth, *Quarterly Journal of economics* 70, no.1:65-94. https://doi.org/10.2307/1884513

Sulaiman C. et al. (2015). Human Capital, Technology, and Economic Growth: Evidence from Nigeria , *SAGE Open :* 1–10, DOI: 10.1177/215824401561516

Tallman, E.W. & Wang,P. (1994).Human capital and endogenous growth evidence from Taiwan, *Journal of Monetary Economics*, 34(1) : 101-124, https://doi.org/10.1016/0304-3932(94)01152-4.

UKEssays (2018). The Concept Of Human Capital Economics Essay. Accessed May 2020 https://www.ukessays.com/essays/economics/the-concept-of-human-capital-economics-essay.php?vref=1

Wang. Wei (2016): *"Vertical specialization and increasing productive employment", Achieving Inclusive Growth in China Through Vertical Specialization,* Elsevier. Science Direct , 10.1016/B978-0-08-100627-6.00004-7

Wößmann, L.,(2000). Specifying Human Capital: A Review, Some Extensions, and Development Effects.*Kiel Working Paper* No. 1007. Accessed May 2020 . http://dx.doi.org/10.2139/ssrn.246294

Wößmann, L. (2003). Specifying Human Capital, *Journal of economic surveys* 17, no.3, (July): 239-270. https://doi.org/10.1111/1467-6419.00195

World Health Organization. (2014). World Health Statistics 2014. Geneva: WHO.

World Bank Open Data (2017).Free and open access to global development data, indicators.Accessed May 2020. http://data.worldbank.org/indicator

Zaman, S.B., et al.(2017). An Association of Total Health Expenditure with GDP and Life Expectancy. *Journal Of Medical Research And Innovation* 1, no.2 : AU7–AU12. https://doi.org/10.5281/zenodo.576546.