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The Sources of Economic Growth in Iran's Economy

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Abstract. This paper estimates the shares of Total Factor Productivity Growth (TFPG), labor accumulation, and capital stock accumulation in Iran's economy, and analyzes the time trend of the TFPG over the course of 1360-1392 of the Solar Hijri calendar (approximately equal to the 1981-2013 of the Gregorian calendar). Few studies have already been carried out for estimating sources of economic growth in various countries and different economic sectors. Nevertheless, little attention has been paid to Iran's economy in recent years. After testing for the stationarity of the variables using Dickey-Fuller tests, this study estimates an aggregate production function for Iran's economy using times-series econometric methods. The results suggest that the production structure of Iran's economy is more capital-intensive than being labor-intensive. In fact, the elasticities of production with respect to capital and labor have been 0.59 and 0.41, respectively. The findings show that the average annual growth rate of TFP has roughly been 0.5% over the study time period. The other results imply that the average contributions of TFPG, labor accumulation and capital accumulation in Iran's economic growth have been 15%, 30%, and 55%, respectively. As a result, it could be inferred that the performance of Iran's economy in terms of long-run, economy-wide productivity growth has been weak compared to that of other developed and developing countries, in most of which TFPG possesses relatively greater shares in their economic growth.
Keywords. Iran, Sources of economic growth, Aggregate production function, Capital accumulation, Employment.
JEL. O47.

1. Introduction

In economics, Total Factor Productivity (henceforth, TFP) is a variable that explains any changes in output level caused by any factor other than the increased quantities of the traditional factors of production, i.e. labor and capital stock. In this sense, TFP Growth (TFPG) is introduced as a third source of economic growth in an economy, in addition to labor accumulation and capital stock accumulation. When all inputs are accounted for, then TFP can be thought of as a measure of an economy's long-term technical change. TFPG may account for up to %50 of economic growth in some developed and developing economies or economic sectors (Central Bank Report, 2016). TFPG can bring about many economic advantages, such as increased output, decreased inflation, decreased costs of production, and increased competitive power on the sales market against competitors.

For the first time in Iran, TFPG was mentioned in the second national economic development plan of Iran, and was quantitatively targeted in the fourth national economic development plan. In the fourth national development plan, the average

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annual growth rate of TFP was targeted to be 2.5% of the planned 8% target for the total economic growth (i.e. a share of 31.3% was attributed to TFPG).

The present paper attempts to estimate an aggregate production function for Iran's economy, and thereby compute the shares of the sources of economic growth in Iran's economy over 1360-1392. More formally, the research questions of this paper are: What are the elasticities of production with respect to labor and capital in Iran's economy? What are the shares of each of economic growth sources in Iran?

The paper is organized as follows: In the next section, the theoretical bases of production functions and TFP are explained. The third section reviews some related empirical studies. Afterwards, in the fourth and fifth sections, an aggregate production function is estimated and the shares of economic growth sources are calculated. The final section summarizes and concludes.

2. Theoretical Background

According to Moosavian (2015), "a production function is a mathematical equation that represents the relationship between physical inputs and physical outputs. It can represent various ways of combining factors of production to produce goods and services." He also goes on to introduce various types of production functions, whose discussion is beyond the scope of the present paper.[1] Accordingly, the production function can be expressed as the following mathematical equation:

$$Q = f(L, K, ...) \tag{1}$$

where the dependent variable (Q) is the output and the independent variables are various production inputs, such as labor (L), capital (K), and the like. Aggregate production function is a neoclassical economic concept where L>0 and K>0, and is defined as a continuous twice-differentiable function, and its partial derivatives are as follows:

$$\frac{\partial Q}{\partial L} = f_L \qquad \frac{\partial Q}{\partial K} = f_K \qquad \frac{\partial^2 Q}{\partial L^2} = f_{LL} \qquad \frac{\partial^2 Q}{\partial K^2} = f_{KK} \tag{2}$$

Furthermore, it is assumed that:

$$f_L \succ 0 \qquad f_K \succ 0 \qquad f_{LL} \prec 0 \qquad f_{KK} \prec 0 \tag{3}$$

It is now guaranteed that the marginal products of inputs are all positive and diminishing.

Aggregate production function is a mathematical relationship that is applied to describe technical relations among a set of inputs with output at a macroeconomic level. Theoretically, this function is the sum of micro production functions. Empirical evidence suggests that assuming an aggregate production function allows macroeconomic models to fit aggregate data quite well and be highly predictive (Moosavian, 2015).

