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TEKPOL Working Paper Series
STPS-WP-12/07

The Role of Knowledge on Economic Growth: The Case of Turkey, 1963-2010

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Abstract

The importance of knowledge for long-run economic growth has long been an important research area for economists and policy makers. This paper attempts to analyze the impact of knowledge on economic growth in Turkey over the 1963-2010 period, by using a production function approach. In contrast to early studies, which have analyzed the impact of a single dimension of knowledge on economic growth, a knowledge index is constructed to see the impact of various dimensions of knowledge with a single and comprehensive measure of the "level" of knowledge in the economy. Moreover, time series methods -such as cointegration and impulse response analysis- are used to analyze the role of knowledge on economic growth in Turkey. The empirical results indicate that higher level of knowledge had a positive impact on the growth rate of Turkish economy over the sample period. It is, therefore, necessary to create an economic environment that is conducive to enhance the level of knowledge and hence economic growth in Turkey.

Keywords: Knowledge, Economic Growth, Turkey

JEL Code: O47

[1] This paper is based on my Ph.D. Thesis in progress in the Department of Science and Technology Policies, METU.

1. Introduction

Prior 1960s economists were mainly analyzing the impact of two factors of production, namely capital and labor, on long-run economic growth. Other important determinants like technology and knowledge were considered to be “manna from heaven”. Later on, Arrow (1962), Nelson and Phelps (1966) and Uzawa (1965) introduced the role of education and learning into the growth literature. During the late 1980s, with the publications of Romer (1986) and Lucas (1988), this strand of literature has exploded and these studies have equipped economists with more advanced models to analyze the long-run growth trends of countries.

During the last five decades the developments in the communication sectors (e.g. information and communication technology (ICT)), changes in the international world order (globalization), increasing importance of research and development (R&D) and variations in socio-political environment have also contributed to the growth performances of countries. Thus, not surprisingly, these factors have been widely analyzed in the economic growth literature.

When we analyze the studies on the role of knowledge in economic growth of Turkish economy we see that the majority of them are descriptive and/or review articles.[2] Most of the empirical studies on the relationship between knowledge and the economic growth of Turkey focus on the role of a single or specific dimension of knowledge (e.g. education)[3] on economic growth. Furthermore, most (empirical) studies are, unfortunately, not sufficient either in terms of empirical analysis or data or scope. Without any doubt, these studies attempted to provide useful insights on the role of specific dimensions of knowledge on economic growth. However, a more efficient analysis would be to use a production function framework to see the effects of various pillars of knowledge - education, R&D, ICTs and institutional environment-, taken together within a single model, on economic growth of Turkey.

In this paper, I have analyzed the impact of knowledge on economic growth in Turkey over the 1963-2010 period by using a production function approach. In contrast to early studies, which have analyzed the impact of a single dimension of knowledge on economic

[2] For example, Saygılı (2003), Kelleci (2003), Çakmak (2008), Kibritçioğlu (1998) and Uçkan (2006).
[3] See, for example, Kar and Ağır (2004), Özsoy (2009) and Şimşek and Kadılar (2010).

growth I constructed a knowledge index that helps us to see the impact of various dimensions of knowledge with a single and comprehensive measure of the “level” of knowledge in the economy. Moreover, I used popular time series methods, such as cointegration and impulse response analyses, to analyze the role of knowledge on economic growth in Turkey.

The following section provides a brief literature review and the next section introduces the model. Section 4 provides the knowledge index and Section 5 provides the empirical results and finally, Section 6 provides the concluding remarks.

2. Growth Theories: A Brief Literature Review

The neoclassical growth theory (Solow-Swan Model) is based on production functions with strict neoclassical assumptions, such as, constant returns to scale, diminishing returns to inputs and the perfect competition assumption. Only two factors, capital and labor, are considered in the production function. According to this model economic growth performance of a country is influenced by exogenous factors, namely, technology and population growth.[4] According to Solow (1956) time was the only variable that affected the level of productivity. More specifically, he used the following aggregate production function:

$$Y = A(t)\, F(K, L) \qquad (1)$$

where Y is the level of aggregate output, K is the level of the capital stock, L is the size of the labor force, A is total factor productivity and t is time.

