# Source of Economic Growth in Libya (1970-2014): A case of Oil-based Economy

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# مصادر النمو في الاقتصاد الليبي (1970–2014):

## حالة الاقتصاديات النفطية

**Abstract**

Economic growth in Libya during 1970 to 2014 can be explained more by capital accumulation rather than labour or TFP. TFP contribution to growth was insignificant. A lower share of labour in GDP means that it was also less important than capital in determining the growth rate of Libya. Human capital also has no significant effect on economic process; decline in its productivity was observed despite some progress in in education and health services over the period of interest. Such declining productivity is an unsolved question not only in Libyan economy, but also in other oil-based MENA countries with similar features.

**Key words:** Economic Growth; Oil; Technological Change

**ملخص**:

استهدفت الدراسة تحديد مصادر النمو الاقتصادي في ليبيا خلال الفترة 1970–2014، وقد ظهر منها انه يمكن ارجاع جل النمو الى التراكم الرأسمالي أكثر منه الى عنصر العمل او التغير التقني TFP، أظهرت الدراسة من خلال التقدير القياسي لدور كل عنصر من عناصر الانتاج انه لا أهمية للتغير التقني في العملية الاقتصادية من خلال حساب قيمة البواقي لدالة انتاج كوب دوغلاس، بل ان هذا العنصر ساهم سلبيا في النمو الاقتصادي احيانا. كذلك أظهرت الدراسة الاهمية الاقل نسبيا لعنصر العمل كمحدد للنمو. رأس المال البشري كعنصر مستقل أيضا لم يظهر له أهمية ضمن عناصر الانتاج، بل أظهر قيما متواضعة جدا تحت كل التقديرات رغم التحسن الملحوظ في مؤشرات التنمية البشرية خلال فترة الدراسة ومنها مقاييس الخدمات الصحية والتعليمية. المساهمة المتواضعة لهذا العنصر هي موضوع غير مدروس ليس في الاقتصاد الليبي وحده بل في معظم اقتصاديات الوفرة النفطية وذات الخصائص المتشابهة. هذه النتائج تتوافق مع كثير من نتائج الدراسات حول الاقتصاديات المشابهة كما تم التطرق اليها في المتن.

**الكلمات المفتاحية:** النمو الاقتصادي. النفط؛ التغير التكنلوجي.

## 1 -Introduction:

Economic growth has become a common topic for researchers, and a recent phenomenon in human civilisation. Since Keynes (1937) claimed that reduction in physical capital per worker results technical unemployment as business employs less workers, writings in growth as well as related issues have not stopped. Acemoglu and Robinson (2012) finished their book by questioning why some nations are flourishing while others still setback. While others argued that countries have to choose one between development and growth in the economic planning process, taking to account the differences between the two concepts on both theoretical and practical levels (Hirschman 1959). More recently, there was more attention to the source of growth through the last few decades, regarding the functional and size theories of income distribution (Bhattarai 2005, 2016). The size distribution issues widely discussed by Kuznets and many others (Kuznets 1955), and on functional distribution issues, firstly by Adam Smith and then Karl Marx in their well-known books the wealth of nation and capital. Then recently by Thomas Picketty in his book capital (Picketty 2014). In this context, natural resources were playing the centre in many theories and studies (Barbier 2007). Accordingly, economic growth defined in many studies as above centred on the productive capacity of such economy as well as in increasing a nation's total wealth (Lucas 2002, Soubbotina 2004, 2015)

Solow in his pioneering work connected the level of output to its input factors. He disentangled the role of physical inputs (capital and labour) from the effect of technological impact (Solow 1957).He pointed out to the technical change as the cause of any shift in the production function. Since then, empirical works later have enriched this argument in many aspects, especially by focusing on appropriate institutions, human resources and governance as additional supporting factors (Acemoglu 2008). However, some other authors argued that the economic growth is wider than it could be represented by these factors (Fouquet and Broadberry 2015),(Barro and Lee 1994) ).Regarding oil-based economies as per the case of Libya, there was always kind of puzzling phenomenon due to combined natural resource abundance and slower growth despite the traditional view of the importance of natural riches for economic growth (Guilló and Perez-Sebastian 2015), (Sachs and Warner 1995). In this context, this paper aims to investigate the source of growth that determined the economic performance in Libya over the last four decades. The major contribution of the paper lies in shedding light on the determinants of growth for the Libyan economy.