[1] Zeytoon Nejad (2016a, 2016b, and 2017) elaborates the fundamental role of production functions as a crucial part of micro-foundations of macroeconomics. Naumenko & Moosavian (2016, and 2017) also explain and describe the role of production functions in production theory in a visual as well as an algebraic manner.

The initial theoretical foundations of growth accounting were first presented in Solow (1957), Kendrick (1961), Denison (1962), and Jorgenson & Griliches (1967). The method of growth accounting utilizes an aggregate production function with the property of constant returns to scale in order to estimate TFPG (Barro, 1998). In growth accounting, the aggregate production function takes the following form, which implies that output in a given year is a function of labor force employed and capital stock utilized in that given year.

$$Q_t = A_t f\ (K_t, L_t) \tag{4}$$

where Q_t, K_t, L_t, and A_t are real output, stock of capital, employment, and the level of productivity, respectively, in year t. If one takes the derivative of this equation with respect to time, the result would be:

$$\frac{dQ}{dt} = \frac{dA}{dt} f\ (K_t, L_t) + A_t \frac{\partial f}{\partial K}\frac{dK}{dt} + A_t \frac{\partial f}{\partial L}\frac{dL}{dt} \tag{5}$$

By diving both sides of the equation by Q_t, we will get:

$$\frac{dQ}{dt}/Q_t = \frac{dA}{dt}/A_t + \frac{\partial f}{\partial K}\frac{dK}{dt}/f\ (K_t, L_t) + \frac{\partial f}{\partial L}\frac{dL}{dt}/f\ (K_t, L_t) \tag{6}$$

By replacing the marginal products by their corresponding shares in the output produced, we will end up with the following equation:

$$g_t^Q = g_t^{TFP} + (rK_t/Q_t)g_t^K + (wL_t/Q_t)g_t^L = g_t^{TFP} + s_k g_t^K + s_l g_t^L \tag{7}$$

where g_t^Q, g_t^{TFP}, g_t^K, and g_t^L are the growth rates of output, TFP, capital stock, and employment, respectively, at time t, and r is the interest rate and w is wage. Since Constant Returns to Scale (CRS) is assumed, then $s_k + s_l = 1$. As a result, the TFPG equation will be as follows:

$$g_t^{TFP} = g_t^Q - (1 - s_t)g_t^K - s_t g_t^L \tag{8}$$

In the next section, empirical studies on the shares of economic growth sources will be reviewed in brief.

3. Empirical Studies

Sources of economic growth have been studies in many countries and various economic sectors. Here a selected set of studies will be reviewed briefly.

Kim & Lau (1994) study the sources of economic growth of the East-Asian newly-industrialized countries (Hong Kong, Singapore, South Korea, and Taiwan) and the Group-of-Five industrialized countries (France, West Germany, Japan, the United Kingdom, and the United States) by using the aggregate meta-production function framework. They argue that the hypothesis that there has been no technical progress during the postwar period cannot be rejected for the four East-Asian newly-industrialized countries. According to their findings, the main source of economic growth of the East-Asian newly-industrialized countries has been

capital accumulation (accounting for 48% to 72% of their economic growth), in contrast to technical progress (i.e. TFPG) for the case of the Group-of-Five industrialized countries (accounting for 46% to 71%).

Qingwang & Junxue (2005) compare four methods of estimating total factor productivity, and estimate and analyze total factor productivity growth rate and other sources of economic growth in China for the period of 1979-2004. They conclude that TFPG shows a fluctuant behavior, especially before 1993, and that the contribution of TFPG rate to economic growth was lower than other sources of economic growth. They finally state that China's economic growth in 1979-2004 has been mostly input-driven, primarily due to a slow technological progress, technical inefficiency and implausible resource allocation.

Shankar & Rao (2012) attempt to estimate the long-term growth rates in Singapore by specifying a CES production function, concluding that the elasticity of substitution between labor and capital has been 0.6, and that technical progress in the economy has been labor-augmenting, and that the average long-term economic growth rate over the course of study period has been roughly 1.8%.

Mahmoudzadeh & Moosavian (2016) have studied the shares of economic growth in the mining sector of Iran using the growth accounting approach over 1976-2006, concluding that the average annual growth rate of TFP has been 2.94% during the time period of the present study in the mining sector. They also mentioned that the average contributions of TFPG, labor accumulation and capital accumulation in the economic growth of the mining sector have been 56%, 23%, and 21%, respectively, during the time period of the study.