The most important prediction of the neoclassical theory was that the poor countries would eventually converge to the per capita income levels of the rich countries. But in reality the gap between the rich and some poor countries in the world has increased.[5] Moreover, Acemoğlu (2008) has also pointed out that there was divergence in incomes

[4] Technology, or total factor productivity, enters the growth accounting (production function) as a residual, and is called as the Solow residual. And technolgoy is freely available to every single country in the world because it is “manna from heaven”.
[5] It is acknowledged that the performance of the East Asian countries is contradictory to this statement.

across nations[6] in the world rather than convergence over the postwar era. Therefore, with its limited scope and strict neoclassical assumptions the *original* neoclassical growth theory failed to bring explanations to the realities observed in the world.[7] Nevertheless, Mankiw et al. (1992) augmented Solow's model to overcome some of the above mentioned criticisms.[8]

Later on with the new growth theories endogenous factors within the economies were recognized to be the main source that caused economic growth and accounted for the observed differences of the economic growth of countries (Romer, 1994). Lucas (1988) and Romer (1986) have stressed the importance of human capital and technological progress in growth theory. Human capital has been recognized as the most important factor that has influenced performance of the richer countries since it is the key input in R&D which accelerates technological progress (Romer, 1990). Investment in R&D in the richer countries caused technological progress (or innovations) which improved the capital (e.g. machinery) goods used in the production process. This in turn accelerated their growth rate and since this technological progress (via R&D) had a cost, it was not a "manna from heaven", and it was available only to the countries that could afford to buy it. Thus the new strand of growth theory internalized technological progress and tried to explain the growth rates of countries accordingly. The assumptions, in general, are more flexible and more realistic compared to the neoclassical models. There is increasing returns to scale and in some sectors of the economy there is imperfect competition.[9] Other issues such as trade and policy decisions (e.g. on infrastructure spending) have been entered into the growth theory through endogenous growth models.[10]

To sum up, many studies have attempted to endogenize the exogenous component (A) of the Solow Model. More specifically, the following production function can be formed by considering all of the above mentioned strands of the endogenous models

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[6] However, some studies have found conditional convergence. That is, there was convergence in the income between countries that were similar in characteristics, especially high income countries (see, Acemoğlu (2008) for an overview).

[7] It would be unfair not to mention that the economists were aware of the unrealistic assumptions that they were using but argued that these assumptions was what made up the theory (Solow, 1956:65).

[8] Currently this augmented version of the Solow Model is being used by various researchers. See for example Erdil et al. (2009).

[9]The major factor behind this is the improvements in the mathematical techniques which have made it possible for economists to abandon the assumption of perfect competition and work with imperfect competition (The Economist, 1992:18).

[10] See, for example, Barro (1990) and Grossman and Helpman (1989).

$$Y = A(r, h, m, c)\, F(K, L) \quad (2)$$

where r is the level of domestic R&D, h is the level of education, m is the amount of import (or trade) and c is the level of infrastructure spending (e.g. communications).

3. The Primacy of Knowledge and the Model

During the last decade economists have tried to measure the impact knowledge on economic growth in various ways.[11] For example, Chen and Dahlman (2004) postulated that there are four pillars (or preconditions) of knowledge economy which transforms knowledge into *an effective engine of growth*. These pillars are economic and institutional regime, educated and skilled population, dynamic information infrastructure and efficient innovation system. They argue that when these four pillars are strengthened this would increase the level of knowledge used in production, and thus increase economic growth via affecting total factor productivity (TFP). That is, in their study, Chen and Dahlman (2004) have considered the following production function

$$Y = A(g, e, r, i)\, F(K, L) \quad (3)$$

where g represents institutional and/or economic regime of the economy, e represents education and training, r represents country's level of domestic innovation, i represents country's information and communication infrastructure and other variables are as defined before.

In line with Chen and Dahlman (2004) and considering the previous studies I will attempt to use the following Cobb-Douglas production function -as the initial specification- in my empirical investigation of the role of knowledge on economic growth.

$$Y_t = \beta_0 O_t^{\beta_1} E_t^{\beta_2} P_t^{\beta_3} C_t^{\beta_4} K_t^{\beta_5} L_t^{\beta_6} \quad (4)$$

where O represents the economic structure (regime) of the economy, E denotes education, P represents country's level of domestic innovation and C denotes country's communication infrastructure, Y is output, K is capital and L is labor.[12]

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[11] Chen and Dahlman (2004) and Poorfaraj et al. (2011) provide comprehensive review of empirical evidence on the role of knowledge on economic growth at international level.

[12] It should be noted that TFP (A_t) is explicitly modelled in Equation (4), and equals to $\beta_0 O_t^{\beta_1} E_t^{\beta_2} P_t^{\beta_3} C_t^{\beta_4}$. Note that, in terms of Equation (3) O, E, P, C represent g, e, r and I, respectively.

Equation (3) can be restated as the following log-linear model.

$$LnY_t = \beta_0^* + \beta_1 LnO_t + \beta_2 LnE_t + \beta_3 LnP_t + \beta_4 LnC_t + \beta_5 LnK_t + \beta_6 LnL_t \qquad (5)$$

where β_0^*=Ln β_0 and β_i's represent the respective elasticities (e.g. β_5 is the elasticity of output (Y) with respect to capital (K)).

