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A Production Function Explanation of Saudi Economic Growth 1984-2011

Mohammed Abdullah Aljebrin[1]

[1] College of Business Administration, Majmaah University, Saudi Arabia

Correspondence: Mohammed Abdullah Aljebrin, College of Business Administration, Majmaah University, PO Box 11952, Majmaah, Saudi Arabia. E-mail: maljebrin@mu.edu.sa

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Abstract

This paper attempts at an explanation of Saudi economic growth along the lines proposed by the neo-classical growth theory. Production function estimates for gross domestic product is provided using Cobb-Douglas function. A wide range of econometric testing is employed. The functional form is estimated using a constant to express the technical progress. The result shows an elasticity of output with respect to capital and labor of about 0.67 and 0.57 respectively. Technical progress has positive contribution to growth rate of output of 8.67% a year. Therefore, it is a difficult task for the policy makers to determine the best policies for the enhancement of capital and labor on economic growth. The major policy implications and recommendations are that Saudi Arabia needs to improve the rate of return to education in order to raise the productivity of labor. That may be occurred by investing large amount of resources in increasing and improving educational attainment for men and women, and by increasing the training levels in industrial and services sectors.

Keywords: production function, Cobb-Douglas Production Function, FMOLS model, Saudi Arabia

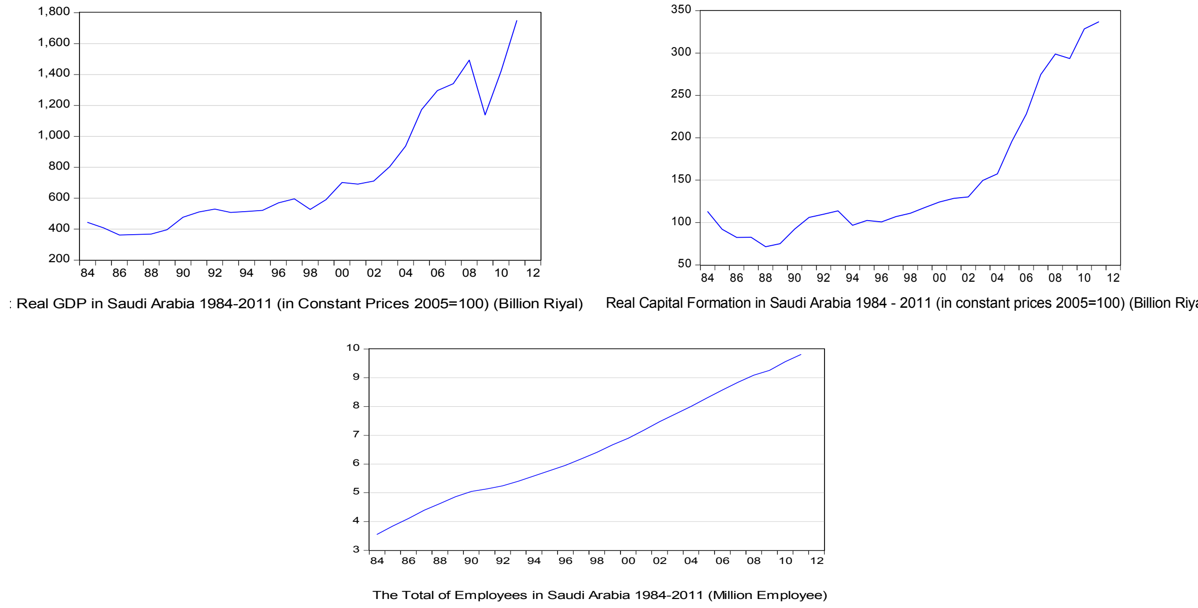
1. Introduction

As global economic recovery lifted up oil prices in 2010, the Saudi economy recorded high growth and enlarged fiscal spending by the government boosted domestic demand and accelerated the growth in non-oil GDP. On the same line, the actual budget recorded a surplus of SAR 87.7 billion or 5.4 percent of GDP in 2010 against a deficit of SAR 86.6 billion or 6.2 percent of GDP in the previous year. On the other hand, the ratio of public debt to GDP declined from 16.1 percent in 2009 to 9.9 percent in 2010. The current account of the balance of payments recorded a surplus for the twelfth year consecutively amounting to SAR 250.3 billion or 14.9 percent of GDP in 2010 (Saudi Arabian Monetary Agency (SAMA, 2011).

