Estimating Egypt's Potential Output: A Production Function Approach

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Abstract

The Egyptian economy has witnessed deterioration in its main macroeconomic indicators over the period (2008-2014). The main purpose of the paper was to estimate Egypt's potential output and identify the factors that might be responsible for the divergence of actual and potential output from each other. We used the production function approach to derive estimates of potential output and output gap over the period (1990-2014). The results of the analysis revealed that capital stock was the dominant factor contributing to GDP growth in Egypt, while the share of both labor and total factor productivity in GDP growth rate has been fluctuating over time. Intellectual property protection, efficiency of legal framework in settling disputes, strength of investor protection, and other factors exhibited a strong positive relationship with output gap in Egypt over the period (2010-2014).

1. Introduction

Potential output is defined as the level of output or productive capacity that an economy can reach without triggering either upside or downside pressures on inflation under full employment. The output gap is an important concept which refers to as the difference between the actual and potential output in percent of potential output (Blagrave et al. 2015). When the output gap is zero, it means that there is no either upward or downward pressure on inflation, as actual demand coincides with economy's potential productive capacity. While when the output gap is positive, it means that actual output level "demand" exceeds the potential level and this would build upside inflation pressures.

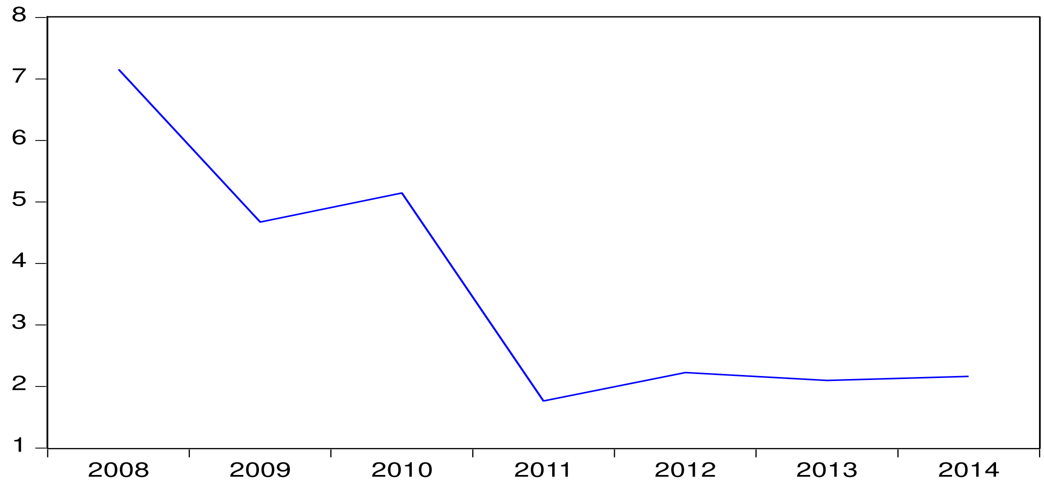
Output gap and potential output estimates are important for policymakers and Economists as it shades light on the economic performance of the country; as it indicates the relative deviation of actual output from its potential level and the availability of spare capacity in the economy. Also, it is an indicator regarding the success of government economic policies in stimulating economic activity and adopting a business friendly environment.

This paper consists of seven sections as follows: **First:** Introduction. **Second:** The Egyptian Economy: Challenges and Stylized Facts. **Third:** Empirical Methodologies to Estimate Potential Output. **Fourth:** Econometric Analysis: The Production Function Approach. **Fifth:** Contributions to Potential GDP Growth Rates in Egypt. **Sixth:** Factors Affecting Egypt's Output Gap. **Seventh:** Conclusion and policy implications.

2. The Egyptian Economy: Challenges and Stylized Facts

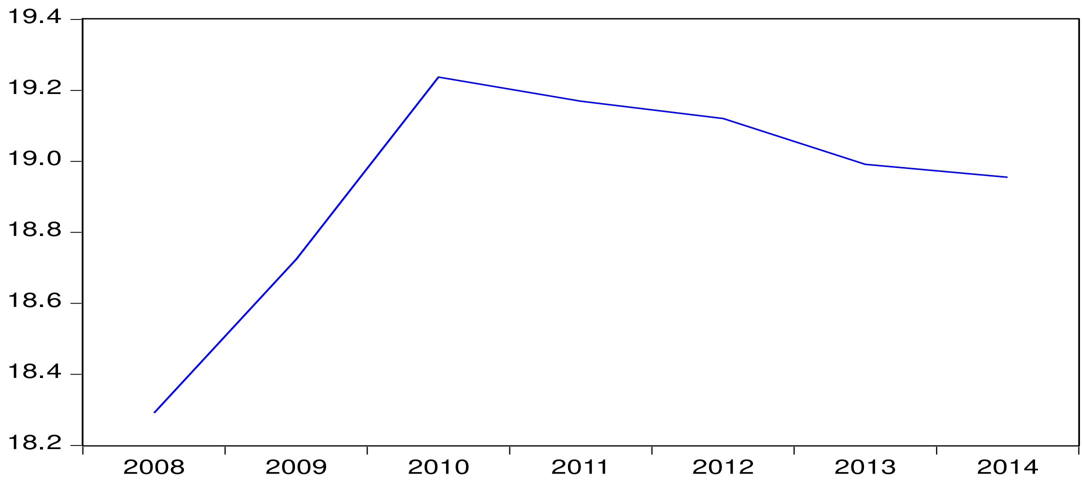
The Egyptian economy has witnessed deterioration in its main macroeconomic indicators over the period (2008-2014). Real GDP growth rates over this period recorded an average of about 3.6 percent, while growth rates exhibited a significant fall starting from 2011 as the average real GDP growth rate during (2008-2010) was around 5.7 percent (Figure 1), also real GDP per capita declined after 2011(Figure 2). Both national saving-to-GDP ratio and total investment-to-GDP ratio declined after 2011 and recoded around 13.2 percent and 14 percent in 2014, respectively (Figures 3 & 4). In tandem with a significant increase in structural budget deficit-to- potential GDP ratio, which increased from 8.3 percent in 2010 to 13 percent in 2014 (Figure 5). Unemployment rate has also increased from 8.3 percent in 2010 to 13 percent in 2014. To sum up, the Egyptian economy suffers problems in its macroeconomic fundamentals and structural reforms needs to be undertaken to put the economy on a sustainable growth path.

Figure (1): Real GDP Growth Rates (2008-2014)



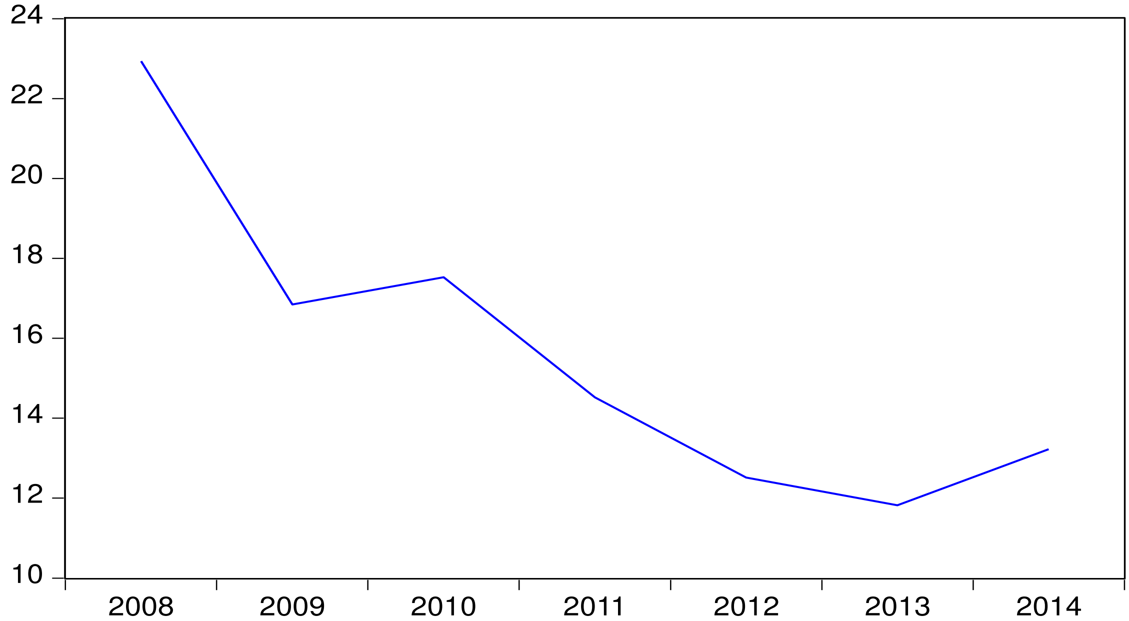
Source: International Monetary Fund. World Economic Outlook.

Figure (2): Real GDP Per Capita (1000 LE) (2008-2014)



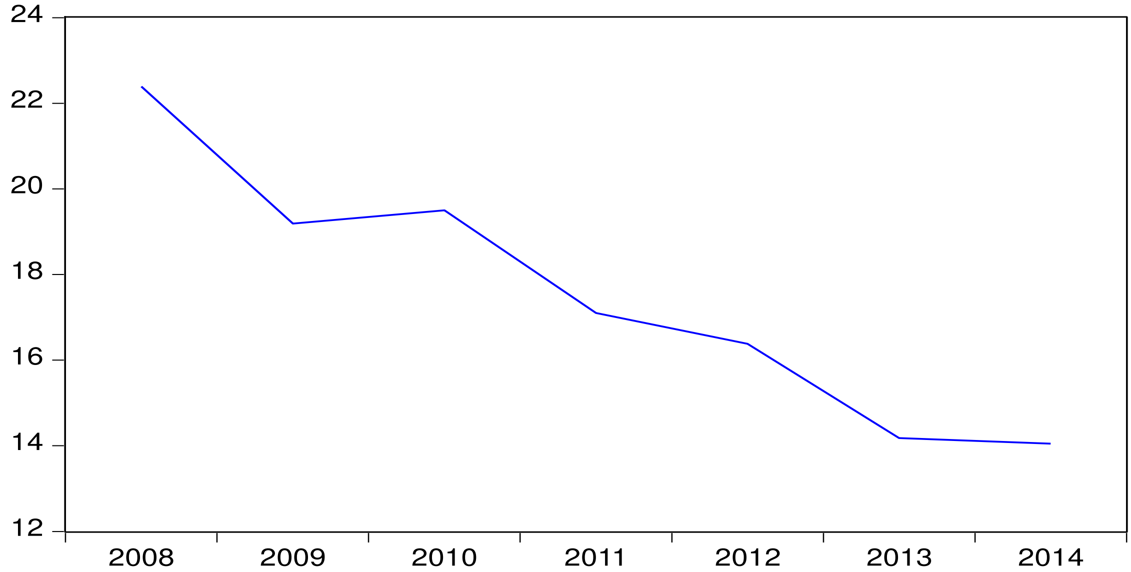
Source: International Monetary Fund. World Economic Outlook.

