The Relationship between human capital and GDP: An ARDL Approach for the case of Iran

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Abstract

The objective of this paper is to examine the relationship between human capital and economic growth in Iran for the period 1970-2010, based on the autoregressive distributed lag (ARDL) approach. The study finds a cointegrating relationship among real GDP, investment, labor force, oil revenues and human capital. Compared to the other variables, human capital proxy, extracted from enrolment rate in different levels and public expenditures on education, contribute little to long-run economic growth. Moreover, in short-run, oil revenues and investment have the strongest effects on economic growth. Estimating error correction model revealed that the speed of adjustment to restore equilibrium is -0.75 which confirms that there is a stable long-run relationship. Regarding weak impact of human capital on long run economic growth, it seems that government and policy makers should employ market-based reforms in formal education system.

JEL classification: O40, O15, I20, C33, C10.
Keywords: ARDL, human capital, Economic Growth, Iran Economy

1. Introduction

The growth models with human capital, consider human capital as an input in the production function, which, just like physical capital, can be accumulated by investment in schooling. In this class of models it is human capital investment which increases productivity growth, either permanently (in endogenous growth models like Lucas (1988)) or temporarily (in augmented Solow models of Mankiw, Romer and Weil (1991)). In recent years the endogenous growth literature, point out that human capital serve as the fundamental engines of growth.

The empirical literature has used education rather than broader measurements for human capital, both for data availability and that measures of education are reasonably standardized and similar across countries. So far, the evidence from empirical studies is diverse. Overall, it seems that there is a positive correlation between education and economic growth, while the relationship between investments in education (or changes in educational levels) and growth rates is more ambiguous. For example, Benhabib and Spiegel (1994) and Pritchett (1996)) suggest that changes in educational levels do not contribute to output changes, but Krueger and Lindahll (1999), Temple (1999, 2000), Topel (1999)) show that the result may be confused by measurement error or presence of outliers.

In this paper we examine the short- and long-run relationships between investment in education and economic growth for Iran over the period 1970-2010, using Autoregressive Distributed Lag (ARDL) approach to cointegration and error correction models (ECM).

The rest of the paper is organized as follows. Section 2 describes data and methodology. Results are reported in Section 3. Section 4 concludes.

2. Data and Methodology

To allow for causality and dynamics and given that not all of our time-series may be stationary to the same order (some are I(0) while others are I(1)), the cointegration technique suggested by Pesaran et al. (2001), the autoregressive distributed lag model (ARDL) procedure will be used. The approach can be implemented regardless of whether the variables are integrated of order (1) or (0) and can be applied to small finite samples. Based on empirical literature, theories of economic growth, and diagnostic tests, the long run relationship between economic growth and human capital can be specified as:

$$\ln RGDP_t = \beta_0 + \beta_1 \ln INV_t + \beta_2 \ln L_t + \beta_3 \ln OILREV_t + \beta_4 HUM_t + u_t \qquad (1)$$

Where RGDP is GDP at constant price, INV is gross domestic investment, L is labor force, OILREV is real oil revenues, HUM stand for quality of human capital. ε_t is an stationary error term. Human capital is proxied by enrolment ratio in all levels of education (including tertiary, secondary and primary education measured as the percentage of the working age population) as well as public expenditures on education relative to total public expenditures. We apply the principle component approach to merge the proxies into one measurement (HUM).

All variables except HUM are expressed in natural logarithm (ln stands for logarithm). The main sources of variables are from the Central Bank of Iran (CBI) and Statistical Center of Iran (SCI). The time period of the study is over the years 1970 to 2010.

To examine long run relation among the series we implement ARDL bounds testing approach to cointegration developed by Pesaran et al., (2001). The bounds testing approach has several advantages: it applies irrespective of the order of integration for independent variables, I(0) or I(1); is better suited to small samples; and a dynamic error correction model (ECM) can be derived from the ARDL model through a simple linear reparametrization. The version of error correction model of ARDL approach is given by:

$$\begin{aligned}\Delta \ln RGDP_t &= \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta \ln RGDP_{t-i} + \sum_{i=0}^{p} \theta_i \Delta \ln INV_{t-i} + \sum_{i=0}^{p} \lambda_i \Delta \ln L_{t-i} \\ &+ \sum_{i=0}^{p} \varphi_i \Delta \ln OILREV_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta \ln SER_{t-i} + \delta_1 \ln RGDP_{t-1} + \delta_2 \ln INV_{t-1} \\ &+ \delta_3 \ln L_{t-1} + \delta_4 \ln OILREV_{t-1} + \delta_5 HUM_{t-i} + \varepsilon_t \qquad (2)\end{aligned}$$

