Ideas, Increasing Return to Scale, and Economic Growth: An Application for Iran

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Abstract

Iran has experienced an increasing rate of economic growth during recent years. We need to explain the causes of this growth if we are to help maintain it. In this study, we try to calibrate and apply a model in the context of new growth models, based on Ideas derived from the Iranian economy. The results show that an increase in education levels and expansion in research activities are the main factors promoting economic growth in Iran during the studied period.

Keywords: Economic growth, Ideas, Nonrivalry, Technological progress, Population growth

JEL Classification:O41, Q55, Q56

Introduction

With the proposition of an ideas function, Paul Romer initiated a new line of research in economic growth models. After some changes in Romer's original specification to make it more applicable, Charles Jones performed a growth accounting exercise for the US economy during the 1950–1993 period that contained at least two innovative contributions. The first was to relate Solow's residual in the US to the number of researchers in G5 countries concentrating the main weight of world tech's innovation. The second was to categorized between the part of the residual that can be assigned to the boost of population in a stationary state and the part that could be assigned to the transition towards such a state (Myro, 2008).After that, Myro posed some useful comments on Jones' model. He proved that the rate of spreading of ideas in leading industrial countries was not equal to other ones. So other countries could not use the entire discoveries which are founded in G5, at least at the same time. Therefore, having done some changes to Jones' idea function, he makes it applicable to countries.

Here aims to apply Jones' and Myro's ideas functions to Iran's economy, and to offer another technological progress proxy as a substitution for the aggregate multifactor productivity in them. Therefore, in the following section we first expose some evidence from Iran's recent economic indices. Then we model the economic growth of Iran. In the fourth section, we will try to measure the technological progress according to the WB report in 2008. Section five of the paper uses the presented model to calculate the parameters of the economic growth of Iran over the period 1996 to 2006 and discuss them.

It is a short period, and it is hard to extend the result to long term growth, but because of the lack of data in Iran, the associated problem is inevitable; especially, starting passing UN Security Council resolutions on Iran from 2006, the essence of the treatments of the data might not be consistent. In the further section, constant growth path and its factors will be declared. Finally, last section offers some concluding remarks relating to the results.

Evidence from Iran

The rate of GDP per capita in Iran has been fluctuating during the past four decades because of changing oil prices in the world market and also, in particular, the revolution and the war between Iran and Iraq. On the one hand, the average of this rate is about 1.8 percent that could explain the relative stability of the rate of economic growth in Iran during past decades. Figure (1) shows the GDP per capita in Iran.

Until 1977, there was an ascending trend in the growth rate of the economy in Iran.However, this rate experienced severe downfall every year before revolution until the end of the war. Likewise, population growth in Iran during past half century has an ascending trend. Figure (2) shows that.

During those years, the GDP has grown more than five times. Accelerating the growth of population in studied period could lead to a constant growth path. Figure (3) indicates the rate of increasing the level of literacy. It is noticeable that at the beginning of the studied period, it was about 30% however it reached 90% at the end of the period.

Furthermore, during the studied period two controversial developments occurred. First, an increase in educational attainment that raised the level of human capital[1] and the second was the expansion of research activities[2]. In 1991 only one percent of Iranian was participating in academic training but this number was raised to over 6.5 percent in 2008. Also, the ratio of researchers-to-workers increased by more than five times during ten years.

In practically any model of economic growth, such changes should lead to long-run increases in income. In neoclassical models, these shifts would generate transition dynamics in the short run and "level effects" in the long-run. Then growth rate of an economy rises temporarily and so returns to its original value; however the income level is permanently higher as a result. In most of the endogenous growth models, such changes should lead to permanent increases in the growth rate itself (Jones 2002). One of the major topics in the new theory of endogenous growth is that ideas are different from other economic goods. They are nonrivalry. When an idea comes out, others could use it without any cost. The quality of the idea could lead the economy into an increasing return to scale. Romer, Lucas, Becker and Jones are the vanguards promoters of this theory. In the past two decades, extensive research has been done to verify the role of human capital and technological progress in economic growth by many researchers and institutes. Most of these findings were about the industrial leader countries. However, some similar works have been done in South Korea, Turkey, and Nigeria. Considering the significant growth in the level of education and research intensity in Iran[3] during recent years, we can use this idea of a growth model and try to make it applicable toIran's economy in accordance with the Jones's model (2002) and the viewpoint of Myro (2008) discussed in the next section.