Equation (5) allows us to investigate the role of the four dimensions (indicators) of knowledge on growth (that is, the role of openness, education, country's level of domestic innovation and country's communication infrastructure). However, these four indicators are highly correlated (see Section 4); therefore, I attempted to construct a proper knowledge index (KNIW). Construction of such an index provides us a single but comprehensive measure on the "level" of knowledge in the economy, which has a multi-dimensional facets (see, for instance, World Bank, 2006). Thus, considering all these issues, equation (5) can be re-written as follows,

$$LnY_t = \beta_0^* + \theta\ KNIW_t + \beta_5 LnK_t + \beta_6 LnL_t \qquad (6)$$

where KNIW is the knowledge index[13] and all the other variables are as defined earlier.

In line with the literature constant returns to scale is imposed on equation (6) and we obtain the following specification.

$$\ln\left(\frac{Y}{L}\right)_t = \beta_0^* + \theta\ KNIW_t + \beta_5 \ln\left(\frac{K}{L}\right)_t \qquad (7)$$

where Y/L is the output per labor, K/L is the physical capital per labor and KNIW is the knowledge index.

Therefore, the following empirical (stochastic) log-linear model is used in empirical applications.

$$\ln\left(\frac{Y}{L}\right)_t = \alpha_0 + \alpha_1 KNIW_t + \alpha_2 \ln\left(\frac{K}{L}\right)_t + u_t \qquad (8)$$

Note that $\alpha_0=\beta_0^*$, $\alpha_1=\theta$, $\alpha_2=\beta_5$ and u is the disturbance term and all other variables are as defined earlier.

[13] Details of the knowledge index are provided in Section 4.

From here onwards my empirical analysis proceeds in two steps. First I will construct the knowledge index in the next section. Then I will estimate the production function provided in Equation (8) in Section 5.

4. The Knowledge Index

As noted before, construction of a knowledge index would provide us with a single and comprehensive measure on the "level" of knowledge in the economy. Moreover, such an index could also prevent the potential problem of multi-collinearity in the empirical analyses since the indicators of knowledge economy are highly correlated (Table 1).

Table 1. Correlation Matrix of the Knowledge Indicators

	LNC	**LNP**	**LNE**	**LNO**
LNC	1.000000	0.780799	0.988333	0.955331
LNP	0.780799	1.000000	0.718296	0.680130
LNE	0.988333	0.718296	1.000000	0.967248
LNO	0.955331	0.680130	0.967248	1.000000

Since the four physical indicators of knowledge are in different units and have different ranges (minimums and maximums), I use the Human Development Index (HDI) methodology to obtain a common range for them. That is, I set a minimum and a maximum bound to each one of the four indicators and obtain a number (index value) for each observation of these indicators between 0 and 1. Formally speaking, with this conversion the four indicators become indices which are labeled as ILNC, ILNP, ILNE and ILNO. More precisely, the four indices are calculated as follows:

$$ILNC_t = \frac{LNC_t - Min(LNC)}{Max(LNC) - Min(LNC)} \qquad (9)$$

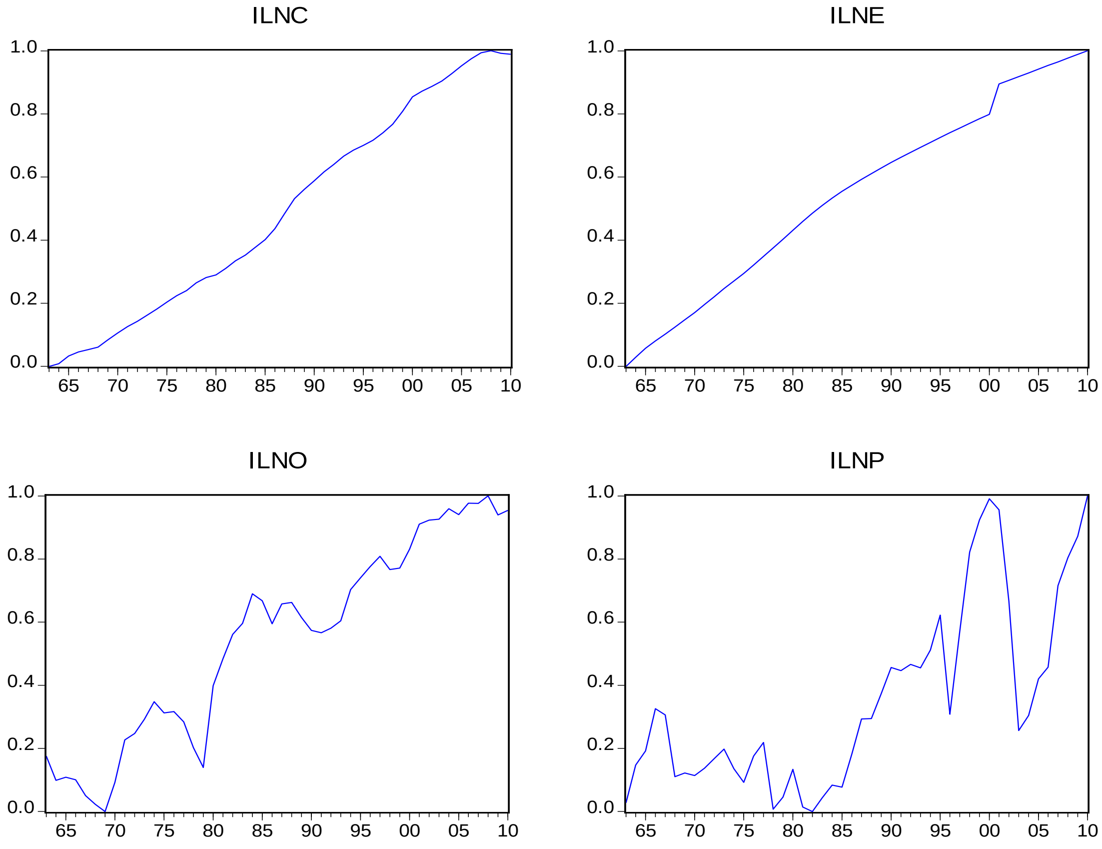
$$ILNP_t = \frac{LNP_t - Min(LNP)}{Max(LNP) - Min(LNP)} \qquad (10)$$