Where $\phi, \theta, \lambda, \varphi\_and\ \gamma$ refer to short run and δ_1 to δ_5 to long run parameters. The null hypothesis of no cointegration is H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ against the alternative hypothesis H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$. The rejection of the null based on the F-statistic suggests cointegrating relationship. The critical bounds have been tabulated by Pesaran et al. (2001). The upper critical bound (UCB) is based on the assumption that all series are I(1). The lower bounds (LCB) applies if the series are I(0). If UCB is lower than the calculated F-statistic, the null of cointegration is sustained. If the F-statistic is less than the LCB then there is no cointegration. The decision about cointegration will be inconclusive if the F-statistic lies between UCB and LCB. In such situation, we will have to rely on the lagged error correction term to investigate long run relationship.

The orders of the lags in the specification (2 are selected by the Schwarz Bayesian criterion (SBC). For annual data, Pesaran and Shin (1999) recommended choosing a maximum of 2 lags. From this, the lag length that minimizes SBC is selected.

If a long run relationship exists, the ARDL representation of equation (1) is formulated as follows:

$$\ln RGDP_t = \alpha_1 + \sum_{i=1}^{p+1} \phi_{1i} \ln RGDP_{t-i} + \sum_{i=0}^{p+1} \rho_{1i} \ln INV_{t-i} + \sum_{i=0}^{p+1} \theta_{1i} \ln L_{t-i} + \sum_{i=0}^{p+1} \lambda_{1i} \ln OILREV_{t-i}$$
$$+ \sum_{i=1}^{p+1} \varphi_i HUM_{t-i} + \varepsilon_t \qquad (3)$$

The ARDL method estimate $(p+1)^k$,number of regressions in order to obtain the optimal lags for each variable, where p+1 is the maximum number of lags to be used and k is the number of variables in the equation (Shrestha and Chowdhury, 2005). The model is selected based on the Schwartz-Bayesian Criterion (SBC) that use the smallest possible lag length and is therefore described as the parsimonious model.

The ARDL specification of short run dynamics is investigated using ECM version of ARDL model of the following form:

$$\Delta \ln RGDP_t = \alpha_2 + \sum_{i=1}^{p} \phi_{2i} \Delta \ln RGDP_{t-i} + \sum_{i=1}^{p} \rho_{2i} \Delta \ln INV_{t-i} + \sum_{i=0}^{p} \theta_{2i} \Delta \ln L_{t-i} + \sum_{i=0}^{p} \lambda_{2i} \Delta \ln OILREV_{t-i} +$$
$$\sum_{i=0}^{p} \varphi_{2i} \Delta HUM_{t-i} + \psi ECM_{t-1} + \varepsilon_t \qquad (4)$$

The lagged residual term (ECM) in equation 4 shows the disequilibrium in long renrelationship (ut in equation 1). The goodness of fit for ARDL model is checked through stability tests such as cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ).

3. *Empirical Results*

Pesaran et al. (2001) critical values are based on the assumption that the variables are integrated of order I(0) or I(1). Unit root tests insure that none of the series is integrated of I(2) or higher. Both the augmented Dickey–Fuller (ADF) (1979) and Phillips–Perron (PP) (1988) unit-root tests have been employed for that purpose and the results are summarized in Tables 1. Test for stationarity shows that all variables are integrated of order 1 and thus stationary in difference.

Table 1: Unit Root Test

Variables	ADF test statistic (with trend and intercept)		PP test statistic (with trend and intercept)	
	Level	First Difference	Level	First Difference
ln RGDP	-1.29	-4.14**	-1.34	-3.82**
ln INV	-1.67	-3.91**	-0.85	-3.62**
ln L	-1.91	-3.99**	-1.10	-3.99**
ln OILREV	-1.38	-7.81***	-1.62	-11.20***
HUM	-0.67	-6.41***	-.92	-5.71***

Notes: ** and *** denotesignificancy at 5% 1% levels respectively.The optimal lag structure is determined by SBC

To investigate the presence of long-run relationships among the variables, testing of the bound under Pesaran, et al. (2001) procedure is used. The results of the bound test are given in Table 2. The critical values used in this paper are extracted from Narayan (2004). The calculated F-statistics is 6.19 while upper critical bound at significance level 1% is 5.642. This implies that there is long run relationship among GDP, INV, oil revenues, labor force and human capital proxy over the period of 1970-2010 in Iran.