Figures 1, 2 and 3 illustrate the developments of real GDP, real capital formation and total number of employees in Saudi Arabia during the period 1984-2011. The Figures indicate that there are similar directions among real GDP and Gross capital formation and a less degree of similarity with the number of employees.

This study aims at determining the contribution of capital and labor in Saudi economy by applying Cobb-Douglas Production Function in order to determine how the growth rate can be maximized.

Table 1 and Figure 2 illustrate the structure of gross capital formation, it indicates that non-oil private sector absorb the highest share in Saudi capital formation with a percentage reached 42.8% in 2011. While the oil sector ranked second in terms of relative importance and finally the government sector.



: Real GDP in Saudi Arabia 1984-2011 (in Constant Prices 2005=100) (Billion Riyal)

Real Capital Formation in Saudi Arabia 1984 - 2011 (in constant prices 2005=100) (Billion Riyal)

The Total of Employees in Saudi Arabia 1984-2011 (Million Employee)

Figure 1. Real GDP, real capital formation and total number of employees in Saudi Arabia (1984-2011)

Source: Table (A-1) in the appendix.

Table 1. Gross capital formation structure in Saudi Arabia 1984-2011 (constant prices 2005=100) (Billion Riyals)

Year	Government Sector	Non-Oil Private Sector	Oil Sector	Change in Stock	Gross Fixed Capital Formation
1984	49.301	43.244	10.170	33.183	135.898
1985	35.989	38.692	9.116	-3.449	80.348
1986	28.569	36.339	10.127	-11.380	63.654
1987	31.574	35.774	7.781	-17.050	58.079
1988	27.438	36.131	1.424	2.875	67.869
1989	29.707	36.833	1.734	3.435	71.709
1990	47.046	31.088	4.688	-19.210	63.612
1991	47.727	38.861	4.757	-5.110	86.234
1992	34.120	57.786	7.397	11.628	110.931
1993	31.400	63.179	8.365	13.471	116.416
1994	24.923	54.156	8.478	7.150	94.707
1995	24.954	53.164	14.643	2.249	95.010
1996	12.650	79.733	8.361	3.975	104.719
1997	15.764	82.084	9.098	3.755	110.701
1998	12.219	87.497	11.265	9.428	120.409
1999	12.905	91.715	13.093	9.383	127.096
2000	16.472	93.627	14.120	8.968	133.185
2001	17.833	96.100	14.505	3.562	132.001
2002	18.415	99.042	12.689	11.222	141.368
2003	23.531	104.745	21.349	11.492	161.116
2004	30.599	109.803	17.039	23.976	181.416
2005	54.940	118.461	22.231	20.055	215.687
2006	57.472	127.137	43.422	16.669	244.700
2007	78.936	137.511	61.008	13.117	290.572
2008	93.936	146.978	56.594	40.992	338.500
2009	91.201	136.841	44.8	20.807	293.649
2010	103.169	144.917	47.175	33.051	328.312
2011	145.705	143.474	46.343	1.247	336.769

Note: Saudi Arabian Monetary Agency (SAMA), *Annual Report*, No. 48. World Bank, *World Bank Development Indicator*.