Figure (3): National Saving-to- GDP Ratio (2008-2014)



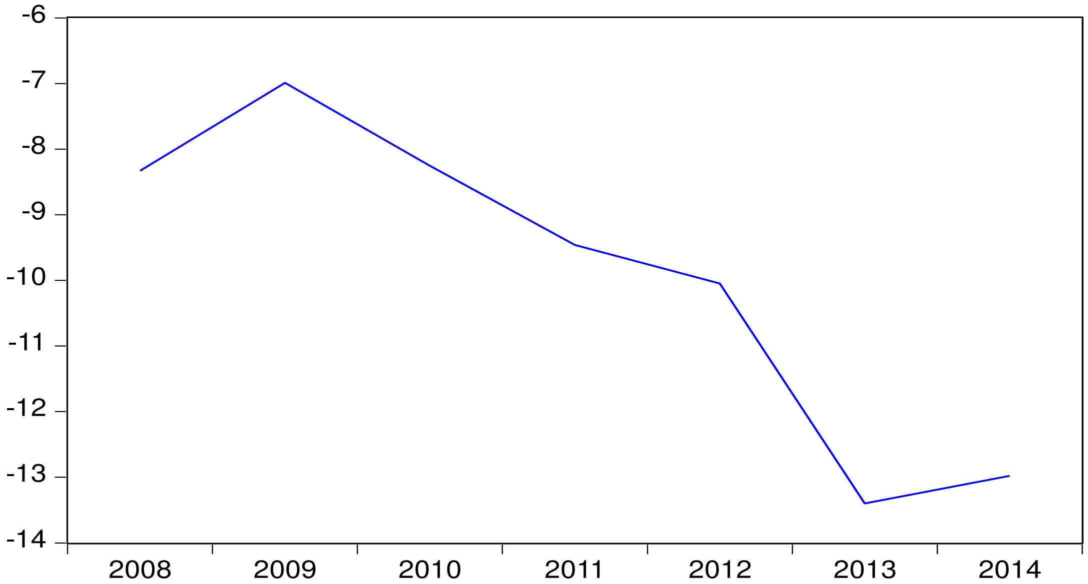
Source: International Monetary Fund. World Economic Outlook.

Figure (4): Total Investment-to-GDP Ratio (2008-2014)



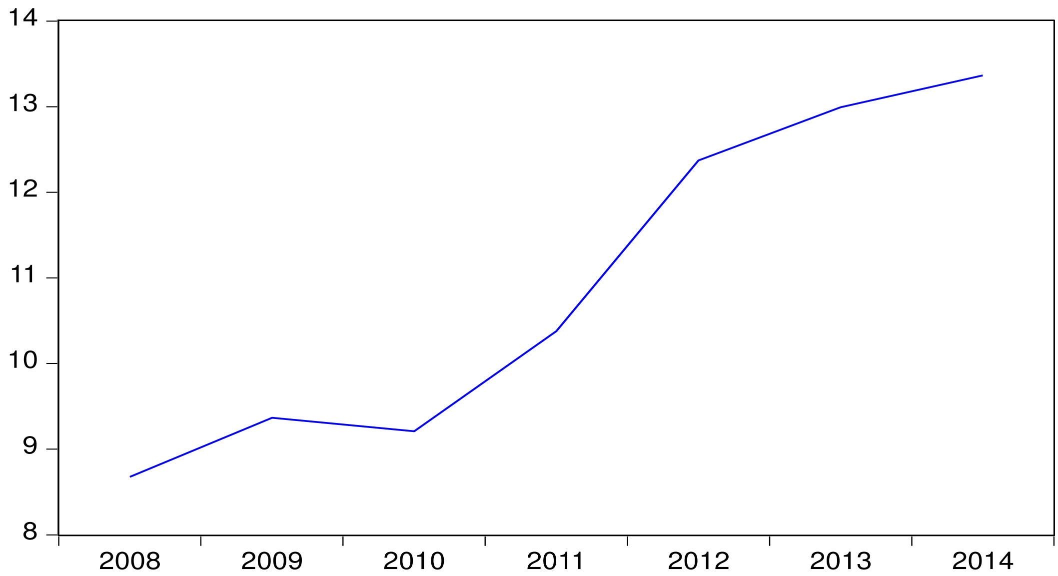
Source: International Monetary Fund. World Economic Outlook.

Figure (5): Structural Government Budget Balance-to-potential GDP Ratio (2008-2014)



Source: International Monetary Fund. World Economic Outlook.

Figure (6): Unemployment Rate in the Egyptian Economy (2008-2014)



Source: International Monetary Fund. World Economic Outlook.

3. Empirical Methodologies to Estimate Potential Output

All commonly used methodologies to estimate the potential output involve filtering of the macroeconomic time series to extract the unobservable underlying potential output level from cyclical variations in the output series. There are three main methodologies which are commonly used to estimate potential output, which are singlevariate, multivariate, and hybrid methods.

- **Singlevariate Statistical Methods:**

Hodrick Prescott (HP) filter has become the most commonly used statistical method to estimate potential output due to its flexibility in tracking the fluctuations of trend output and decomposing the aggregate output into both trend and cyclical components. The HP filter estimates potential output by minimizing the sum, over the sample period, of squared distances between actual and potential output at each point in time, subject to a restriction on the variation of potential output. The restriction parameter λ captures the importance of cyclical shocks to output relative to trend output shocks, and thereby controls the smoothness of the series of potential output; a smaller value of λ indicates a smaller weight of cyclical shocks and leads to a more volatile series of potential output.

The singlevariate (SV) methods provide an easy tool to estimate potential output. However, these methods are purely statistical techniques, which filter the actual GDP data to extract the trend component as its estimate of potential output. The most common SV filter is the Hodrick-Prescott (HP) filter. The HP filter is advantageous as it only requires one data series (output). However, the HP filter does not take into consideration the information available from other economic indicators such as inflation or labor market indicators, to guide its estimate of potential output.

- **Hybrid Methods:**

The Production Function (PF) approach is better than a SV filter because it allows for more detailed examination of the drivers of potential output. A downside of this approach is that it assumes capital is always at its potential. The hybrid approach also suffers from the end of-sample problems. This approach takes into consideration the contribution of labor, capital, and total factor productivity to potential output. This approach will be used in this paper to estimate Egypt's potential output.

- **Multivariate Methods:**

Multivariate (MV) filtering methodologies are used in the literature to estimate potential output. Some examples are models of Laxton and Tetlow (1992), Kuttner (1994), Benes and others (2010), Fleischman and Roberts (2011), and Blagrave and others (2015). MV filtering involves separating potential output from cyclical fluctuations, through the use of data and relationships between output and other macroeconomic variables, such as inflation, labor market indicators, capital formation indicators, etc. This approach adds economic structure to estimates by conditioning them on some basic theoretical relationships, such as the Phillip’s curve equation which expresses the relationship between inflation and output gap. MV filtering methodologies are more complicated than SV filtering methodologies and require more data, but are at the same time more reliable because they use more information from the data for their estimates.

The MV filtering approach needs a long time series data. However it provides the advantage of imposing well-known empirical relationships.

4. Econometric Analysis
The Production Function Approach

- **Methodology:**

Following a standard application in the literature (Konuki. 2008) and (Epstein and Macchiarelli. 2010).the Egyptian economy is assumed to be characterized by a Cobb-Douglas production function with constant returns to scale (CRS) ($\alpha+\beta=1$).

$$\mathbf{Y_t = A_t\, L_t^{\alpha}\ K_t^{\beta}} \qquad \mathbf{(1)}$$

where Y_t is output and L_t, K_t and A_t are labor and capital, and total factor productivity (TFP), respectively; and the output elasticities sum up to one under the assumption of constant returns to scale (CRS).

The Terms on the right hand side of equation (1) are defined as follows:

- **The labor input:** it is defined as the number of people employed in the economy.
- **The capital stock**: this series is constructed from total investment assuming perpetual inventories, hence:

  $$\mathbf{K_t = K_{t-1}(1-\mu) + I_t} \qquad \mathbf{(2)}$$

  capital stock in each period is estimated using the previous-period stock (net of depreciation) augmented with new investment flows. Consistent with previous studies, the depreciation rate (**μ**) ranges between .04 and .05. In order to construct a time series for capital stock an initial value is needed for a reference year, which could be estimated by the following formula:

$$\mathbf{K_t = K_t / (\mu + i)} \quad \mathbf{(3)}$$

Where (i) is the average growth rate of investment over the sample period included in the analysis.

- **The total factor productivity** term is obtained from equation (1) as a Solow residual as expressed by equations (4) and (5).

$$\mathbf{A_t = Y_t / (L_t^{\alpha} K_t^{\beta}), \text{ where: } \alpha = 1 - \beta} \quad \mathbf{(4)}$$

$$\mathbf{Ln\ A_t = Ln\ Y_t - (1-\beta)\ Ln\ L_t - \beta\ Ln\ K_t} \quad \mathbf{(5)}$$

- **Output elasticities** to inputs of labor and capital are needed to estimate total factor productivity (TFP), we will estimate them using the following OLS regression models:

$$\mathbf{Ln\ Yt = Ln\ At + (1-\beta)\ Ln\ L_t + \beta\ Ln\ K_t} \quad \mathbf{(6)}$$

$$\mathbf{(LnYt - Ln\ Lt) = Ln\ At + \beta\ (Ln\ K_t - Ln\ L_t)} \quad \mathbf{(7)}$$

Equation (7) could be estimated by an OLS regression model to estimate **β and α, where (α= 1-β).**

- **Potential Values of K, A, and L:** potential values of capital, labor, and total factor productivity are needed in order to estimate potential output using the following equation:

$$\mathbf{Y^*_t = A^*_t L^{*\alpha}_t K_t^{\beta}} \quad \mathbf{(8)}$$

As for the potential utilization of the capital stock, a capacity utilization series is not available. In this regard, and consistent with the literature, we assume the full utilization of the existing stock of capital. Such a simplification mostly relies on the assumption that, given the perpetual inventories rule, the capital stock can be regarded as an indicator for the overall capacity of the economy. Potential values of both total factor productivity and labor could be estimated by Hodrick Prescott (HP) filter to derive their trend components from their actual values.