The main question is, what are the shares of labour and capital in Libya? Are they similar to other oil-based economies?

## 2 - Theoretical framework:

Plenty of studies have been achieved to understand where the economic growth stems from. Collins and Bosworth investigated the source of growth among 88 countries, results mainly toggled capital accumulation for emerging East Asian economies(Collins, Bosworth et al. 1996), while Klenow and

Rodriguez-Clare find that 90 percent of growth in output per worker is attributed to TFP in 90 percent of the 98 countries studied(Klenow and Rodriguez-Clare 1997).

Clearer results were revealed by Kim and Lau, who find that in the developed economies TFP is likely to play the main role in growth, whilst in emerging countries the capital accumulation is more important (Kim and Lau 1994). In addition, studies are still investigating different types of economies to build robust outcomes in this topic. On one hand, these studies pointed two types of sources of growth in emerging economies, whereas TFP seems to be the long run driver, it is the capital accumulation for the short run (Ali 2016). On the other hand, the results vary between TFP and physical capital accumulation as an accounted source of economic growth, depending on the type of production function used. (Park and Ryu 2006).

A different study showed a relation between the source of growth and the level of growth, hence, in the high growth years the TFP seemed to be the main contributor, whilst in the slow periods the labour is the main one, and for the modest, capital is more important source (Fuentes et al 2006).

For oil-based economies- like Libya-, studies on this topic are not copious, and in particular, for Libya, this issue has not been tracked to the best of our knowledge. Ali and others investigated the source of growth in MENA countries, which in fact have almost similar features of Libyan economy, under the assumption of neutral technological progress, they found that economic growth stems from capital accumulation rather than from TFP, Their study included not oil-based economies such as Turkey, Morocco and Egypt. For Israel and Saudi Arabia the situation was reverses- TFP more important than capital (Ali 2016). Abu-Qarn et al studied 10 MENA countries for the period 1960-1998, and found that capital accumulation is the lead driver of the growth, and TFP contribution is negligible, even negatively. K is more contributor rather than labour in all countries without exception (Nehru and Dhareshwar 1993, Abu-Qarn and Abu-Bader 2007).

Alkhathlan arrived at results that oil has the main impact on real GDP among all other inputs in both the short and the long run for Saudi Arabia's economy (Alkhathlan 2016).Given above, the objective of this study is to determine sources of growth in Libyan economy.

**3 -Methodology and data:**

This topic specifically has been studied empirically upon two approaches, the national accounting approach, and the regression approach. (Park and Ryu 2006). The first approach calculates the labour share from national accounts data assuming that capital and labour are partners in output yielding, while the later estimates the TFP share from the given data. Without going further in the comparative argument for both approaches, it is appropriate here to clarify that this study will follow the second approach – regression- and will apply Solow model, due to two reasons, one is theoretically related to national accounts data availability, and the second is due to the wide using of this approach in the literature. Solow model has enough substance to apply (Acemoglu 2009).Also, the assumption of Hicks-neutral technical change has been employed to assess the source of growth, and determining factors with constant returns to scale (CRS).

**3-1-Micro foundation:**

Starting with common formula of Cobb-Douglas production function for output.

$Y_t = A_t K_t L_t e^{ut}$ ….. (1)

Where $Y_t$ stands for annual output represented in GDP in year t as usual.

K, L are the input factors, capital and labour respectively.

A denotes the level of technology used in the country for economic process.

$e^{ut}$ is the error term.