Modeling the growth

As discussed previously in this paper, we use the method that was presented by Jones (2002). The production function O_t at time of study defines as below:

$$(1)\quad O_t = I_t^{\nu} C_t^{\beta} H_{ot}^{1-\beta}$$

In which C_t is physical capital, $H_{ot}$is the total quantity of human capital employed to produce output, and I_t is the total stock of ideas available to Iran's economy. It is assumed that $0 < \beta < 1$ and $\nu > 0$. Physical capital is accumulated by the foregoing consumption:

$$(2)\quad \dot{C}_t = S_c O_t - \sigma C_t C_0 > 0$$

[1]In 1991 only one percent of Iranian had attended to university, however in 2008 this number reach 6.5 percent

[2]In 1996 only % 0.03 of the people worked in R&D section but in 2006 % 0.15 of the employed people were working in this section

[3]206 patents were registered in 1996; however this number wasraised to 4073by 2006

S_c, the fraction of output which is the investment and $\sigma > 0$, the rate of depreciation are assumed to be exogenous. Total human capital that is used to produce output calculates from this equation:

(3) $H_{ot} = h_t L_{ot}$

$h_t$is the human capital for each individual in the economy and L_{ot} is the total laborthat the economy employs to produce output. As Mincer (1974) said, each additional year of education e_t could raise the level effect of human capital on the following equation:

(4) $h_t = \exp(\psi e_t)$

In which ψ is constant and given. Consider if $e_t = 0$ then$h_t = 1$, so H_{ot} would be equal to the raw labor force. In this model, ideas are the only link between the G5 economies[4] and Iran. There is no trade in goods, and capital and labor are not mobile. New ideas which are produced by researchers in Iran are calculated by Myro's equation (2008):

(5) $\dot{I}_t = XH_{It}^{\varepsilon} I_{gt}^{\rho} I_t^{\theta-\rho} I_0 > 0$

Here X is a constant value and g stands for G5 countries.

New ideas that are created in G5's countries[5] and affect the Iran's ideas production function (5) with the proficiency of ρ are given by:

(6) $\dot{I}_{gt} = \delta H_{I_{gt}}^{\epsilon} I_{gt}^{\zeta} I_{g0} > 0$

In which H_I is the effective research that could be obtained by the foregoing equation:

(7) $H_{It} = \sum_{i=1}^{l} h_{it}^{w} L_{I_{it}}$

$L_{It}$is the quantity of researchers in the economy and h_{it} is their quality in producing new ideas. We assumed that $w \geq 0$, $0 < \varepsilon \leq 1$ and $\theta < 1$.ρ could somehow be interpreted as openness efficiency of Iran's economy to absorb new ideas that are created all around the world. The economy of Iran has an identical populationN_t:

(8) $N_t = N_0 \exp(n_t)$ $N_0 > 0$

Each individual is given with one unit of time and allocates this unit between producing goods, producing ideas, and producing human capital. Because time spent in school is removed from labor-force data, the resource constraint is written as:

(9) $L_{It} + L_{ot} = L_t = (1-e_{nt}) N_t$

WhereL_t denotes employment and $l_I = L_I / L_t$, $l_o = L_o / L_t$

To simplify the model, S_u,l_I, $l_o$ande_{nt}, are assumed to be constant.
Rewritingequation (1) in terms of output per worker$o_t = O_t / L_t$

(10) $$o_t = \left(\frac{C_t}{O_t}\right)^{\frac{\beta}{1-\beta}} * l_o * h_t * I_t^{\frac{\nu}{1-\beta}}$$

If “C” and “I” are growth at the constant rate, then by substitution of equations (5) and (6) in (10):