- **Data and Variables:**
  - **Real GDP (Real Output)**: real gross domestic product was estimated using data for gross domestic product at market prices deflated by the GDP deflator.
  - **Employed People (Labor):** employed people in millions.
  - **Real Investment:** total investment was deflated by the GDP deflator.

All data used are from the IMF World Economic Outlook database and covering the period (1990-2014).

- **Model Estimation:**
  - The elasticities of output to labor and capital inputs could be estimated using the following regression model:

$$(LnYt - Ln\ Lt) = Ln\ At + \beta\ (Ln\ K_t - Ln\ L_t) \qquad (1)$$

Both the dependent and the explanatory variables were tested for stationarity using Augmented Dickey Fuller (ADF) unit root test, they were found to be integrated of order one (Table 1). The output of the regression model is summarized by (Table 2), and diagnostic tests were used and it was found that the model does not suffer any serial correlation, hetroscedsaticity, and normality problems (Table 3), all details of the model and diagnostic tests are in the appendix. The elasticities of output to capital and labor inputs were found to equal 0.74 and 0.26, respectively.

Table (1): ADF Unit Root Test for Variables of Equation (1)

Variable	t-Statistic	P- Value	Order of Integration
(LnY – Ln L)	-4.241	.0174	I(1)
(Ln K- Ln L)	-3.60	.0569	I(1)

Source: Researcher's calculations

Table (2): Elasticity of Output to Capital and Labor Inputs

Variable	Coefficient	t- Statistic	P- Value
C	.008730	3.235195	0.0038
D(Ln K- Ln L)	0.743021	9.121040	0.0000

Source: Researcher's calculations

Table (3): Results of Diagnostic Tests

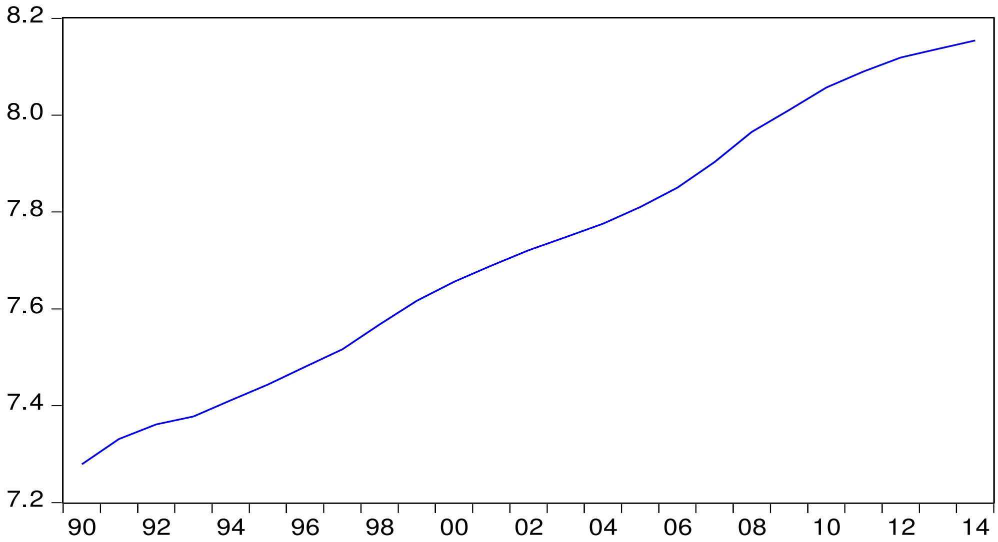
Variable	Test Statistic	P- Value
Jarque Bera Test of Normality	0.2715	0.8730
Breusch-Godfrey Serial Correlation LM Test	2.167666	0.1406
Heteroskedasticity Test: Breusch-Pagan-Godfrey	3.143538	0.0901

Source: Researcher's calculations

- Capital Stock was estimated according to equations (2 &3) (Figure 7), and total factor productivity was calculated as a solow residual using the following equation (Figure 8):

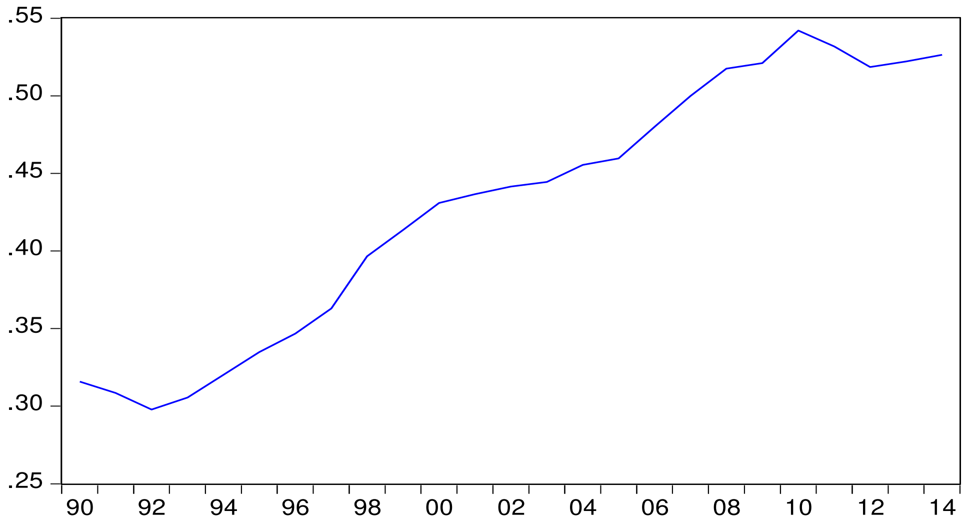
$$\ln A_t = \ln Y_t - (1-\beta) \ln L_t - \beta \ln K_t \quad (2)$$

Figure (7): The Natural Logarithm of Estimated Capital Stock (1990-2014)



Source: Researcher's calculations

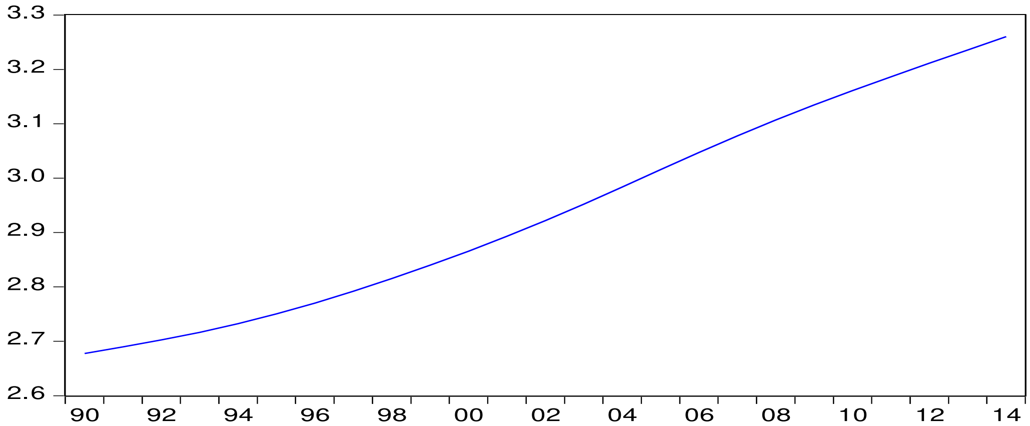
Figure (8): The Natural Logarithm of Estimated Total Factor Productivity (1990-2014)



Source: Researcher's calculations

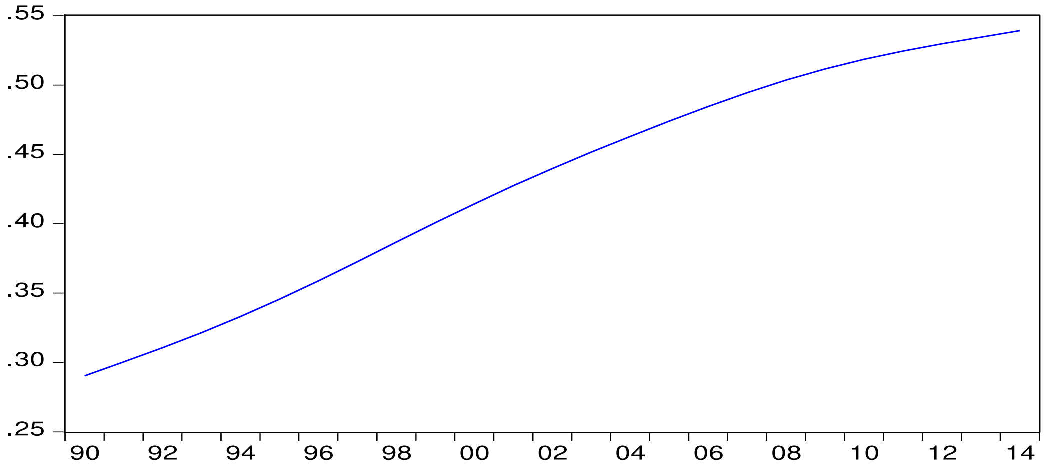
- In order to estimate potential output level (Y*), the potential levels of both labor employed (L*) and total factor productivity (A*) were derived as the Hodrick Prescott filtered series of the aggregate series of actual labor and TFP (Figures 9&10). Potential output was estimated using the production function approach (Y*) and was compared to potential output level estimated by the HP filter (YHP*) (Figure 11). Output gap was also estimated, it is important to mention that the Egyptian economy exhibited negative output gaps starting from 2012 (Figure 12).