$$ILNE_t = \frac{LNE_t - Min(LNE)}{Max(LNE) - Min(LNE)} \tag{11}$$

$$ILNO_t = \frac{LNO_t - Min(LNO)}{Max(LNO) - Min(LNO)} \tag{12}$$

Figure 1 provides the time plots of the four sub-indices; namely, ILNC, ILNP, ILNE and ILNO.

Figure 1. The Time Plot of the Sub-indices



The Knowledge Index (KNIW) is calculated as a weighted average of the four sub-indices:

$$KNIW = w_1\, ILNC + w_2\, ILNE + w_3\, ILNP + w_4\, ILNO \tag{13}$$

where w_i's denote weights of the respective variables.

In order to determine the weights of the four sub-indices I have used the method of principal component analysis.[14] The results are presented in Table 2.

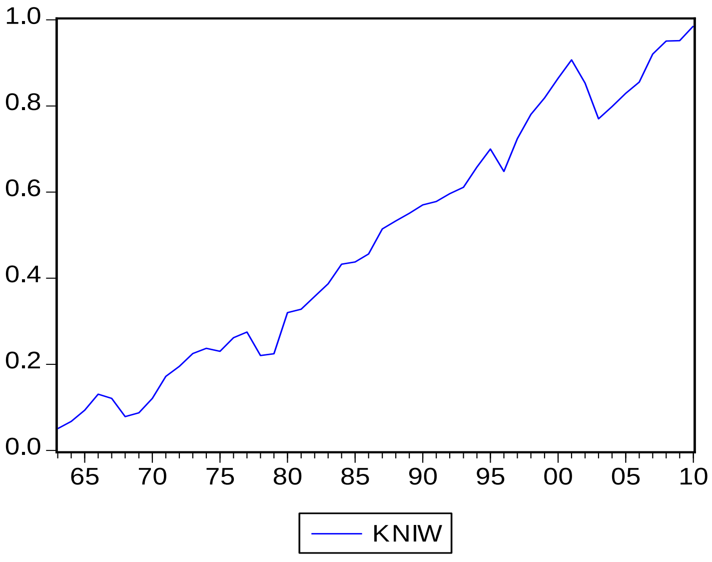
Table 2. Principal Component Analysis		
Variable	**Eigen Vectors (Weights)**	**Relative Weights (w_i)**
ILNC	0.525308	0.2633
ILNE	0.519244	0.2602
ILNP	0.441353	0.2212
ILNO	0.509553	0.2554

By using the results obtained in Table 2 I have constructed KNIW as follows:

KNIW= 0.2633 ILNC+ 0.2602 ILNE + 0.2212 ILNP + 0.2554 ILNO (14)

Figure 2 shows the time plot of the knowledge index.

Figure 2. KNIW, 1963-2010.



In sum, the knowledge index (KNIW) is a composite of the four sub-indices which roughly captures the four main dimensions of knowledge. Therefore, the KNIW shows the level of knowledge in a given time period. As a consequence, KNIW gives us the possibility to analyze performance of Turkey, in terms of the attainment of knowledge.

[14] See Alesina and Perotti (1996) for more detail.

over time. For example, if Turkey has a higher KNIW value in the current year compared to the previous year, then we may say that there has been improvement in the knowledge level. Nevertheless, it should be noted that some components (ILNO and ILNP) of the KNIW are sensitive to economic conditions (for example, economic crisis).

5. Empirical Results

5.1. Unit Root Tests

Before estimating the production function with the yearly time series data from 1963 to 2010, it is essential to check for the presence of a unit root in each series. Figure 4 provides the time plots of Ln (Y/L), Ln (K/L) and KNIW. There is a visual evidence of nonstationarity in each series (Figure 3).