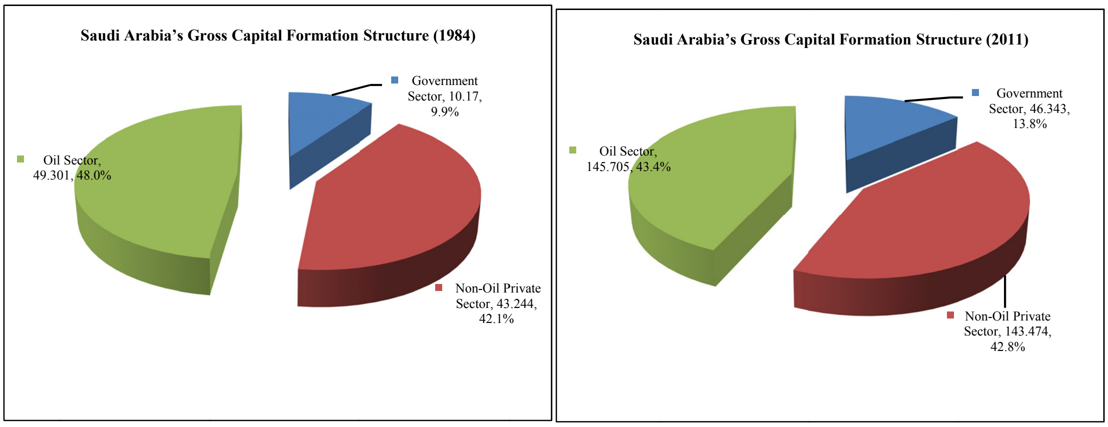


Figure 2. The structure of Gross Capital Formation in Saudi Arabia 1984-2011

Table 2 shows that the services sector is the most sectors that absorb labor in Saudi Arabia, as it accounted for three-quarters of employees during the period 1999-2009. While the industrial sector absorbed about fifth of employees, finally the agriculture sector absorbed only about 5% of total employment during the same period.

Table 2. Employment structure by economic activities in Saudi Arabia (% of total employment)

Year	Agriculture (%)	Industry (%)	Services (%)
1999	6.3	21	72.7
2000	6.1	19.9	74
2001	6.1	21.1	72.8
2002	4.6	21	74.4
2006	4	20.2	75.8
2007	4.3	20.8	74.9
2008	4.3	19.8	75.9
2009	4.1	20.4	75.5

Notes: Saudi Arabian Monetary Agency (SAMA), *Annual Report*, No. 48. World Bank, *World Bank Development Indicator*.

2. Literature Review

Cobb-Douglas Production Function is one of the most widely used production function in Economics and Management research (Douglas 1934 and 1948). This production function not only satisfies the basic economic law but also easy in its computation and interpretation of the estimated parameters. The objectives of applying Cobb- Douglas production function is to estimate the co-efficient of inputs, their marginal productivities, factor shares in total output and degree of returns to scale. It is based on unitary elasticity of substitution of inputs and this production function has been widely applied in empirical studies.

Given the Cobb-Douglass function components, for the capital factor (K) we have used data of the gross capital formation, for labor (L) the number of employees. The data series is for the period 1984-2011, the value expressions for GDP and K are expressed in billions of riyal in constant prices (2005=100). Labor is expressed in millions of workers employed.

In our analysis, we have assumed the general form of Cobb-Douglass production function:

$$Y_t = A\, K_t^{\alpha}\, L_t^{\beta} \tag{1}$$

Where:

Y_t = gross domestic product for year t

K_t = fixed capital formation for year t

L_t = labor employed for year t;

t = time

We also mention that A, α, β, shows the overall significance related to the function, namely "A" is the size factor reflecting overall productivity of production factors, "α" is the elasticity of output relative to the capital formation, and finally "β" is the elasticity of output in relation to work. The factors that influence the productivity level are different and with different impact on the outcome.

If $\alpha + \beta > 1$, it would imply that the output increase would be more than proportionate to the increase in inputs, if $\alpha + \beta < 1$, it would imply that the output increase would be less than proportionate to the increase in inputs and if $\alpha + \beta = 1$ the output would just increase proportionately to the rate of increase of inputs. Therefore there will be economies of scale, constant returns to scale or diseconomies of scale depending upon whether $\alpha + \beta$ is greater than 1, equal to 1, or less than 1 respectively.

3. The Model and the Methods

The logarithm of both sides of the above Cobb-Douglass production function was taken to convert the equation into linear form; its log transformation is specified below, which is to be estimated by Fully Modified Ordinary Least Squares (FMOLS) approach. FMOLS was originally designed first time by Philips and Hansen (1990) and Philips and Moon (1999) to provide optimal estimates of Co-integration regressions. This technique employs kernal estimators of the Nuisance parameters that affect the asymptotic distribution of the OLS estimator. In order to achieve asymptotic efficiency, this technique modifies least squares to account for serial correlation effects and test for the endogeneity in the regressors that result from the existence of a Co-integrating Relationships. The model that has been estimated is:

$$\log(Y) = \log(A) + \alpha \log(K) + \beta \log(L) + \varepsilon \quad (2)$$

The variable of "Y" has been expressed by the real Gross Domestic Product, while "K" has been be proxied by real gross capital formation and finally, labor force "L" has been expressed by the number of employees and "ε" is the error term.