Alimoradi (2003) measures TFPG and its contribution to GDP growth (GDPG) in Iran's economy over 1966-2000. She concluded that during the mentioned study period the average annual TFPG has been roughly -8%, and that the share of increased employment has been greater than the share of capital accumulation in the time period of the study.

Shahabadi (2007) investigates the sources of economic growth in the industrial sector of Iran for the two time periods of pre- and post-revolution. He concludes that the main sources of economic growth in this sector in the order of magnitude have been capital accumulation, increased employment, and TFPG in the pre-revolution period, whilst for the case of post-revolution the order has been as capital accumulation, TFPG, and increased employment.

4. Variables, Model, Results, and Discussion

The data is drawn from the national accounts published annually by the Central Bank of Iran, which is publically available on the central bank website under the section of the time-series databank. The main variables to be studies and used in the present study are as follows:

Table 1. *Variables, Symbols, and Data Sources*

Symbol	Variable	Resource
Y	GDP	Central Bank of Iran, Time-Series Data Bank
L	Employment	Central Bank of Iran, Time-Series Data Bank
K	Capital stock	Central Bank of Iran, Time-Series Data Bank

Table 2 provides the summary statistics of the main variables of the study.

Table 2. *Table of Summary Statistics*

Variable	Obs	Mean	Std. Dev.	Min	Max
Y	33	1286128	457444.9	686902	2157934
L	33	15424.95	3863.663	9677.951	21022.03
K	33	4860048	1543605	3126699	8304161

Figure 1 illustrates the time trend of the logged variables over the time period of study (1360-1392).

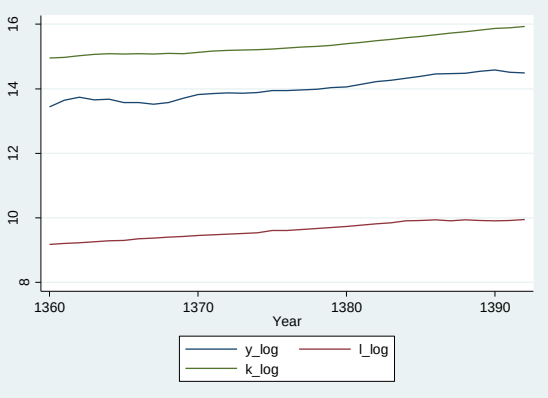

Figure 1. *Time Trends of the Logs of the Variables*

As implied in the above figure, all of the three variables exhibit some sort of a time trend. To deal with these time trends, and to test for stationarity, Dickey-Fuller test was used, and all the three variables yielded test statistics larger than the corresponding tabulated critical values, and the null hypothesis of a unit root could not be rejected. Next, the stationarity of the I(1) version of each of the variables were checked, and it turned out that all the variables at I(1) level are stationary. Finally, it became known that all the three variables are integrated of order one, i.e. I(1). The results of these tests have been reported in appendix 1.

Afterwards, in order to avoid encountering the issue of spurious regression when estimating the aggregate production function for Iran's economy, a restricted version of Cobb-Douglass production function was estimated by using the first-difference model that make all the variables stationary.[2] The results of this estimation have been reported in appendix 2. The results indicate that the share of labor and capital in Iran's GDP have been 41% and 59%, respectively. The results of this estimation are, to a great extent, consistent with the cost shares of factors of production reported in the national accounts. This consistency highly enhances the reliability of the results of the resent study. In fact, no matter whether we want to use directly the national accounts for estimating factors' shares[3], or we want to estimate the parameters of an aggregate production function for Iran's economy to obtain productive shares of the inputs in an indirect way, the results of using these two different methods will not change the results and findings of the present study eventually. On the basis of these results and by using the TFPG equation derived in section 2, the shares of economic growth in Iran's economy were estimated. Table 4 reports the related results.

[2] Incidentally, prior to the imposition of the restriction, the validity of the restriction of constant returns to scale was tested, and it turned out that the restriction could not be rejected at 10% level.

[3] Using the costs shares of inputs reported in national accounts is technically an alternative way to compute the parameters of the production function.

Table 3. *The Shares of the Sources of Economic Growth in Iran's Economy*

Source of Growth	Share of Sources of Economic Growth	Relative Shares of Sources of Growth in Percentage
Capital Accumulation	0.0180	54.62
Labor Accumulation	0.0100	30.15
TFP Growth	0.0050	15.23
Total	0.0330	100.0000

As shown above, Iran's GDP has grown by the average annual rate of 3.3% over the course of the studied period. Of this 3.3% annual economic growth, 1.8% is attributed to the occurred capital stock accumulation, 1% is attributed to the increased labor employment, and the rest which equals 0.5% is attributed to TFPG. In other words, the relative shares of 54.62%, 30.15%, and 15.23% in the whole economic growth can be attributed to the capital stock accumulation, the increased labor employment, and the TFPG, respectively.