Figure 3. The Time plot of Ln (Y/L), Ln (K/L) and KNIW, 1963-2010.

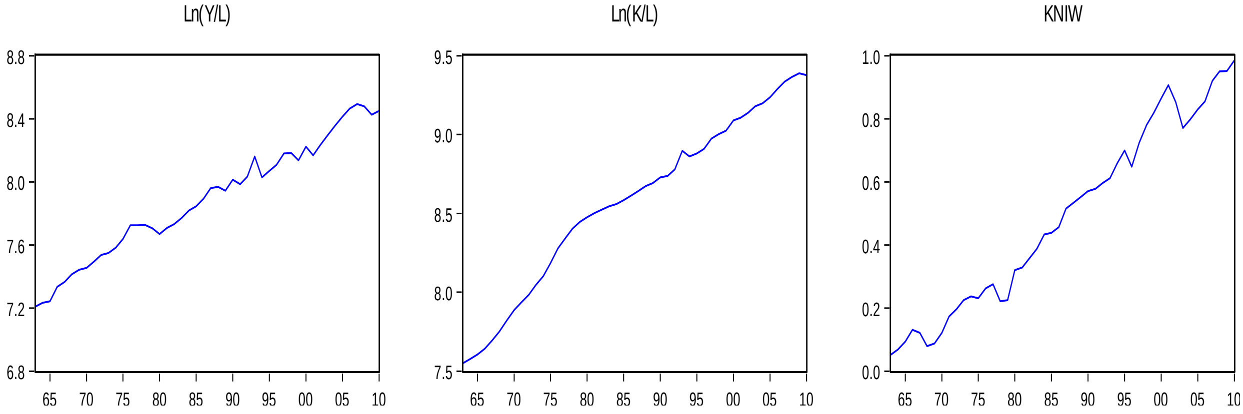


Table 3 provides the unit root (DF-GLS)[15] test results. As is clear from this table, for the levels of all the variables, the null hypothesis of a unit root is not rejected at the 5% significance level, including only constant term in deterministic components of the tests. Furthermore, the null hypothesis of a unit root for the first differences of all variables is rejected at the 5% significance level. Considering these results, it can be stated that all variables contain a unit root. However, if we add linear trend as an additional

[15] The Elliott-Rothenberg-Stock (ERS) DF-GLS tests (Elliott et al.,1996) are considered to be better (i.e. more powerful) than ordinary ADF tests (see for example, Zivot and Wang (2006) and Enders (2010)).

deterministic component, the null hypothesis of a unit root -for the levels of all the variables- is not rejected at the ***1%*** significance level but rejected at the 5% significance level for Ln (Y/L) and KNIW**.** Therefore, there is some evidence of the existence of deterministic (linear) trend in these two variables. Fortunately, Johansen cointegration method is capable for handling this empirical issue.

Table 3. Unit Root (DF-GLS) Tests			
Variables	**DF-GLS Test**		
	Level		**First Difference**
	Without Trend	**With Trend**	**Without Trend**
Ln (Y/L)	1.1518 (0)[a]	-3.4266 (0)*[b]	-8.3375 (0)*
Ln (K/L)	-0.2111 (2)	-0.8158 (0)	-5.6709 (0)*
KNIW	1.6291 (0)	-3.3598 (1)*	-5.9842 (1)*

[a] The optimal lag chosen by SBC (Schwarz Bayesian Criterion) are given in parentheses. The maximum lag length is 2. SBC is recommended by ERS (1996) for selecting lag length (Also see Enders (2010:241)). [b]The asterisk indicates the rejection of null hypothesis (i.e. the existence of unit root) at the 5% significance level

5.2. Cointegration Analysis

I use Johansen cointegration analysis (Johansen, 1995) for investigating the long-run relationship between knowledge and output (growth).[16] Considering the possibility of linear trends in data and following Hendry and Juselius (2001), the deterministic components of the VAR model is specified as constant term entering unrestrictively and with no trend term in the cointegration relation.

Johansen cointegration tests; namely the Trace and Max tests suggest one cointegration relation among the three variables in Equation (8) (see Table 4).

Table 4. CointegrationTests			
Eigenvalue	0.416716	0.117626	0.021231
Null Hypothesis	$r = 0$	$r \leq 1$	$r \leq 2$
Trace Statistic	32.22694	6.890156	1.008623
95% Critical Value	29.79707	15.49471	3.841466
Max Statistic	25.33679	5.881533	1.008623
95% Critical Value	21.13162	14.26460	3.841466

Note: r denotes cointegration rank (the number of cointegration relation).

[16] Johansen approach is more efficient than the Engle-Granger approach in the case of more than two variables.