Figure (9): The Natural Logarithm of Potential Employment (1990-2014)



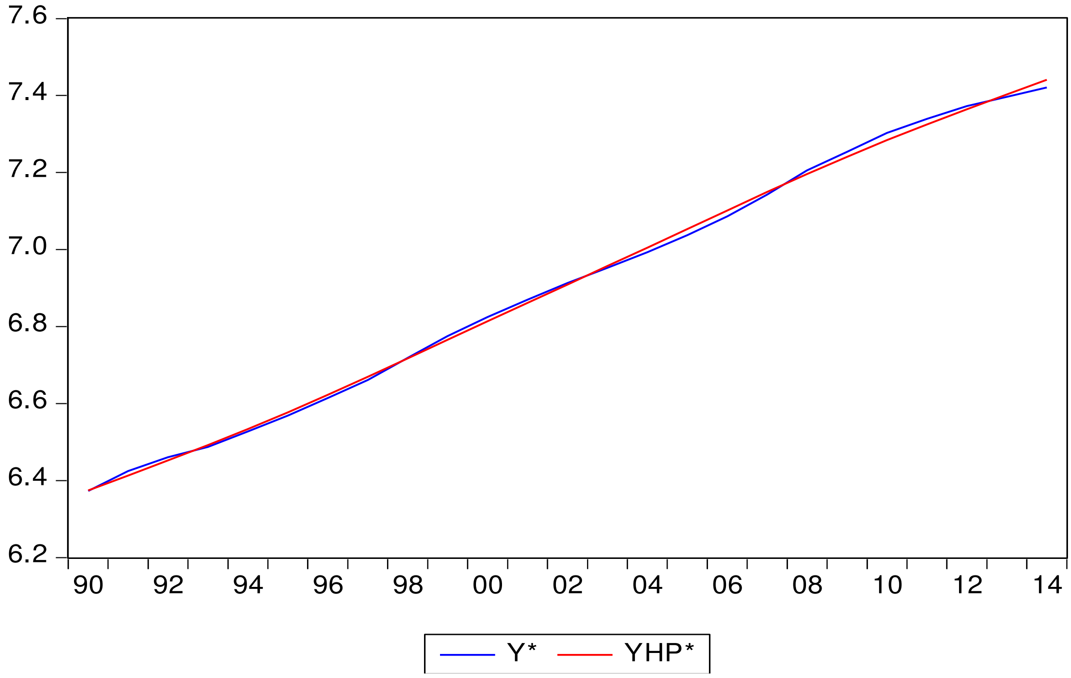
Source: Researcher's calculations

Figure (10): The Natural Logarithm of Potential Total Factor Productivity (1990-2014)



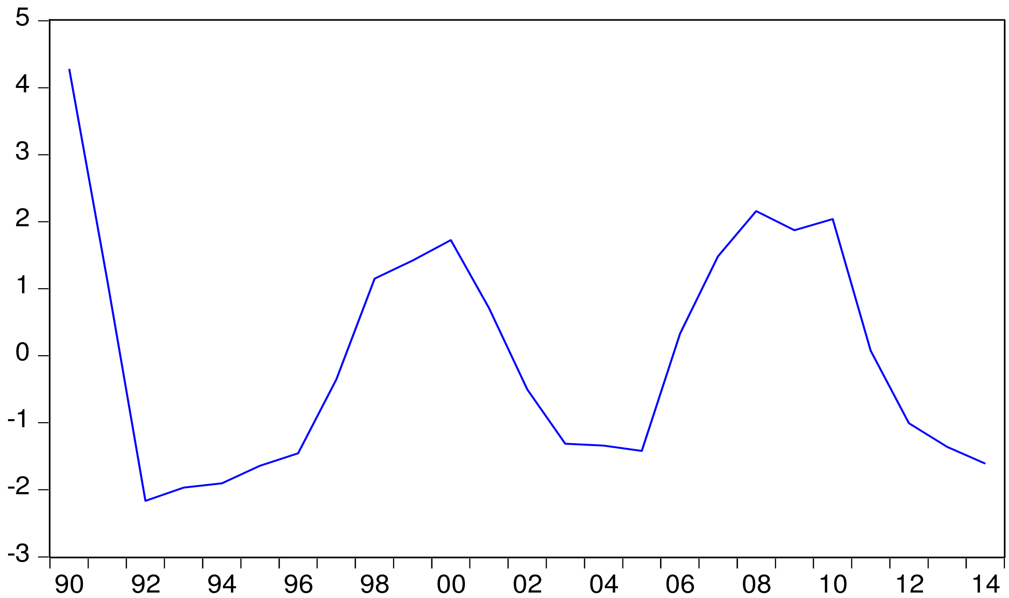
Source: Researcher's calculations

Figure (11): Potential Output Estimates for the Egyptian Economy (1990-2014)



Source: Researcher's calculations

Figure (12): Output Gap Estimates for the Egyptian Economy (1990-2014)



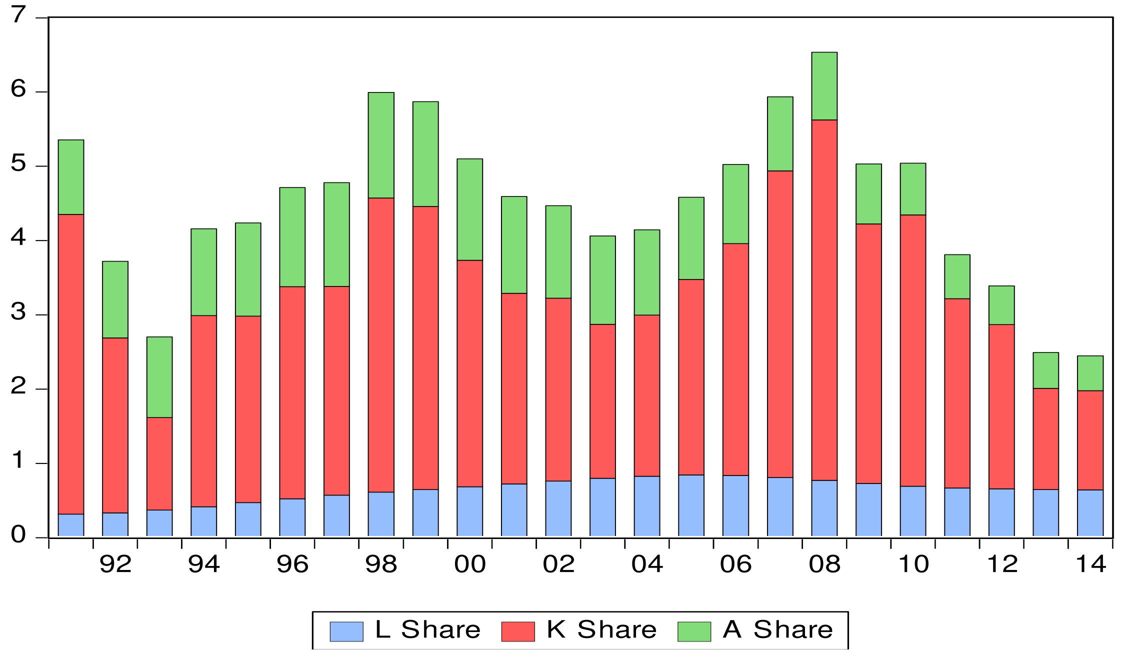
Source: Researcher's calculations

5. Contributions to Potential GDP Growth Rates in Egypt

The production function framework enables us to estimate the contribution of each factor of production to potential GDP growth. Changes in these contributions can be assessed as a signal for structural changes in the economy. The contributions of labor and capital inputs to potential GDP growth rate were estimated, accounting for their respective shares in output. Contributions are computed as year-on-year percentage changes (Epstein and Macchiarelli, 2010). Labor, capital and TFP contributions sum up to potential GDP growth rates, as according to equation (1) it is accepted that the sum of percentage changes in labor, capital , and total factor productivity equals the percentage change in output "GDP Growth".

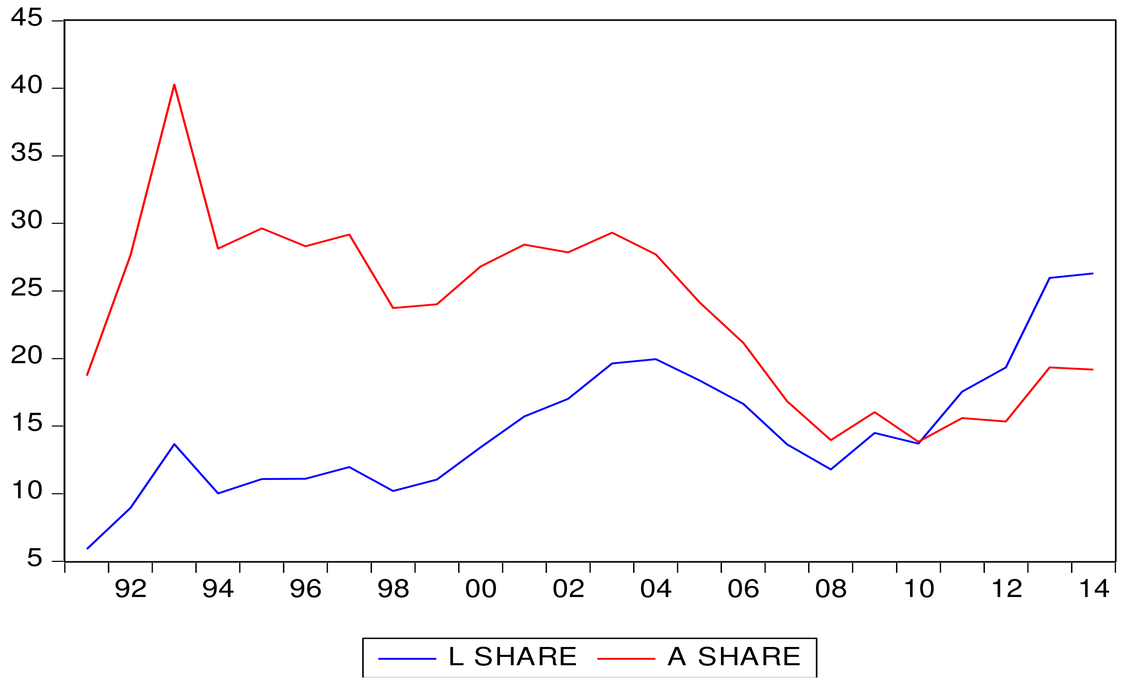
The contributions of Labor, capital and TFP to potential GDP growth rates were estimated (Figure 13). It could be easily visualized that capital stock was the dominant factor contributing to GDP growth in Egypt over the period (1991-2014), while the share of both labor and total factor productivity in GDP growth rate has been fluctuating over time. As for labor and TFP, it is noticed that the relative importance of both of them in GDP potential growth rate has changed over the period (1991-2014); the contribution of TFP to potential GDP growth rate over the period (1991-2010) has been outweighing that of labor, while starting from 2011 the contribution of labor to potential GDP growth rate exceeded that of TFP (Figure 14). The average share of labor and TFP in potential GDP growth rate over the period (2011-2014) recorded 22.3% and 17.4%, respectively.