Table 2: Bounds Test Results

F-statistics	Lag	Significance Level	Bound Critical values	
			I(0)	I(1)
7.52	2	1%	4.324	5.642
		5%	3.116	4.094
		10%	2.596	3.474

The next stage of the procedure would be to estimate the coefficients of the long-run relations and the associated error correction model (ECM) using the ARDL approach. The optimal lags on variables were selected by the Schwartz Bayesian Criterion (SBC) and turned out to be the ARDL (1, 0, 1, 1, 1). The long-run estimated coefficients are shown in the Table 3. As can be seen, all the coefficients are significant. One percent rise in INV is expected to increase GDP per capita by just 0.21 percent. The labor force and the proxy of human capital contribute the least to long-run economic growth. The variable of oil revenues has also the expected positive sign.

Table 3. Estimated long run coefficients based on ARDL approach

Regressor	Coefficient	p-value
constant	4.20	0.00
ln INV	0.21	0.00
ln L	0.14	0.00
ln OILREV	0.23	0.00
HUM	0.12	0.02

The results of error correction model, reported in Table 4. The short-run coefficients are less than the long-run ones. The results suggest that the short-run impact of labor force and human capital on the economic growth are small and insignificant. The coefficients for the other explanatory variables have the expected sign and are significance. Moreover, the coefficient of the ECM is negative and strongly significant at 1% level. This corroborates the existence of a stable long-run relationship and points to a long-run cointegration relationship among variables. The ECM represents the speed of adjustment to restore equilibrium in the dynamic model following a disturbance. The coefficient of the ECM is around -0.75, implying that a deviation from the long-run equilibrium is corrected by 75% after each year.

The diagnostic tests e.g., Lagrange Multiplier (LM) for serial correlation, ARCH effects, normality of residual terms, white heteroskedasticity and Ramsy RESET for functional form reported in Table 5 suggest that the short-run model passes all diagnostic tests. We find no evidence of serial correlation, autoregressive conditional heteroskedasticity and white heteroskedasticity. The residual terms are normally distributed and the functional form of the model appears well specified.

Table4. Error correction representation for the selected ARDL model

Regressor	Coefficient	p-value
Δln INV	0.17	0.00
Δln L	0.12	0.15
Δln OILREV	0.15	0.00
ΔHUM	0.05	0.31
ECM	-0.75	0.00
Serial Correlation LM = 0.83 (0.71)		
ARCH Test = 0.62 (0.47)		
Normality Test = 1.53(0.46)		
Heteroscedisticity Test = 0.81 (0.76)		
Ramsey RESET Test = 1.89 (0.38)		

Notes: The probability values for the diagnostic tests are given in parenthesis

Issue 3, Vol.4 (June-July 2013)
ISSN 2249-6149

The plots of the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) stability tests as shown respectively in figures 1 and 2 indicate that all the coefficients of estimated model are stable over the study period as they fall within the critical bounds.