Also, the annual TFPG rates for each year in the study period were estimated using the TFPG equation. These results are reported in appendix 3 in greater detail. Figure 2 demonstrates the time trend of the annual TFPG rates in a visual manner.

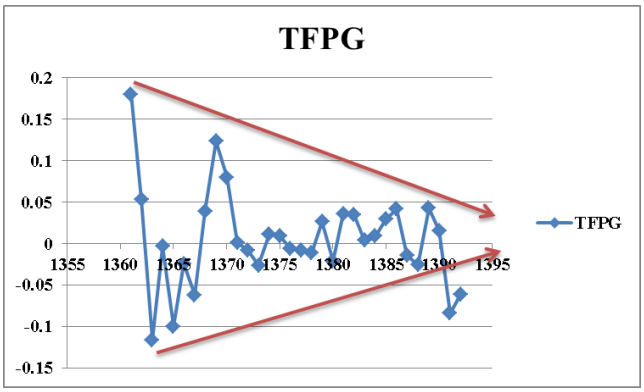

Figure 2. *Time Trends of the annual TFPG rates*

As evident in the above figure, the annual TFPG rate has had a fluctuant behavior in the 32-year study period. However, there is an interesting, general pattern with it which shows that the TFPG has been converging to zero over the past three decades. In what follows, these 32 years are split into four 8-year periods, each of which corresponds with a presidency time period, which are known as the within-war-period government[4], post-war-reconstruction government, political-reform-and-development government, and under-economic-sanction government[5]. Table 4 presents the time intervals and average annual TFPG rates corresponding with each government, and figure 3 exhibits the time trend of the average annual TFPG in a graph in terms of the corresponding period numbers of the governments.

[4] The government in power over the time period of Iran-Iraq war

[5] The government in power over the time period of severe international economic sanctions due to Iran's nuclear activities

Table 4. *The Average Annual TFPG Rate in Each Governmental Period in Iran's Economy*

Period #	Post-Revolution Governments	Years Intervals	Governments Known as	Average Annual TFPG
1	3th & 4th	1361_1368	within-war-period government	-0.004274
2	5th & 6th	1369_1376	post-war-reconstruction government	0.023016
3	7th & 8th	1377_1384	political-development government	0.008502
4	9th & 10th	1385_1392	under-economic-sanction government	-0.007157

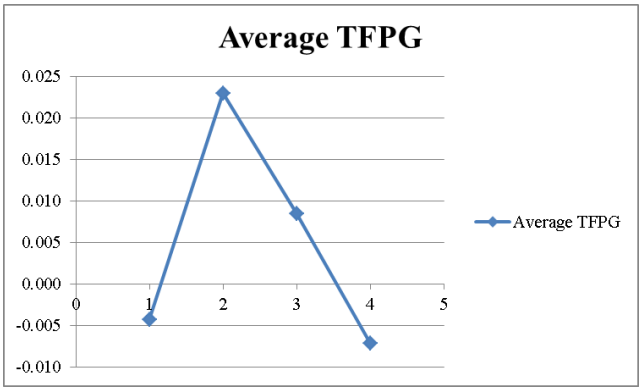

Figure 3. *Time Trends of the Average Annual TFPG Rate in Each Governmental Period*

As shown above, when the 32 years are split into four 8-year periods, one can easily see that the average annual TFPG rate for the within-war-period government has been roughly -0.4%, for the post-war-reconstruction government has been +2.3%, for the political-reform-and-development government has been +0.8%, and for the under-economic-sanction government has been -0.7%. From these results, it can readily be inferred how destructive the effects of wars and economic sanctions could be on the level of TFP in an economy like Iran.

Finally, it should be noted that a striking result about the average of the annual TFPG during the under-economic-sanction government is that this lowest TFPG rate has occurred while the 8-year average oil sales price, as a major contributor to Iran's GDP, had been unbelievably high and around $80 per barrel, which had been much higher than the average oil sales prices during the other governments' periods. This simply shows how deeply economic sanctions have negatively influenced Iran's economy in that period of time.