4. Data

This study used the annual data from 1984 to 2008 for Saudi Arabia. All data in this study was obtained from Saudi Arabian Monetary Agency (SAMA) and World Bank Development Indicator, the data has been converted to real values (2005 constant prices) by using consumer price index (2005=100). All these factors are illustrated at Table (A-1) in the appendix.

5. Empirical Results

5.1 Unit Root and Cointegration Tests

Augmented Dickey- Fuller unit root test is calculated for individual series to provide evidence as to whether the variables are stationary and integrated of the same order.

The results of Augmented Dickey-Fuller (ADF) test for each variable appear in Table 2. The lag parameter in the ADF test is selected by Akaike information criterion (AIC) to eliminate the serial correlation in residual (Akaike, 1973). As shown in Table 3, the null hypothesis of a unit root can't be rejected for all series. However, the unit root hypothesis is rejected for all variables in the first-differenced data. Therefore, we conclude that the series are integrated of order one.

Table 3. Unit root test

		ADF
Log(Y)	Level	0.916719
	First Diff.	-4.592865[a]
Log(K)	Level	0.005893
	First Diff.	-3.164287[b]
Log(L)	Level	-0.674087
	First Diff.	-3.201651[b]

Notes: ADF-Dickey DA, Fuller WA., (1979) unit root test with the Ho: Variables are I (1); a, b and c indicate significance at the 1%, 5% and 10% levels, respectively.

The linear combination of the variables may however be stationary. This claim is being supported by the cointegrating relationships explored using 5% critical value. The Johansen approach in Tables 4 and 5 under the trace and Maximal Eigenvalue statistics indicate only one cointegrating equation testifying to the long run relationship among the variables with Y as the dependent variable. The parameter instability approach in Table 5 further confirms this claim of long run relationship among the variables with probability value greater than 0.2 thereby accepting the null hypothesis of existence of cointegrating relationship.

Table 4. Cointegration test based on trace of the stochastic matrix

Hypothesized No. of E(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.997885	187.7262	29.79707	0.0001
At most 1	0.420682	15.28659	15.49471	0.0537
At most 2	4.65E-05	0.001302	3.841466	0.9703

Notes: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level; * denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) p-values.

Table 5. Cointegration test based on maximal eigenvalue of the stochastic matrix

Hypothesized No. of E(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.997885	172.4396	21.13162	0.0001
At most 1 *	0.420682	15.28529	14.26460	0.0344
At most 2	4.65E-05	0.001302	3.841466	0.9703

Notes: Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level; * denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) p-values.

Table 6. Cointegration result of Hansen parameter instability approach

Lc statistic	Trends (m)	Trends (k)	Trends (p2)	Prob.*
0.150597	2	0	0	> 0.2

Notes: *Hansen (1992) Lc(m2=2, k=0) p-values, where m2=m-p2 is the number of stochastic trends in the asymptotic distribution.

Since the two variables are cointegrated, they can be represented equivalently in terms of a long run FMOLS framework.

5.2 Model Results

In Table 7, we see the results of the long run FMOLS estimates for equation 3. The explanatory power is high (R^2=97.4). All the explanatory variables are significant at 1% level.

$$\log(Y) = 2.16 + 0.67\log(K) + 0.57\log(L) + \varepsilon \tag{3}$$

$$\widehat{\mathrm{A}} = \mathrm{e}^{2.16} = 8.67$$

Then,

$$\mathrm{Y_t} = 8.67\ \mathrm{K_t^{0.67}}\ \mathrm{L_t^{0.57}}$$

According to above results, A = 8.67, α = 0.67, β = 0.57, provided that α + β >1 and α, β> 0. We also saw that the influence of the capital on the production of GDP is much higher than in the case of labor. We therefore conclude that the national economy is one more capital-intensive and less based on the use of labor in the production process.