(11) $$o_t = \left(\frac{S_c}{n+g_c+\sigma}\right)^{\frac{\beta}{1-\beta}} * l_o * h_t * \left(\frac{X}{g_t}\right)^{\frac{\eta}{\varepsilon}} \left(\frac{\delta}{g_{Ig}}\right)^{\left(\frac{\rho}{\varepsilon}\right)\left(\frac{\eta}{1-\zeta}\right)} * H_{Ig}^{\left(\frac{\rho\eta}{\varepsilon}\right)\left(\frac{\epsilon}{1-\zeta}\right)} * H_t^{\eta}$$

Where$\eta = \left(\frac{\nu}{1-\beta}\right)\left(\frac{\varepsilon}{1+\rho-\theta}\right)$, $c = \frac{C}{L}$ and $g_x = \dot{x}/x$

What is noticeable from equation (11) is that the growth rate of output per worker in proportion to the growth of researchers in Iran and G5's countries if the growth rate of h would be constant.

[4]Here we assume G5 countries as leading countries instead of the whole world
[5]We assumed just these countries(U.S, U.K, France, Germany and Japan) because the most useful research is done by them

Finally, this economy could indicate the growth path in which S_e, n,g_c, σ, l_o,h_t,g_I,g_{Ig}andH_{Ig} are constant along this path. By differentiate from the equation (11) along the constant growth path, this result is obtained:

(12) $$g_y \equiv \eta g_H \equiv \eta n$$

According to equation (12), long-run growth depends on the population of the economy

Measuring Technological Progress

Technological progress is the important key to economic growth and the efforts to realize how the two could be quantitatively estimated have led to extensive investigation into modeling the two both independently and linked, using composite indicators. Empirical research as well as recent reports determine the continued use of composite indicators for studying economic growth and technological progress at national and further broad scales. All these studies elaborate upon the use of a composite indicator/number to study a nation's progress in the relevant aspect either linked or independently, stating it as a standard practice. For instance, Grupp looked at the use of composite technological innovation indicators estimated from technology, science, and innovation to measure a nation's progress made in technology. The central point of all such controversies discussed over the years has been centered on the ways in which weights are given to achieve the aggregated or averaged combine value. Consistently, economists view the process by which goods and services are produced as one that combines labor, capital, and other factors of production (land natural resources), using a particular technology. The relative efficiency with which a given economy produces goods and services given a fixed quantity of capital and labor is called total factor productivity (TFP) (Shanmuganathan 2008).

TFP is commonly interpreted as a measure of the technology of production and its rate of growth as a measure of technical progress. The correlations between income growth, capital accumulation, technological progress, and welfare are much more complicated than can be summarized the simple measure of TFP, partly because each factor of production and the technology with which elements are combined are dependent on one another. Capital goods often embody significant technological progress, and there is no simple way to distinguish between the contributions each makes to growth. Similarly, technology in the form of knowledge of business processes, general experience, and science is embodied in labor. Additionally, the contribution of innovation to welfare is only imperfectly measured by its impact on GDP. Even though the estimation of TFP and its improvement give us a sense of the relative diffusion of technological progress, they tell us not much about the mechanisms by which technology influences development. Technological progress involves much more than doing the same things better or with fewer resources. It is more dynamic, involving both the creation of new and new-to-the-market products and production techniques, but also the spread of these techniques across firms and throughout the economy (WB 2008).

Measuring technological progress through TFP would face several problems. TFP data for G5 countries is calculated for the total industries including mining, agriculture, and energy section. However, there is no such data for Iran. Second, to measure TFP usually uses two methods:

(13) $$\text{TFP} = \frac{V_t}{\alpha K_t \beta L_t} \quad \text{Euler}$$

(14) $$\text{TFP} = \frac{V_t}{K^{\alpha} L^{\beta}} \quad \text{Divisia}$$

Where K is the physical capital, and L is the labor force. V is obtained from two methods: Added value approach, GDP approach. It is noticeable that these equations are somehow another form of Solow's extension equation:

(15) $$Y = AK^{\alpha}L^{\beta}$$

In which A is a technological progress. So the problem is that to measure TFP; we use neoclassical production function and then we use these data instead of the technological progress in Jones equation to estimate the impact of TP on economic growth. To avoid the above problems, and to obtain the level of technological progress in Iran and G5 countries by the same procedure, in this paper, the method is used which is presented in the WB report (2008). In this report, four groups of indices are used to measure technological progress:

- Scientific innovation and invention
- Scientific innovation and invention

- Penetration of recent technologies
- Exposure to external technology

Figure (4) shows the technological progress trends in G5 countries and Iran during the period 1996-2006.