The production function in Equation (8) is estimated by Johansen method as follows: [17]

$$\ln\left(\frac{Y}{L}\right)_t = 4.1910 + 0.5914\ KNIW_t + 0.3974\ \ln\left(\frac{K}{L}\right)_t \qquad (15)$$

Equation (15) implies that the output per labor is positively affected by both physical capital per labor and knowledge index. These findings are statistically significant and consistent with theoretical expectations.

Fully Modified Least Squares (FM-OLS) method (Philips and Hansen, 1990) provided a similar results:[18]

$$\ln\left(\frac{Y}{L}\right)_t = 4.0134 + 0.4731\ KNIW_t + 0.4244\ \ln\left(\frac{K}{L}\right)_t \qquad (16)$$

As before, these findings are statistically significant and consistent with theoretical expectations.

Both Johansen and FM-OLS methods yield similar estmates for Equation (8) and they are consistent with the theory. Thus, we can confidently conclude that knowledge has a positive impact on the Turkish economy during the 1963-2010 period.

5.3. Impulse Response Analysis

In order to investigate the short-term dynamics of the production function model, this section provides the impulse response analysis. Figure 5 provides the generalized impulse

[17] Considering the sample size, lag length of the VAR is chosen as 1. Residuals of the equations of vector error correction (VEC) model are not serially correlated and homoscedastic at 5% and satisfy normality at 1% level of significance. After examining the residuals plot of the equations, I also re-performed the analysis by including an impulse dummy for 1994, to account for the significant economic crisis. In this case (including 1994 impulse dummy), residuals are not serially correlated, homoscedastic and normal at 5% level of significance. Estimated equation is quite similar to that of equation (15).

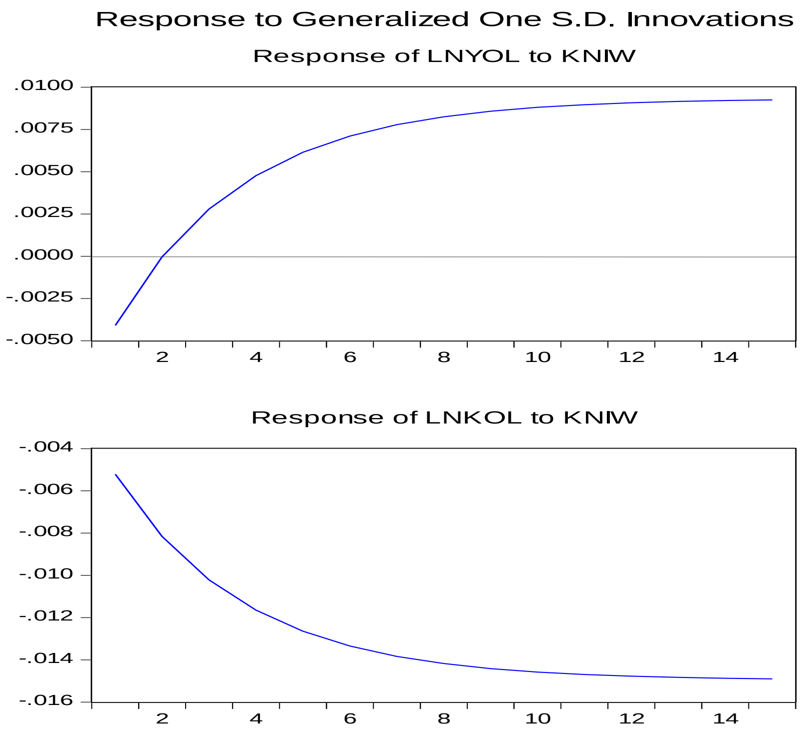
[18] The FM-OLS approach takes into consideration the endogenity problem and non-stationarity of the data (Philips and Hansen, 1990). Finally, note that the OLS method has provided quite similar results but unsurprisingly the estimates are not as close as the estimates of Johansen and FM-OLS techniques.

response functions of Ln (Y/L) [LNYOL] and Ln (K/L) [LNKOL] to a positive unit shock in KNIW.[19]

As is seen from the upper panel of Figure 4, Ln (Y/L) is initially negatively affected from an increase in KNIW. However, Ln (Y/L) is eventually positively affected from KNIW. That is, in the end a rise in the level of knowledge has favorable effects on output per worker. This is consistent with the theoretical arguments that I have mentioned before: improvements in TFP (here, via knowledge indicators) is not "manna from heaven" but requires deliberate policy actions and is available at a cost.

Lastly, as can be seen from the lower panel of Figure 4, the dynamic effects of a rise in KNIW on Ln (K/L) is not favorable. This result is also in line with the theory. The higher level of knowledge (or a rise in total factor productivity) requires less capital per labor to produce same output.

Figure 4. Impulse Responses to KNIW



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[19] I have preferred generalized impulse responses rather than the ones based Cholesky (orthogonalized) innovations because generalized impulse responses are not sensitive to the ranking of the variables within the model (Pesaran and Shin, 1998).