Figure (13): Contributions to Potential GDP Growth Rates in Egypt (1991-2014)



Source: Researcher's calculation

Figure (14): The Relative Share of Labor and TFP's Contributions to Potential GDP Growth Rates in Egypt (1991-2014)



Source: Researcher's calculations

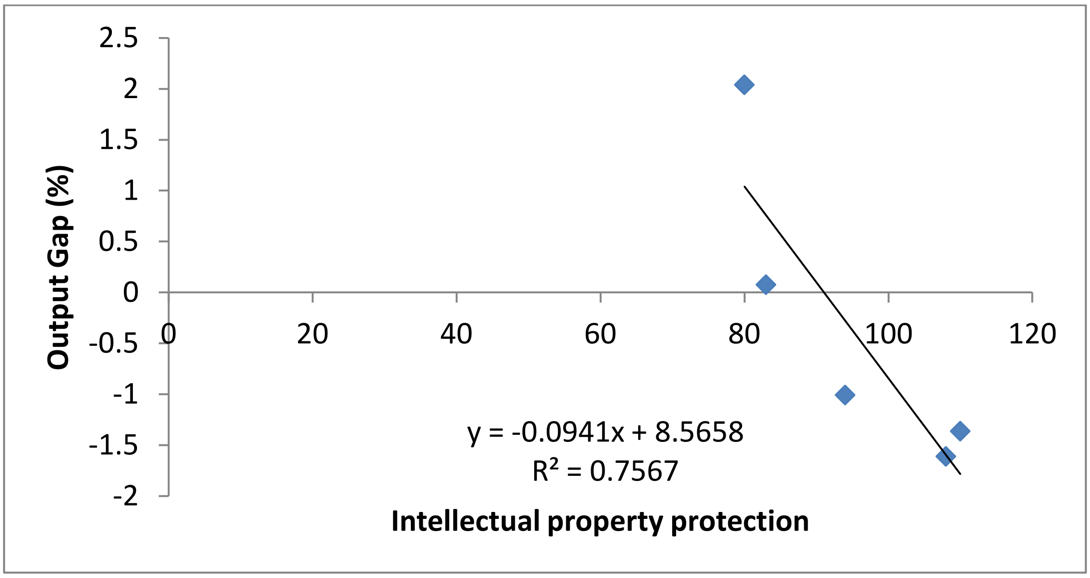
6. Factors Affecting Egypt's Output Gap

In order to identify the economic factors that might affect output gap in the Egyptian economy, we will depend on selected sub indices which falls under the umbrella of the Global Competitiveness Index, and Egypt's rankings in them were used to identify their relationship with output gap.

The indices used were intellectual property protection, efficiency of legal framework in settling disputes, strength of investor protection, quality of overall infrastructure, government budget balance-to-GDP ratio, quality of the education system, intensity of local competition, pay and productivity in labor market, availability of financial services and capacity for innovation.

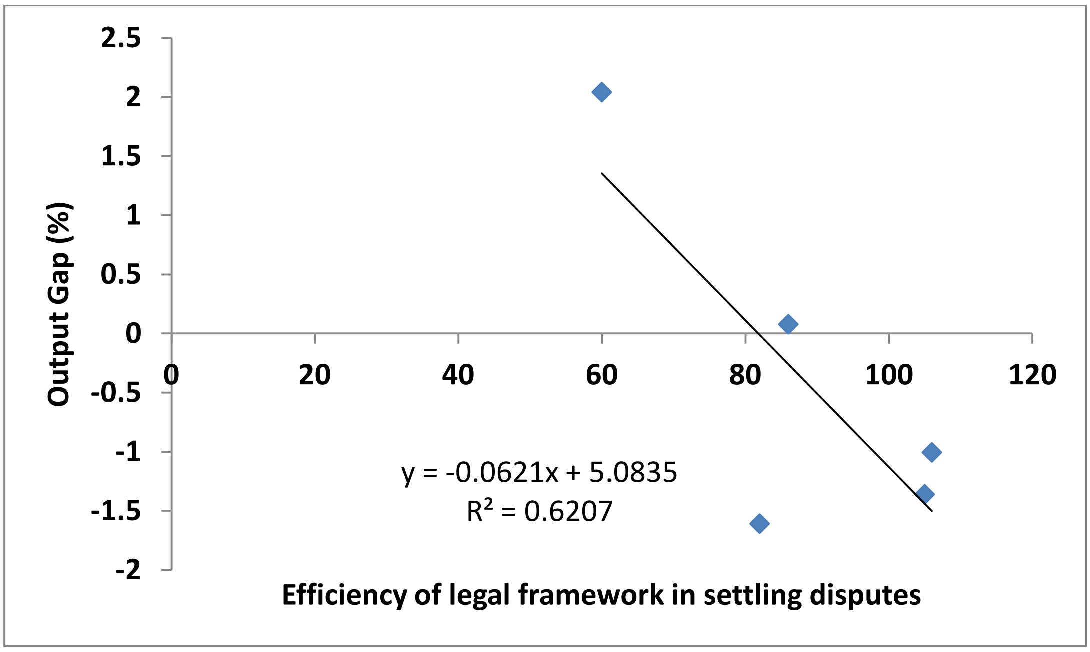
Data used for these indices are covering the period (2010-2014), and output gap estimates for the same period were derived from the production function analysis conducted in section four. It could be visualized that the rankings of Egypt in all the variables mentioned earlier are inversely related to output gap; which means that better rankings of the Egyptian economy in these sub indices implies the convergence of actual output to potential output or exceeding it with the absence of negative output gaps (figures 15 : 24).

Figure (15): Relationship between Intellectual Property Protection and Output Gap (2010-2014)



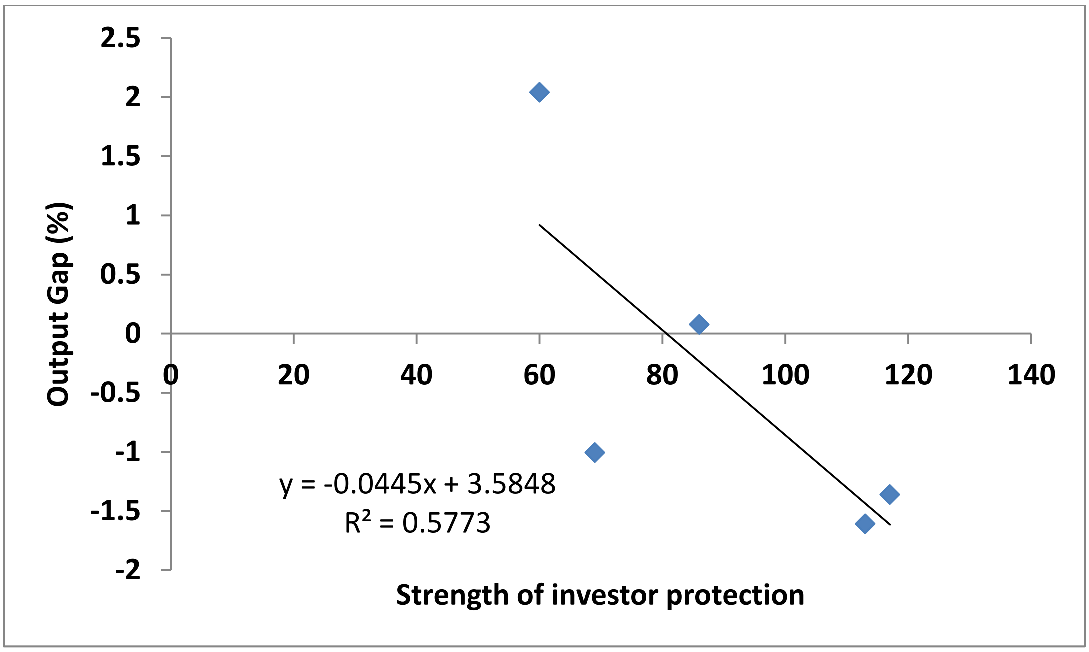
Source: Researchers' Calculations.

Figure (16): Relationship between Efficiency of Legal Framework in Settling Disputes and Output Gap (2010-2014)



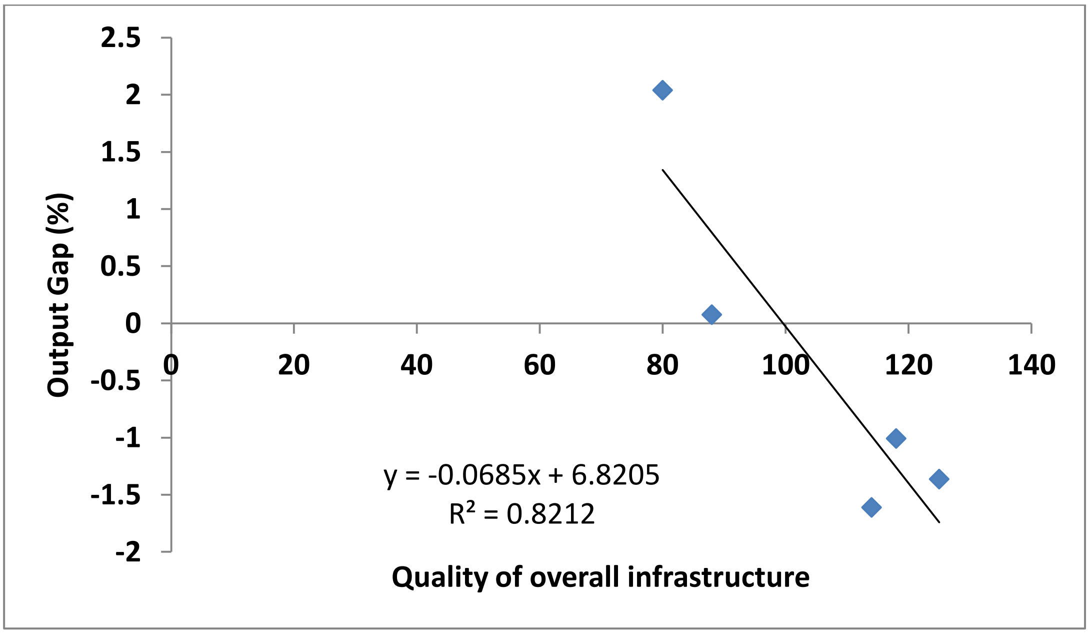
Source: Researchers' Calculations.