According to the Figure (4), Iran has experienced about 13 percent growth rate of technological progress in these years. In 1996, the level of TP in Iran was about one-ninth of G5 countries; however in ten years this value reached no less than one-fourth which shows a rapid growth in this section. Also, it shows a significant gap between the front edge countries and Iran.

Now by the obtained values for TP of the G5 countries and Iran, and the level of TFP for these countries, we could compare between two indices and discuss the differences. Table (1) shows the quantities of main factors relates to economic growth.

Considering table (1), the trifle value of TFP could not explain the output-worker ratio. For example, Japan has negative growth values in the labor force and capital-output ratios; therefore another fact should explain its economic growth. The rate of TFP is inconsiderable according to the economic growth, so it could not be the proper scale as a technological progress. Correspondingly, it is remarkable that the method which is presented in this study is much better than TFP to measure the technological progress.

Quantitative Analysis

In this section, we use the equations from section 2 to calculate the parameters for the growth rate of the economy in Iran.

Data

Because of the lack of data for researchers in Iran before 1996, the period 1996-2006 is employed in this paper. The factor e is computed directly from years of schooling Ψ equals to 0.07 as Jones (2002) used it. Figure (5) shows the human capital and years of schooling in Iran along the period.

According to the Figure (5), the years of schooling in Iran increased about 1.5 years during this short period, which that should be an acceptable prospect for educational system.

Having measured H_I (effective researchers in idea function), w is assumed to be zero. This simplification allows us to use the quantity of researchers directly in idea function. By assuming the ω zero, the quality of the researchers and their effect on the new ideas are the same. Figure (6) shows the percentage of the researchers to total employment in G5 and Iran's economies.

As shown in Figure (6) the percentage of the researchers in Iran is increased about five times during these years.

Calculating the parameters of the economic growth of Iran

Estimating different unknown nonlinear parameters of the economic growth simultaneously to the minimum the percentage of error, here used the standard genetic algorithm in MATLAB software through functions (5) and (10).

Finding the Lag

It is remarkable to see if the technological progress effect on the economic growth in the same year or not. Table (2) shows the results of the variance from the output.

The results show that the minimum quantity of error occurred in lag 2. So the technology affects the output after two years according to the calculation.

By converting equation (10) to the logarithmic form an important equation would be obtained:

$$\hat{o} = \left(\frac{\beta}{1-\beta}\right)\left(\hat{C} - \hat{O}\right) + \hat{l}_o + \hat{h}_t + \left(\frac{\nu}{1-\beta}\right)\hat{l}_t \tag{16}$$

Table (3) shows the average growth rate of the primary factors of growth

Considering the results of table (3), the major factors in the economic growth of Iran can be recognized as an increase in the educational level that leads to higher human capital and an increase in the growth rate of technological progress. As shown above, the growth rate of capital-output is about zero, and it has no effect on economic growth. The growth of the labor force defines only five percent of the growth of the economy in Iran.

Therefore, it is obvious in these results that more than 95 percent of recent economic growth is due to educational attainment and technological progress. Table (4) shows the values of the parameters that are obtained through the estimation by MATLAB.