6. Conclusion

In this study I have constructed a knowledge index to see the impact of various dimensions of knowledge with a single and comprehensive measure of the “level” of knowledge in the economy. Moreover I used time series methods to analyze the role of knowledge on economic growth in Turkey over the 1963-2010 period by using a production function approach. The empirical results indicate that the higher level of knowledge had a positive impact on the growth rate of Turkish economy over the sample period. Therefore, it is necessary to create an economic environment that is conducive to enhance the level of knowledge and hence economic growth in Turkey.

The Data Appendix

Output (Y) is measured by Gross Domestic Product (GDP) at 1998 constant prices. The Turkish Statistical Institute (TurkStat) has provided a new GDP series (at 1998 prices, billion TL) from 1998 onwards. The Turkish State Planning Organization (SPO)[20] extended the series back to 1950s.

Capital Stock (K_t) is constructed based on the perpetual inventory method[21], that is,

$$K_t = (1-\delta) K_{t-1} + I_t , \qquad \text{(A.1)}$$

where I_t is gross fixed capital investment and δ is the depreciation rate ($0 < \delta < 1$).

Turkstat has recently changed the definitions of investment series (I_t) for 1998-2010 period and Saygılı and Cihan (2008) extended it back to 1948. In accordance with various studies (see for example, Bosworth and Collins (2003)) I have set the depreciation rate at 5% (δ =0.05). Initial capital stock is calculated in line with Altuğ et al. (2008).[22] It should be noted that the estimated capital stock series is at 1998 constant prices.

Labor (L) input is measured by employment data. TurkStat provides L from 1988 onwards. For 1963-1988 period data series in the Bulutay (1995) study is used. Saygılı and Cihan (2008) and Altuğ et al. (2008) have used the same data in their studies.

Foreign trade to GDP ratio (O)[23] is used as an indicator of the openness that has been followed by Turkey. Data is obtained from Turkstat.

Education (E) is measured by the average years of schooling of the labor force (age 15-64). I have used the series in Altuğ et al. (2008) and I have extended this series to 2010.

A Country's Level of Domestic Innovation (P)[24] is measured by the total patent applications. I have used the series of World Bank (WDI).

Total number of telephone subscribers (C)[25], including mobile phone subscribers, is used to represent communications infrastructure. The data on telephone subscribers are obtained from the Turkstat and Telecommunications Authority.

[20] Ministry of Development.
[21] See, for example, among many others, Bosworth and Collins (2003) and Altuğ et al. (2008).
[22] The initial capital stock is calculated as $K_{49}=I_{50}/(g+\delta)$, where g is average growth rate of GDP over 1950-2010.
[23] O is used to represent the variable S in Equations (1) and (2).
[24] P represents the variable R in Equations (1) and (2).

REFERENCES

Acemoğlu, D. (2008). Introduction to Modern Economic Growth, Princeton University Press, USA.

Alesina, A. & Perotti, R. (1996). "Income Distribution, Political Instability, and Investment", European Economic Review, 40, 1203-1228.

Altuğ, S., Filiztekin, A. and Pamuk, Ş. (2008). "Sources of long-term economic growth for Turkey, 19880-2005", European Review of Economic History, 12, 393-430.

Arrow, K. J. (1962). "The Economic Implications of Learning by Doing", Review of Economic Studies, 29, 155-173.

Barro, R. J. (1990). "Government Spending in a Simple Model of Endogenous Growth", Journal of Political Economy, October, Part II, 98 (5), pp. 103-125.

Bulutay, T. (1995). Employment**,** Unemployment and Wages in Turkey, ILO&SIS, Ankara: SIS.

Chen, D. H. C. and Dahlman C. J. (2004). "Knowledge and Development: A Cross-Section Approach", World Bank Research Working Paper 3366, August 2004.

Çakmak, Ö. (2008). "The Influence of Education on Economy and Development", D.Ü.Ziya Gökalp Eğitim Fakültesi Dergisi 11, 33-41.

Elliott, G., Rothenberg T. J. and Stock, J. H., (1996). "Efficient Tests for an Autoregressive Unit Root", Econometrica, 64, 813-836.

Enders, W. (2010) Applied Econometric Time Series, 3rd edition, Wiley, U.S.A..

Erdil, E., Türkcan, B. and Yetkiner, H. (2009). "Does Information and Communication Technologies Sustain Economic Growth? The Underdeveloped and Developing Countries Case", TEKPOL Working Paper Series, 09/03.

[25] C represents the variable I in Equations (1) and (2).

Grossman, G.M. and Helpman, E. (1989). “Product development and International Trade”, Journal of Political Economy, 97, pp.1261-1283.

Hendry, F. D. and Juselius K. (2001) “Explaining cointegration analysis: part II”, The Energy Journal, 22(1), 75-120.