Table 7. FMOLS estimates in the long run (1984-2011)

Variable	**Coefficient**
C	2.16[a]
LOG(K)	0.67[a]
LOG(L)	0.57[a]
	R^2 = 97.4
	Durbin-Watson: 1.47

Source: Table (A-2) in Appendix. a indicates significance at the 1% level.

The 0.67 estimate for α indicates that a 10 percent increase in the capital leads to a 6.7 percent increase in the output level, which implies there is diminishing returns to capital. Similarly, the 0.57 estimate for β indicates that a 10 percent increase in the labor leads to a 5.7 percent increase in the output level, which implies there is diminishing returns to labor. However, the sum $\alpha+\beta=0.67+0.57=1.24$ is greater than one, which implies production exhibits "increasing returns to scale". Increasing returns to scale means a proportionate increase in all inputs leads to a more than proportional increase in the output. For example, doubling all inputs would lead to more than a doubling of output. In this case, $\alpha+\beta=1.24$ indicates a one hundred percent increase in (or doubling of) the inputs leads to a 124 percent increase in the output level.

6. Concluding Remarks and Policy Implications

This paper introduces an explanation of Saudi economic growth along the lines proposed by the neo-classical growth theory. Production function estimates for gross domestic product is provided using Cobb-Douglas function. A wide range of econometric testing is employed. The functional form is estimated using a constant to express the technical progress. The result shows an elasticity of output with respect to capital and labor of about 0.67 and 0.57 respectively. Technical progress has positive contribution to growth rate of output of 8.67% a year.

Production in Saudi Arabia exhibits "increasing returns to scale." Increasing returns to scale means a proportionate increase in all inputs leads to a more than proportional increase the output. Therefore, it is a difficult task for the policy makers to determine the best policies for the enhancement of capital and labor on economic growth. The major policy implications and recommendations from our analysis are that Saudi Arabia needs to improve the rate of return to education in order to raise the productivity of labor. That may be occurred by investing large amount of resources in increasing and improving educational attainment for men and women, and by increasing the training levels in industrial and services sectors.

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Appendix

Table A1. Economic data (1984-2011)

Period	Real Gross Domestic Product (RGDP) (2005=100) (Billion Riyal)	Real Gross Capital Formation (RI) (2005=100) (Billion Riyal)	Number of Employees (L) (Million)
1984	443.27	112.89	3.55
1985	408.93	92.10	3.85
1986	361.62	82.47	4.11
1987	365.81	82.57	4.39
1988	368.01	71.43	4.63
1989	395.94	75.04	4.87
1990	476.47	92.18	5.05
1991	511.95	106.09	5.14
1992	529.78	109.85	5.24
1993	507.80	113.79	5.40
1994	514.45	96.70	5.59
1995	521.54	102.44	5.77
1996	569.97	100.74	5.96
1997	596.01	106.95	6.18
1998	527.24	110.98	6.40
1999	591.53	117.71	6.67
2000	702.06	124.22	6.90
2001	691.78	128.44	7.18
2002	711.04	130.15	7.48
2003	804.78	149.63	7.74
2004	936.45	157.44	8.01
2005	1172.40	195.63	8.29
2006	1295.95	228.03	8.57
2007	1340.98	274.58	8.85
2008	1492.63	298.69	9.09
2009	1138.88	293.69	9.26
2010	1422.83	328.31	9.56
2011	1749.11	336.77	9.81

Source: Saudi Arabian Monetary Agency (SAMA), *Annual Report*, No. 48. World Bank, *World Bank Development Indicator*.

Table A2. Fully modified ordinary least squares (fmols) regression results

Dependent Variable: LOG(RY)
Method: Fully Modified Least Squares (FMOLS)
Date: 03/18/13 Time: 19:48
Sample (adjusted): 1984 2011
Included observations: 28 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth= 4.0000)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LOG(RI)	0.670715	0.062295	10.76671	0.0000
LOG(L)	0.571598	0.099364	5.752579	0.0000
C	2.163141	0.172901	12.51090	0.0000
R-squared	0.973838	Mean dependent var	6.510146	
Adjusted R-squared	0.971745	S.D. dependent var	0.477476	
S.E. of regression	0.080260	Sum squared resid	0.161043	
Durbin-Watson stat	1.468732	Long-run variance	0.005634	