As it seen in table (4), the technological progress of leading industrial countries has had an inconsequential impact on Iran's TP. The reason that could be indicated is the restricted economy of Iran in the absorption of ideas of frontier countries or the reluctance of foreigners to invest in Iran because of unstable policies.**β** is 0.138 which shows the elasticity of the labor force to output is as six times as the elasticity of capital to output. Discovered ideas have a complete impact on new ideas as **Θ** shows including the grade of **C** and **L** shows an increasing return to scale as it has been assumed. Finally,**η** which is an important parameter in this research has been estimated 0.014. **(**According to equation (11) along the long-run path when the main factors of the equation growth at a constant rate, if the ratio of the Iranian researchers will be as twice as it is then the level of income will be increasing by 1.01[6]**).** By adding and subtracting the steady-state growth rate of **ηn** in equation (13) the equation below is extracted:

$$(17) \qquad \hat{o} = \left(\frac{\beta}{1-\beta}\right)\left(\hat{C} - \hat{O}\right) + \hat{l}_o + \hat{h}_t + \left\{\left(\frac{\nu}{1-\beta}\right)\hat{l}_t - \eta n\right\} + \eta n$$

$\left\{\left(\frac{\nu}{1-\beta}\right)\hat{l}_t - \eta n\right\}$is the excess ideas growth clause (Jones 2002). Table (5) shows the quantity of these factors and the percentage of their effect on economic growth.

According to the table(5)the growth rate in the economy of Iran is too much far from its intended long-term run growth. It can be shown from these quantities that economic growth in Iran is due to transition dynamics, and when these factors reach their steady state form, the rate of economic growth will fall considerably.

Constant growth Path

The question could be arises here which if 95 percent of the economic growth during the recent years is up to the transition dynamics, as educational attainment and extension in research, why we do not see any decreases along the growth path during this period? And how come this growth is stable, to some extent?[7]

One reason could be that the constant growth path formed following as a result of different transition dynamics. Now we want to declare this path.

Considering the equation (11):

$$o_t = \left(\frac{S_c}{n + g_c + \sigma}\right)^{\frac{\beta}{1-\beta}} * l_o * h_t * \left(\frac{X}{g_t}\right)^{\frac{\eta}{\varepsilon}}\left(\frac{\delta}{g_{Ig}}\right)^{\left(\frac{\rho}{\varepsilon}\right)\left(\frac{\eta}{1-\zeta}\right)} * H_{Ig}^{\left(\frac{\rho\eta}{\varepsilon}\right)\left(\frac{\epsilon}{1-\zeta}\right)} * H_t^{\eta}$$

If we substitute the equation (4) in it and consider the value of $\left(\frac{S_c}{n+g_c+\sigma}\right)$ as A and assume that the rate of technological progress in G5 and Iran and also the rate of growth of physical capital per capita are constant, then we have:

$$(18) \qquad \frac{\dot{O}_t}{O_t} = \left(\frac{\beta}{1-\beta}\right)\frac{\dot{A}_t}{A_t} + \frac{\dot{l}_{o_t}}{l_{o_t}} + \psi\Delta e_t + \left(\frac{\rho\eta}{\varepsilon}\right)\left(\frac{\epsilon}{1-\zeta}\right)\frac{\dot{H}_{Igt}}{H_{Igt}} + \eta\frac{\dot{H}_t}{H_t}$$

Then by putting $l_{Ig}*L_{gt} = H_{Ig}$ and $l_I*L_t = H_t$ while substituting $\left(\frac{\rho\eta}{\varepsilon}\right)\left(\frac{\epsilon}{1-\zeta}\right)$ for B the constant growth equation would be obtained:

$$(19) \qquad g_0 = \left(\frac{\beta}{1-\beta}\right)g_A + g_{l_o} + \psi\Delta e_t + Bg_{l_{Ig}} + Bg_{n_g} + \eta g_{l_I} + \eta n$$

In steady state, all the parts of the equation (19) would be equal to zero except the last one. So in that case we reach equation (12) that was gathered before. Table (6) shows the value of the different parts of the constant growth equation.

As it is shown in table (6), in the constant growth path in which the growth of transition dynamics would be equal to zero, labor force has a weak effect on economic growth and justifies just 3.5 percent of it.

[6] It is important to know that increasing the numbersof researchers needs an extension of its infrastructures like financial resources, expansion of researching areas, and, etc.

[7] Undoubtedly we should extract the years of revolution and war

The main factor of this growth relates to educational attainment. The growth rate of researchers also plays the important role in recent years.