Figure (17): Relationship between Strength of Investor Protection and Output Gap (2010-2014)



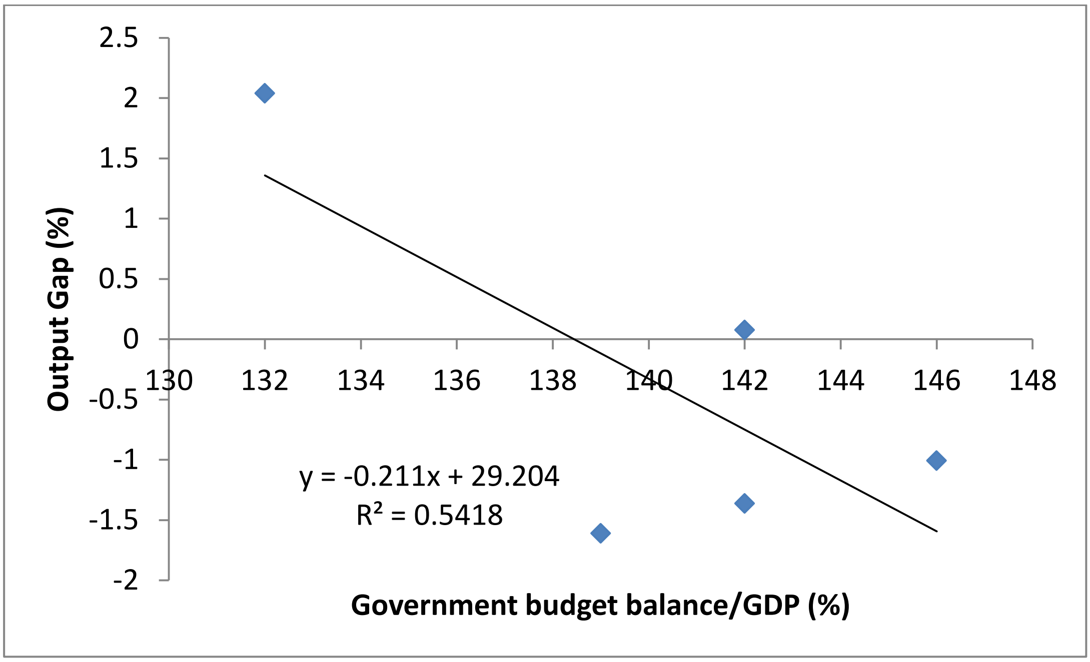
Source: Researchers' Calculations.

Figure (18): Relationship between Quality of Overall Infrastructure and Output Gap (2010-2014)



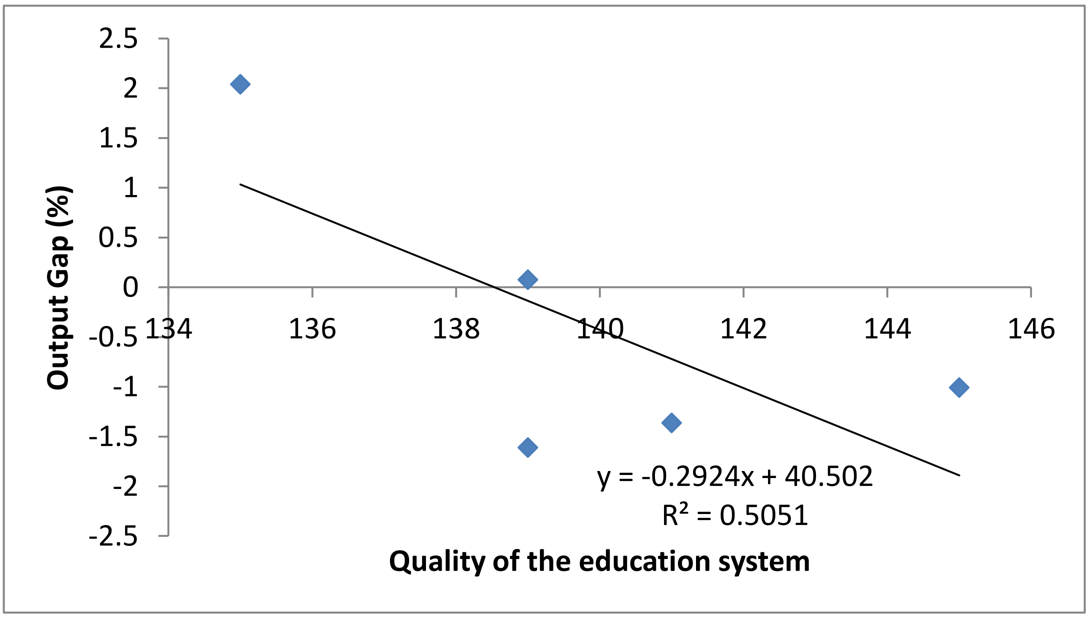
Source: Researchers' Calculations.

Figure (19): Relationship between Government budget balance/GDP (%) and Output Gap (2010-2014)



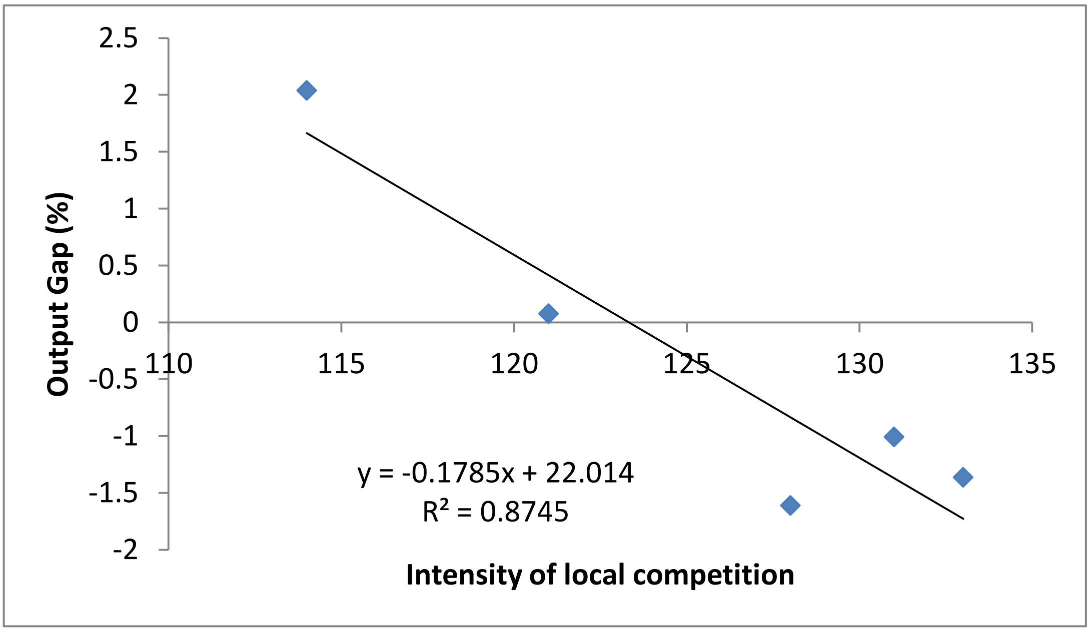
Source: Researchers' Calculations.

Figure (20): Relationship between Quality of the Education System and Output Gap (2010-2014)



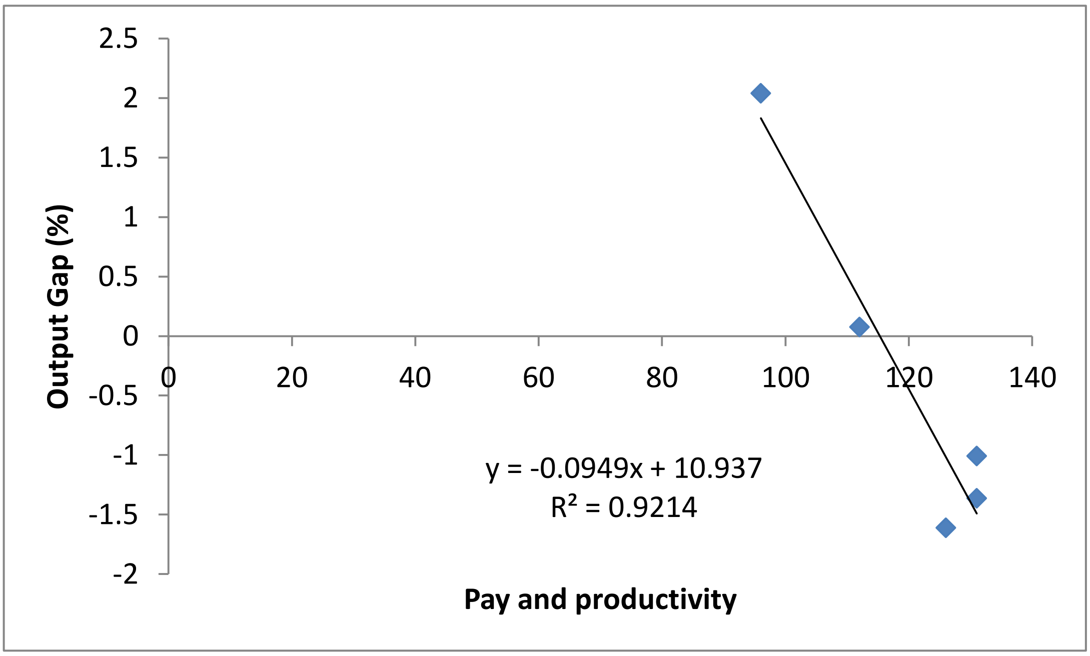
Source: Researchers' Calculations.