6. Conclusion

In economics, Total Factor Productivity (TFP) is a notion that explains the changes in the output level caused by any factors other than the effects of the increased quantities of the traditional factors of production, i.e. labor and capital. TFP can be thought of as a measure of an economy's long-term, technological progress. In this paper, the shares of Total Factor Productivity Growth (TFPG), labor accumulation, and capital stock accumulation in Iran's economy are estimated. Additionally, the time trend of TFPG share over the course of 1981-2013 is analyzed, so as to fill in the existing gap in the attention to Iran's economy-wide, long-run productivity in recent years. The data is drawn from the national accounts published annually by the Central Bank of Iran, which is publically available on the central bank website under the section of the time-series databank. After testing for the stationarity of variables, an aggregate production function for Iran's economy was estimated using the first-difference method. Other findings of the study imply that the structure of Iran's economy is more capital-intensive than

being labor-intensive. Indeed, the elasticities of production with respect to capital and labor have been 0.59 and 0.41, respectively. The results indicate that the average annual growth rate of TFP has roughly been 0.5% over the study time period. The other results show that the average shares of TFPG, labor accumulation and capital accumulation in Iran's economic growth have been 15%, 30%, and 55%, respectively. As a result, it could be inferred that the performance of the Iran's economy in terms of long-run, economy-wide productivity growth has been weak compared to that of other developed and developing countries, in most of which TFPG has greater shares in their economic growth.

The annual TFPG rate has had a fluctuant behavior in the 32-year study period. However, there is an interesting, general pattern with it that shows the TFPG has been converging to zero over the past three decades. The 32 years are split into four 8-year periods, each of which corresponds with a presidency time period. Looking at the results of this time division, one can easily see that the average annual TFPG rate for the within-war-period government has been roughly -0.4%, for the post-war-reconstruction government has been +2.3%, for the political-reform-and-development government has been +0.8%, and for the under-economic-sanction government has been -0.7%. From these results, it can readily be inferred how destructive could be the effects of war and economic sanctions on the level of TFP in an economy like Iran. A striking result about the average of the annual TFPG during the under-economic-sanction government is that this lowest TFPG rate has been achieved while the 8-year average oil sales price, as a major contributor to Iran's GDP, had been around $80 per barrel, which had been much higher than that during the other governments' periods. This simply shows how deeply economic sanctions have negatively influenced Iran's economy in that period of time. Finally, it is suggested that promoting technology, stabilizing economy to provide a bed for investment, developing infrastructures, making and implementing economic policies to increase incentives, and increasing R&D can be helpful in the improvement of long-term, economy-wide productivity, and eventually in the stimulation of economic growth.

Appendix 1. *The results of Dickey-Fuller tests for unit root*

```
Dickey-Fuller test for unit root                   Number of obs   =        32

                                 ---------- Interpolated Dickey-Fuller ----------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)            -1.920           -4.316            -3.572           -3.223
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.6442
Dickey-Fuller test for unit root                   Number of obs   =        32

                                 ---------- Interpolated Dickey-Fuller ----------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)            -0.105           -4.316            -3.572           -3.223
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9930

Dickey-Fuller test for unit root                   Number of obs   =        32

                                 ---------- Interpolated Dickey-Fuller ----------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)            -0.866           -3.702            -2.980           -2.622
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7988
```

Appendix 2. *The results of the estimation of the restricted Cobb-Douglas production function*

```
. constraint 1 l_growth + k_growth = 1

.
. cnsreg y_growth l_growth k_growth, constraint (1)

Constrained linear regression                  Number of obs   =         32
                                               Root MSE        =     0.0597

 ( 1)  l_growth + k_growth = 1

------------------------------------------------------------------------------
    y_growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    l_growth |   .4065805   .3869112     1.05   0.302    -.3835975    1.196759
    k_growth |   .5934195   .3869112     1.53   0.136    -.1967585    1.383597
       _cons |   .0050004   .0108278     0.46   0.648    -.0171129    .0271136
------------------------------------------------------------------------------
```

Appendix 3. *The estimated annual TFPG rates in each year*

Year	TFPG		
1361	0.1803	1377	-0.0083
1362	0.0528	1378	-0.0110
1363	-0.1163	1379	0.0262
1364	-0.0032	1380	-0.0213
1365	-0.1003	1381	0.0357
1366	-0.0244	1382	0.0343
1367	-0.0621	1383	0.0037
1368	0.0389	1384	0.0087
1369	0.1235	1385	0.0292
1370	0.0798	1386	0.0415
1371	0.0012	1387	-0.0141
1372	-0.0084	1388	-0.0261
1373	-0.0263	1389	0.0424
1374	0.0115	1390	0.0154
1375	0.0093	1391	-0.0840
1376	-0.0064	1392	-0.0616

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