Conclusion

This paper presented and calibrated a model in economic growth for Iran in the world of ideas. The long-run growth in any countries can be obtained from the discovered ideas all around the world. In the long-run, the stock of ideas is proportional to researchers' intensity that is the ratio of population in the economy. This model has an increasing return to scale because of the nonrivalry property of ideas.

Estimated quantities of this research show that an increase in education level and expansion in research activities correspond to main factors promoting recent economic growth in Iran. The growth rate of Iran labor force accounts for five percent of the economic growth during this period. Whereas in the long term, the growth rate of transition dynamics such as educational level and research activities declines to zero and in that time the income growth would slump intensively because of the improper reallocation of the human and physical capital.

Considering the significant gap between Iran and G5 countries in levels of education and research, investment in these sections is vital for the further economic growth in the short time while lifting the current sanctions may help to absorb and implement new ideas. Migration of graduate level individuals and skilled workers isanother controversial issue. Consider all the time and resources which are invested in an individual from her date of birth, and perhaps before, until her graduation suddenly vanish because of the economic and political instability of the country which forcing her to move abroad and pursue a secure life. In addition to achieve high growth rate in the long term, the economy of Iran needs a fundamental revolution in its structure and optimum use of its human resources and natural resources which would be obtain by adjusting the economic and managerial views of her policy makers but not by population growth.

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Table (1) Average growth rate of the main Factors in Selected Countries Economic growth (1996-2006)

Factor	Iran	US	Germany	UK	Japan	France
TFP	0.017	0.007	0.006	0.0003	0.001	0.008
TP	0.133	0.06	0.076	0.083	0.033	0.067
Capital per capita	0.003	0.028	-0.001	0.025	-0.002	0.033
Labor force	0.037	0.01	-0.0004	0.008	-0.006	0.01
Output per worker	0.031	0.021	0.014	0.025	0.009	0.018

Table (2): The Variance from the Output

Error term	Lag 0	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
R2	**3.62**	**2.02**	**1.59**	**1.94**	**2.66**	**1.73**
R* (%)	**20.0**	**11.0**	**8.8**	**10.7**	**14.7**	**9.6**

*is the percentage of variance from average quantity of GDP per worker

Table (3): Factors of Economic Growth of Iran

Output per worker	Capital intensity	Labor reallocation	Educational attainment	Ideas intensity
Ô	**(β/(1-β))(Ĉ- Ô)**	**ĺy**	**Ĥ**	**(ν/(1-β)) Î**
0.0255	**-0.0004**	**0.0014**	**0.015**	**0.0104**

Table (4): Growth Correlative Parameters

N	**β**	**ε**	**ρ**	**Ө**	**η**	**ηn**
Ideas efficiency	Capital efficiency	Researchers efficiency	Impact of G5 TP on Iran TP	Effect of the past Ideas on new ones	Long-run growth coefficient	Long-run growth rate
0.062	0.138	0.011	0.015	0.956	0.014	0.0005

Table (5) Accounting for Iran growth 1996-2006[8]

Output per worker	Capital intensity	Labor reallocation	Educational attainment	Excess ideas growth	Steady-state growth
Ô	**(β/(1-β))(Ĉ- Ô)**	**ĺy**	**ĥ**	**(ν/(1-β)) Î- ηn**	**ηn**
0.0255	**-0.0004**	**0.0014**	**0.015**	**0.0099**	**0.0005**
100 %	**-1.57 %**	**5.28 %**	**56.62 %**	**37.71 %**	**1.96 %**

[8] The error quantity that is obtained in this table is less than four percent, *so* that it could be acceptable along this short time.