Figure (21): Relationship between Intensity of Local Competition and Output Gap (2010-2014)



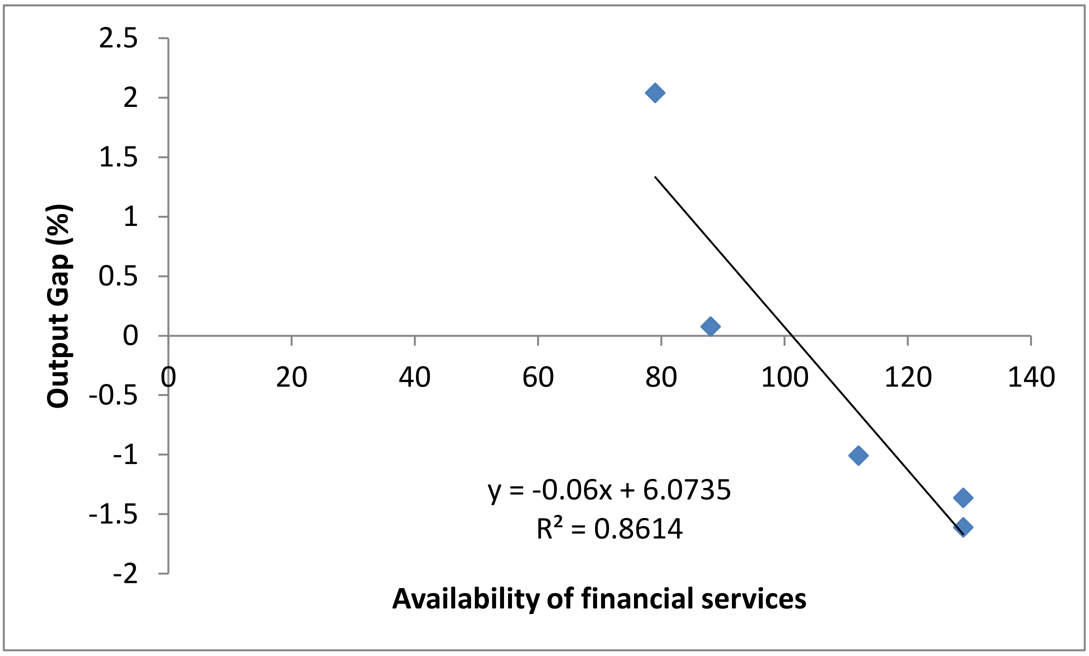
Source: Researchers' Calculations.

Figure (22): Relationship between Pay and Productivity and Output Gap (2010-2014)



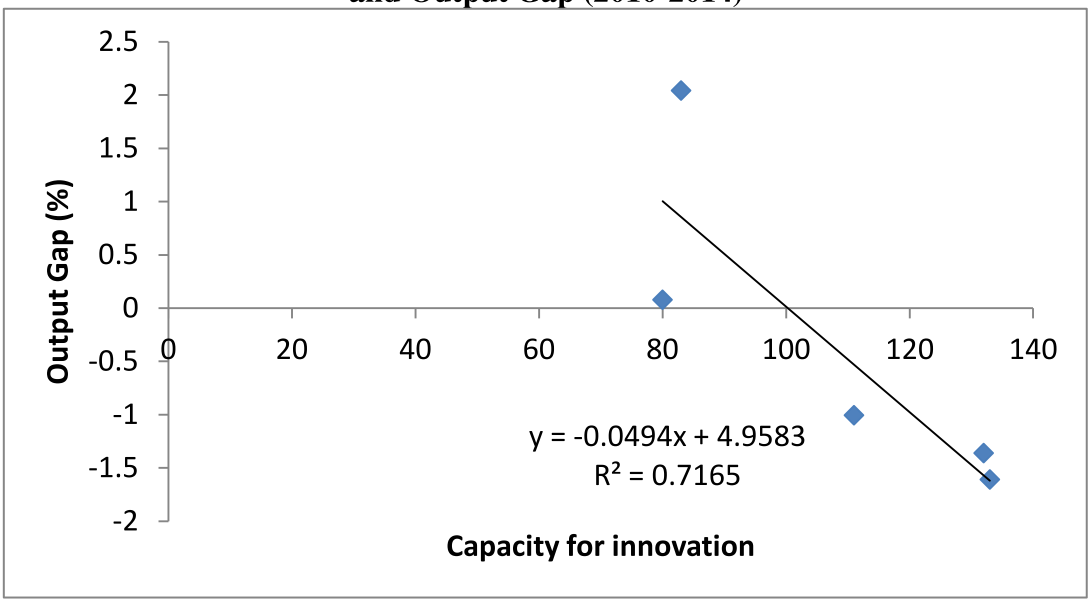
Source: Researchers' Calculations.

Figure (23): Relationship between Availability of Financial Services and Output Gap (2010-2014)



Source: Researchers' Calculations.

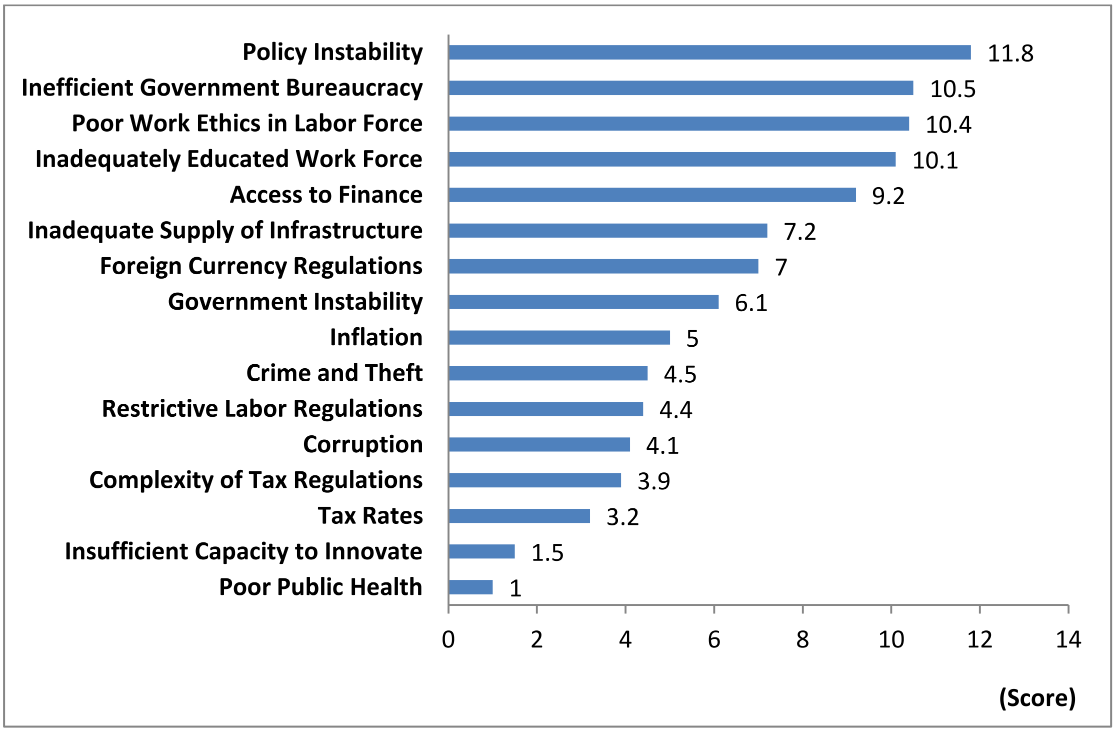
Figure (24): Relationship between Capacity for Innovation and Output Gap (2010-2014)



Source: Researchers' Calculations.

According to the global competitiveness report (2015/2016), the factors adversely affecting doing business in Egypt include policy instability, inefficient government bureaucracy, poor work ethics in labor force, inadequately educated work force, access to finance, inadequate supply of infrastructure, foreign currency regulations, government instability, inflation, and other factors (Figure 25).

Figure (25): Factors Negatively Affecting Doing Business in Egypt



Source: World Economic Forum. "Global Competitiveness Report: (2015-2016)".

7. Conclusion

The Egyptian economy has witnessed deterioration in its main macroeconomic indicators over the period (2008-2014), including real GDP growth rate, GDP per capita, saving-to-GDP ratio, investment-to-GDP ratio, unemployment rate and structural government budget balances. Under these conditions, it is crucial to stimulate investment in order to allow actual output to converge to its potential level and avoid the existence of spare capacity in the economy.

The main purpose of the paper was to estimate Egypt's potential output and identify the relationship between selected economic variables and the estimated output gap, trying to identify the factors that might be responsible for the existence of negative output gaps witnessed in Egypt starting from 2012.

The paper shaded light on different methodologies used in the literature to estimate potential output, and focused on the production function approach which was used to estimate potential output. The contributions of labor, capital stock and total factor productivity to potential GDP growth rates in Egypt over the period (1991-2014) were calculated. Output gap estimates were also derived and used to visualize their relationship with selected economic indicators.

The results of the analysis revealed that capital stock was the dominant factor contributing to GDP growth in Egypt over the period (1991-2014), while the share of both labor and total factor productivity in GDP growth rate has been fluctuating over time. The relative importance of labor and TFP in contributing to GDP potential growth rate has changed over the period (1991-2014); the contribution of TFP to potential GDP growth rate over the period (1991-2010) has been outweighing that of labor, while starting from 2011 the contribution of labor to potential GDP growth rate exceeded that of TFP.

Intellectual property protection, efficiency of legal framework in settling disputes, strength of investor protection, quality of overall infrastructure, government budget balance-to-GDP ratio, quality of the education system, intensity of local competition, pay and productivity in labor market, availability of financial services and capacity for innovation all exhibited a strong positive relationship with output gap in Egypt over the period (2010-2014).

It is important for the Egyptian government to exert efforts to promote investment and facilitate doing business to allow actual output to approach its potential levels. It is important to promote intellectual property protection, improve the efficiency of the legal system in settling disputes, improve the quality of overall infrastructure with more government expenditure on infrastructural projects, ensuring fiscal consolidation and low structural budget deficits, improving the quality of the education system with policies targeting the education- occupation mismatch problem, ensuring competition in the domestic market and curbing monopoly practices, improving the skills of the labor force in order to improve the link between wages and productivity levels, promoting capital market development to attract foreign direct investment and portfolio investments, and encouraging research and development.