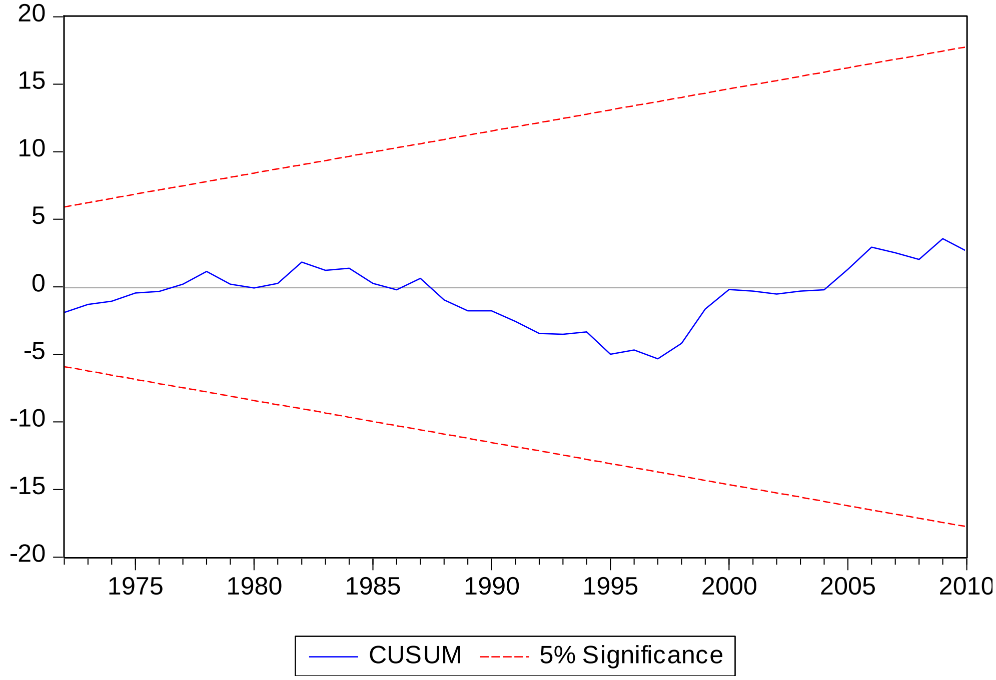

Figure 1: CUSUM Plots for Stability Tests

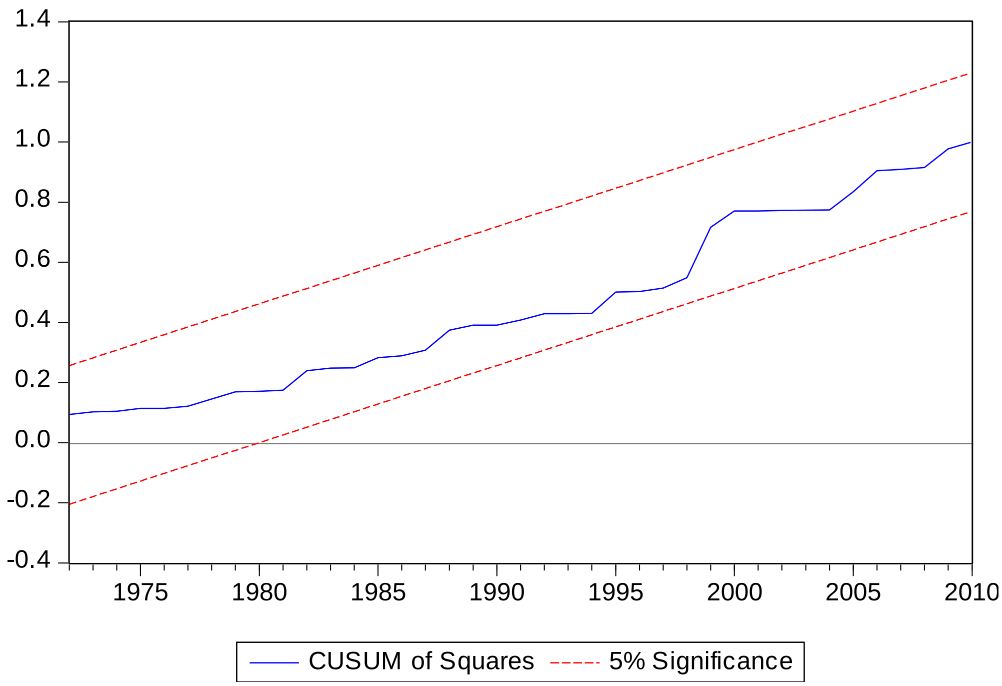

Figure 2: CUSUMSQ Plots for Stability Tests

4. Conclusion

This paper has investigated the determinants of economic growth with an emphasis on the human capital in Iran using annual data for the period 1970-2008 applying autoregressive distributed lag (ARDL) approach. According to the results, we found a cointegration relationship among real GDP, investment, labor force, oil revenues and human capital proxied by formal education indicator. Estimating error correction model revealed that the speed of adjustment to restore equilibrium is -0.75 which confirms that there is a stable long-run relationship. Compared to the other variables, the human capital proxy has the least important effect on economic growth in long-run. In short-run, however, the variables of oil revenue and capital formation do have significant effects on economic growth, explaining just a large part of economic growth. Therefore, it does not seem that formal education would contribute to economic growth particularity in long-run.

With regard to the trivial impact of labor force and formal education on economic growth, it seems necessary to reshuffle formal education system toward market-based reforms, training skilled labor and professionals in various sectors and giving schools and universities more flexibility.

Acknowledgements

The authors would like to acknowledge the financial support of University of Tehran for this research under grant number 4401012/1/20

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