Table (6) Average growth Rate Factors in Iran 1996-2006[9]

Description	Variable	Value	Percent of g_o
Output per worker	g_o	**0.0143**	**100%**
Capital-output ratio	$(\beta/1-\beta)g_A$	**-0.0002**	**-1.3%**
Share of labor in goods	g_{l_o}	**0.0009**	**6.3%**
Educational attainment	$\varphi\Delta e_t$	**0.011**	**76.5%**
G5 researchers	$Bg_{l_{lg}}$	**0.0001**	**0.7%**
G5 labor force	Bg_{n_g}	**0.00005**	**0.3%**
Iran researchers	ηg_{l_I}	**0.002**	**13.9%**
Labor force	ηn	**0.0005**	**3.5%**

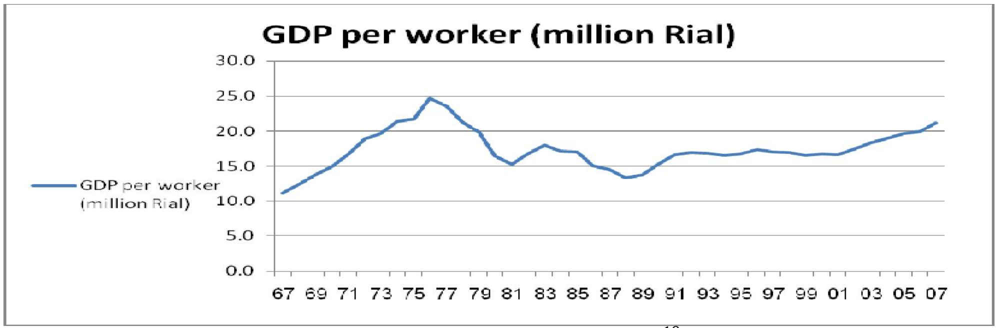

Figure (1): GDP per Capita[10]

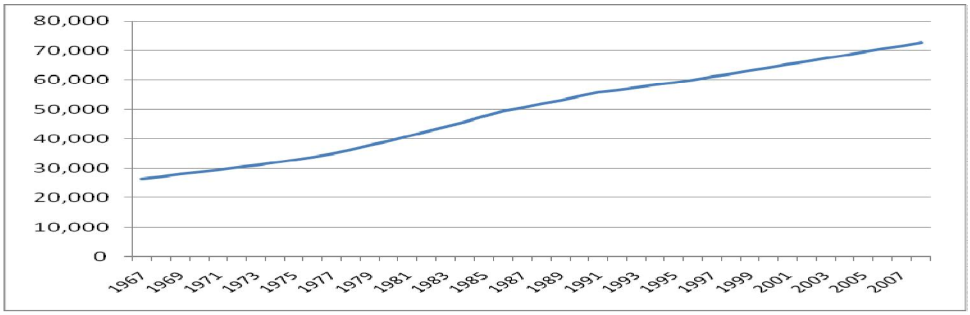

Figure (2): Population growth rate (Thousand People)[11]

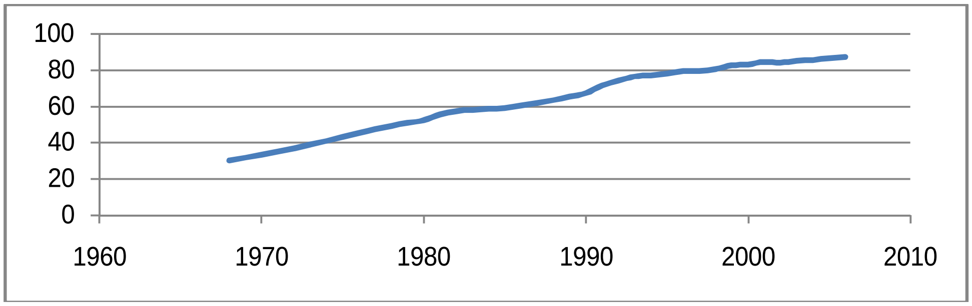

Figure (3) Level of Literacy[12]

[9] The error quantity which is obtained in this table is less than three percent, *so* that it could be acceptable along this short time.
[10] WDI database
[11] WDI database
[12] WDI database