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Appendix

ADF test for (Ln K- Ln L):

Null Hypothesis: LN_K__LN_L has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 5 (Automatic - based on SIC, maxlag=5)

Prob.*	t-Statistic		
0.0862	-3.364543	Augmented Dickey-Fuller test statistic	
	-4.532598	1% level	Test critical values:
	-3.673616	5% level	
	-3.277364	10% level	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 19

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_K__LN_L)
Method: Least Squares
Date: 05/18/16 Time: 17:09
Sample (adjusted): 1996 2014
Included observations: 19 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0063	-3.364543	0.330854	-1.113173	LN_K__LN_L(-1)
0.0233	2.631609	0.252684	0.664965	D(LN_K__LN_L(-1))
0.0568	2.127501	0.239396	0.509315	D(LN_K__LN_L(-2))
0.0422	2.297592	0.270473	0.621437	D(LN_K__LN_L(-3))
0.1305	1.634253	0.207679	0.339400	D(LN_K__LN_L(-4))
0.0470	-2.236134	0.161029	-0.360083	D(LN_K__LN_L(-5))
0.0060	3.388833	1.530806	5.187647	C
0.0127	2.970479	0.003507	0.010417	@TREND(1990)

0.010094	Mean dependent var	0.709832	R-squared
0.024385	S.D. dependent var	0.525179	Adjusted R-squared
-5.038943	Akaike info criterion	0.016803	S.E. of regression
-4.641285	Schwarz criterion	0.003106	Sum squared resid
-4.971644	Hannan-Quinn criter.	55.86996	Log likelihood
2.126794	Durbin-Watson stat	3.844148	F-statistic
		0.023201	Prob(F-statistic)

ADF test for the first differenced series of (Ln K- Ln L):

Null Hypothesis: D(LN_K__LN_L) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on SIC, maxlag=5)

Prob.*	t-Statistic		
0.0569	-3.601270	Augmented Dickey-Fuller test statistic	
	-4.532598	1% level	Test critical values:
	-3.673616	5% level	
	-3.277364	10% level	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 19

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_K__LN_L,2)
Method: Least Squares
Date: 05/18/16 Time: 17:10
Sample (adjusted): 1996 2014
Included observations: 19 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0036	-3.601270	0.480829	-1.731597	D(LN_K__LN_L(-1))
0.0733	1.962406	0.395853	0.776825	D(LN_K__LN_L(-1),2)
0.0680	2.005512	0.354013	0.709977	D(LN_K__LN_L(-2),2)
0.0297	2.466351	0.257250	0.634470	D(LN_K__LN_L(-3),2)
0.0347	2.380689	0.211721	0.504041	D(LN_K__LN_L(-4),2)
0.0679	2.006435	0.018635	0.037389	C
0.3417	-0.990036	0.001085	-0.001074	@TREND(1990)

-0.000580	Mean dependent var	0.637934	R-squared
0.031096	S.D. dependent var	0.456901	Adjusted R-squared
-4.436612	Akaike info criterion	0.022916	S.E. of regression
-4.088661	Schwarz criterion	0.006302	Sum squared resid
-4.377725	Hannan-Quinn criter.	49.14781	Log likelihood
2.032322	Durbin-Watson stat	3.523852	F-statistic
		0.030129	Prob(F-statistic)

ADF test for (Ln Y- Ln L):

Null Hypothesis: LN_Y__LN_L has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

Prob.*	t-Statistic		
0.5105	-2.118020	Augmented Dickey-Fuller test statistic	
	-4.394309	1% level	Test critical values:
	-3.612199	5% level	
	-3.243079	10% level	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_Y__LN_L)
Method: Least Squares
Date: 05/18/16 Time: 17:11
Sample (adjusted): 1991 2014
Included observations: 24 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0463	-2.118020	0.161938	-0.342989	LN_Y__LN_L(-1)
0.0412	2.174600	0.599595	1.303880	C
0.0949	1.749210	0.003399	0.005945	@TREND(1990)

0.020159	Mean dependent var	0.257577	R-squared
0.025039	S.D. dependent var	0.186870	Adjusted R-squared
-4.627121	Akaike info criterion	0.022579	S.E. of regression
-4.479864	Schwarz criterion	0.010706	Sum squared resid
-4.588053	Hannan-Quinn criter.	58.52545	Log likelihood
1.565106	Durbin-Watson stat	3.642883	F-statistic
		0.043837	Prob(F-statistic)

ADF test for the first differenced series of (Ln Y- Ln L):

Null Hypothesis: D(LN_Y__LN_L) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on SIC, maxlag=5)

Prob.*	t-Statistic		
0.0174	-4.241842	Augmented Dickey-Fuller test statistic	
	-4.532598	1% level	Test critical values:
	-3.673616	5% level	
	-3.277364	10% level	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 19

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_Y__LN_L,2)
Method: Least Squares
Date: 05/18/16 Time: 17:11
Sample (adjusted): 1996 2014
Included observations: 19 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0011	-4.241842	0.532249	-2.257717	D(LN_Y__LN_L(-1))
0.0233	2.597584	0.454856	1.181528	D(LN_Y__LN_L(-1),2)
0.0217	2.637396	0.400820	1.057122	D(LN_Y__LN_L(-2),2)
0.0089	3.119401	0.323499	1.009124	D(LN_Y__LN_L(-3),2)
0.0071	3.239992	0.249072	0.806991	D(LN_Y__LN_L(-4),2)
0.0038	3.580948	0.021173	0.075820	C
0.0613	-2.064062	0.000983	-0.002029	@TREND(1990)

-0.000966	Mean dependent var	0.727947	R-squared
0.033107	S.D. dependent var	0.591921	Adjusted R-squared
-4.597136	Akaike info criterion	0.021149	S.E. of regression
-4.249185	Schwarz criterion	0.005367	Sum squared resid
-4.538249	Hannan-Quinn criter.	50.67280	Log likelihood
2.352607	Durbin-Watson stat	5.351510	F-statistic
		0.006688	Prob(F-statistic)

Regression Model

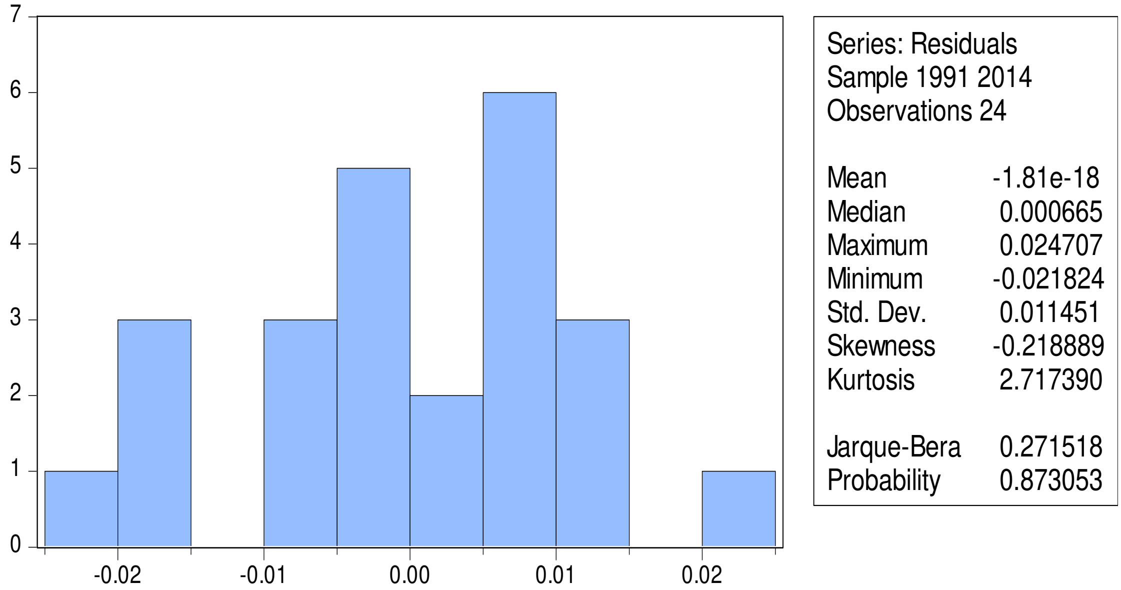
Dependent Variable: D(LN_Y-LN_L,1)
Method: Least Squares
Date: 05/18/16 Time: 17:13
Sample (adjusted): 1991 2014
Included observations: 24 after adjustments

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0038	3.235195	0.002699	0.008730	C
0.0000	9.121040	0.081462	0.743021	D(LN_K-LN_L,1)

0.020159	Mean dependent var	0.790861	R-squared
0.025039	S.D. dependent var	0.781355	Adjusted R-squared
-5.977376	Akaike info criterion	0.011708	S.E. of regression
-5.879204	Schwarz criterion	0.003016	Sum squared resid
-5.951331	Hannan-Quinn criter.	73.72851	Log likelihood
1.081988	Durbin-Watson stat	83.19337	F-statistic
		0.000000	Prob(F-statistic)

Diagnostic Tests for the Regression Model

Normality Test



Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

0.1406	Prob. F(2,20)	2.167666	F-statistic
0.1179	Prob. Chi-Square(2)	4.275593	Obs*R-squared

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/18/16 Time: 17:14
Sample: 1991 2014
Included observations: 24
Presample missing value lagged residuals set to zero.

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.8721	0.163115	0.002574	0.000420	C
0.6915	-0.402654	0.079382	-0.031964	D(LN_K-LN_L,1)
0.0659	1.945733	0.225180	0.438141	RESID(-1)
0.9420	-0.073639	0.225023	-0.016571	RESID(-2)

-1.81E-18	Mean dependent var	0.178150	R-squared
0.011451	S.D. dependent var	0.054872	Adjusted R-squared
-6.006906	Akaike info criterion	0.011132	S.E. of regression
-5.810564	Schwarz criterion	0.002479	Sum squared resid
-5.954816	Hannan-Quinn criter.	76.08287	Log likelihood
2.024802	Durbin-Watson stat	1.445111	F-statistic
		0.259479	Prob(F-statistic)

Hetroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

0.0901	Prob. F(1,22)	3.143538	F-statistic
0.0832	Prob. Chi-Square(1)	3.000569	Obs*R-squared
0.1412	Prob. Chi-Square(1)	2.165037	Scaled explained SS

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/18/16 Time: 17:15
Sample: 1991 2014
Included observations: 24

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0176	2.565518	3.71E-05	9.51E-05	C
0.0901	1.773002	0.001119	0.001985	D(LN_K-LN_L,1)

0.000126	Mean dependent var	0.125024	R-squared
0.000168	S.D. dependent var	0.085252	Adjusted R-squared
-14.55205	Akaike info criterion	0.000161	S.E. of regression
-14.45388	Schwarz criterion	5.69E-07	Sum squared resid
-14.52600	Hannan-Quinn criter.	176.6246	Log likelihood
1.691886	Durbin-Watson stat	3.143538	F-statistic
		0.090075	Prob(F-statistic)