Johansen, S. (1995). Likelihood-based Inference in Cointegrated Vector Autoregressive Models, Oxford: Oxford University Press.

Kar, M. and Ağır, H. (2004). “Türkiye’de Beşeri Sermaye ve Ekonomik Büyüme İlişkisi: Eşbütünleşme Yaklaşımı ile Nedensellik Testi, 1926-1994”, SÜ İİBF Sosyal ve Ekonomik Araştırmalar Dergisi, 2004, 51-68.

Kelleci, A. M. (2003). “Bilgi Ekonomisi, İşgücü Piyasasının Temel Aktörleri ve Eşitsizlik: Eğilimler, Roller, Fırsatlar ve Riskler”, DPT. 2674, Temmuz 2003.

Kibritçioğlu, A. (1998). “Determinants of Economic Growth, and the Role of Human Capital in New Growth Models”, AÜ Siyasal Bilgiler Fakültesi Dergisi, 53(1-4), 207-230.

Lucas, R. E. Jr. (1988). “On the Mechanics of Economic Development.” Journal of Monetary Economics, 22, 3-42.

Mankiw, N.G., Romer, D. and Weil, D.N. (1992). “A contribution to the empirics of economic growth. Quarterly Journal of Economics”, 107(2), 407-37.

Nelson, R. R. and Phelps, E. S. (1966). “Investment in Humans, Technological Diffusion and Economic Growth”, American Economic Review, 56 (2), 69-75.

Özsoy C. (2009), "Türkiye'de Eğitim ve İktisadi Büyüme Arasındaki İlişkinin VAR Modeli İle Analizi", The Journal of Knowledge Economy & Knowledge Management, IV, 71-83.

Pesaran, M. H. and Y. Shin (1998). “Impulse response analysis in linear multivariate models”, Economics Letters, 58(1), 17-29.

Phillips, P. C. B. and Hansen, B. E. (1990), "Statistical Inference in Instrumental Variables Regression with I(1) Processes", Review of Economic studies, 57 (1), 99-125.

Poorfaraj, A., Samimi, A. J. and Keshavarz, H. (2011). "Knowledge and Economic Growth: Evidence from Some Developing Countries", Journal of Education and Vocational Research, 1(1), pp. 21-25.

Rodrik D. and Subramanian, A. (2003). "The Primacy of Institutions: and What this does and does not mean", Finance and Development, 31-34.

Romer, P. M. (1994). "The Origins of Endogenous Growth" The Journal of Economic Perspectives, Winter, 8(1), 3-22.

Romer, P. M. (1990). "Human Capital and Growth: Theory and Evidence." Carnegie-Rochester Conference Series on Public Policy, 32, 251-86.

Romer, P. M. (1986). "Increasing Returns and Long-Run Growth." Journal of Political Economy, 94, 1002-1037.

Saygılı, Ş. (2003). "Bilgi Ekonomisine Geçiş Sürecinde Türkiye Ekonomisinin Dünyadaki Konumu", DPT. 2675, Temmuz 2003.

Saygili, S. and C. Cihan (2008), Türkiye Ekonomisinin Büyüme Dinamikleri: 1987-2007 Döneminde Büyümenin Kaynakları, Temel Sorunlar ve Potansiyel Büyüme Oranı, TÜSİAD-T/2008-06/462.

Solow, R. (1956). "A Contribution to the Theory of Economic Growth." Quarterly Journal of Economics, 50, 65-94.

Sterlacchini, A. (2008). "R&D, higher education and regional growth: Uneven linkages among European regions" Research Policy, Research Policy, 37(6-7), 1096-1107.

Şimşek, M., and Kadılar, C. (2010). "Türkiye'de Beşeri Sermaye, İhracat ve Ekonomik Büyüme Arasındaki İlişkinin Nedensellik Analizi", C. Ü. İktisadi ve İdari Bilimler Dergisi, 11(1), 115-140.

The Economist, 1992, “Economic Growth: Explaining the mystery”, January 4th 1992, 17-20.

Uçkan, Ö. (2006). “Information Policy and Ecnonmics of Information: Productivity, Employment, Growth and Development”, Bilig Dünyası, 7(1), 23-48.

UNDP, (2001). Human Development Report 2001: Making new technologies work for human development . New York: Oxford University Press.

Uzawa, H. (1965). “Optimal Technical Change in an Aggregative Model of Economic Growth”, International Economic Review, 6, 18-31.

World Bank (2011). WDI Database, http://data.worldbank.org/data-catalog/world-development-indicators.

World Bank (2006). Knowledge Assessment Methodology. www.worldbank.org/kam.

World Bank, (1999). Knowledge for Development, New York: The World Bank Group.

Zivot, E. and Wang, J. (2006). Modelling Financial time series with S-PLUS, 2nd edition, Springer Science Business Media Inc., U.S.A..