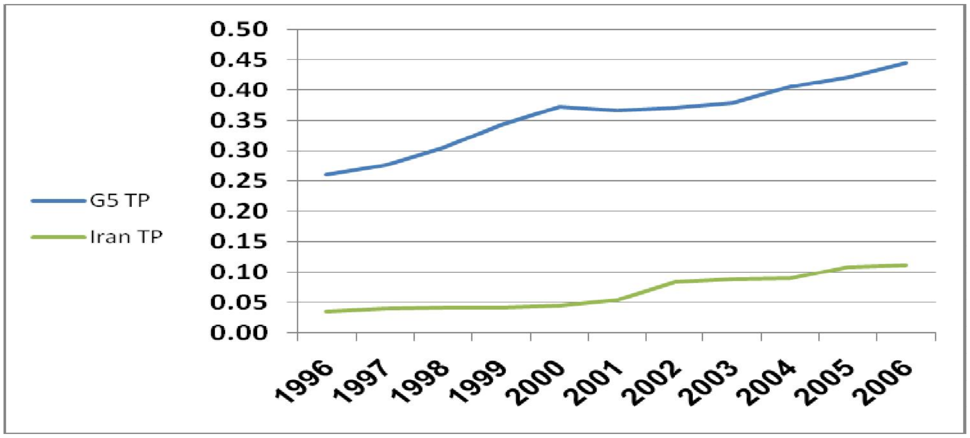

Figure (4) TP of Iran and G5 Countries

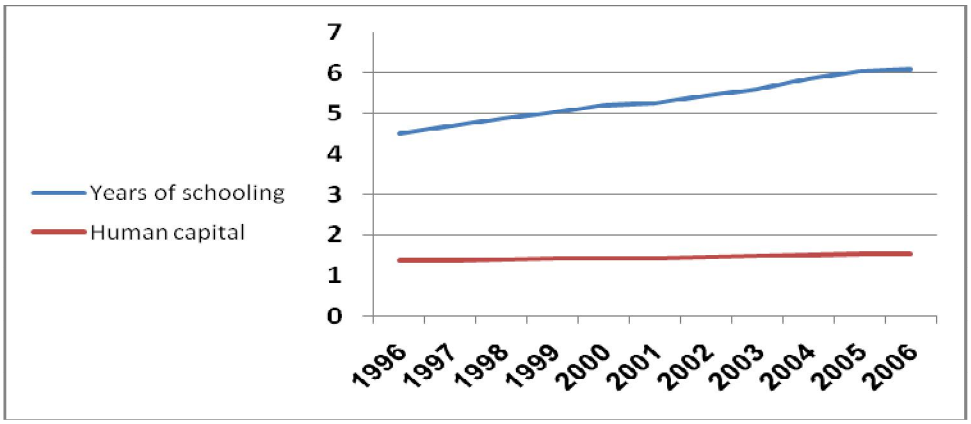

Figure (5) Human Capital and years of Schooling in Iran

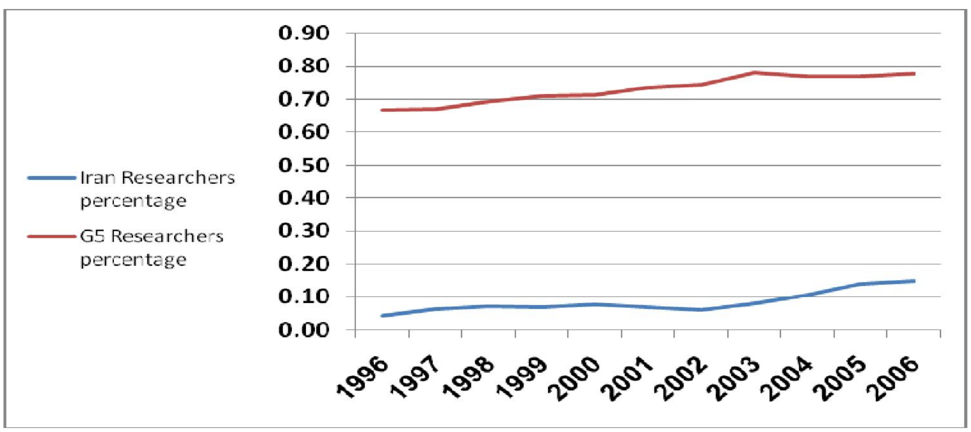

Figure (6): Researchers Percentage in G5 and Iran