Growth in output Y is inevitably sourced in growth in one or all these factors mentioned above, thus, returning to the equation (1), the source of growth can be derived by taking logs of all terms and differentiating with respect to time:

$Ln\,(Y_t) = ln\,(A_t) + \alpha\, ln\,(K_t) + \beta\, ln(L_t) + ln\,(u_t)$ . . . . . (2)

Thus, looking for source of output growth implies looking for growth in the three terms in RH side.

$$\frac{dY/dt}{Y} = \frac{dA/dt}{A} + \alpha \frac{dK/dT}{K} + \beta \frac{dL/dt}{L} \qquad \ldots\ldots\ldots\ldots (3)$$

The term $\frac{dA/dt}{A}$ is known as total factor productivity TFP according to John Hicks, and indicates Hicks neutral TFP as stated by Hicks as the shift in production function due to any other reasons out of common input factors K and L.

As per neoclassical model, capital plays substantial role in the process of economic growth, as this is the case, output $Y_t$ depends along with other factors- on how the corresponding society could accumulate and manage the capital. Savings is the main channel to accumulate capital continuously, and it is just a fraction of the output after consumption, therefore it will be[1]:

$S_t = sY_t$

$0 < s < 1$

Here, (S)is amount of saving, it must be greater than the sum of allowance of depreciation of capital and for equipping new workers at the level of existing workers. Tow opposite factors denoted bydepreciation$\delta$and population growth rate$n$.

Therefore: $S = sY_t > (\delta + n)K_t$. . . . . (4)

[1] See Bhattarai, K., Further Economic Analysis, unpublished lecturers, University of Hull, 2012.

Growth in capital is equal to: $\dot{k} = \widehat{sy} - (n+\delta)k_t \ldots\ldots$ (5)

Equation (5) called fundamental equation of growth in neoclassical model,and $\dot{k}$ is the growth rate of capital with respect to time, equal to$dk/dt$ , $\widehat{sy}$ is per capita saving ratio.

Positive changes in capital reflects in per capita capital up to steady state level when it becomes zero: $\frac{dk/dt}{k_t}=\frac{\dot{k}}{k_t}= 0$

Therefore $\dot{k} = \widehat{sy} - (n+\delta)k_t = 0 \ldots.$ (6)

$\frac{\dot{k}}{k_t} = sk_t^{\alpha-1} - (n+\delta) = 0$ ..... (7)

$sAk^{\alpha}= (n+\delta)k$ ..... (8)

Therefore per capita capital in steady state will be:

$$k = \left(\frac{sA}{(n+\delta)}\right)^{\frac{1}{1-\alpha}} \quad \ldots\ldots \quad (9)$$

Per capita out put $\tilde{y} = \left(\frac{sA}{(n+\delta)}\right)^{\frac{\alpha}{1-\alpha}} \ldots\ldots$ (10)

Per capita consumption $c = (1-s).y = (1-s)\, A\left(\frac{sA}{(N+\delta)}\right)^{\frac{\alpha}{1-\alpha}}$ ..... (11)

The required market clearance condition is obtained from equating the income yielding to the income spending as follows:

$Y_t= C_t+S_t=I_t+C_t$ ..... (12)

Therefore, investment must equal saving to obtain equilibrium on macro-level.

$I_t = S_t$

Given capital at any given period is equal to:

$K_t = (1-\delta)K_{t-1}+ I_t \ldots\ldots$ (13)

This formula is widely applied for this task,and has been employed often,especially for developing economies (Senhadji 2000), (Pritchett 1999),

Equation (1) will be tested firstly to find out if it will give robust outcomes, and alternative form will be applied regarding to natural resources that already have been suggested as a major factor of inputs in many studies (Guilló and Perez-Sebastian 2015), (Doppelhofer and Weeks 2011), (Perman 2003),(Alkhathlan 2013)(Groth 2007). Following Solow process,production function should be decomposed into effective inputs which include capital accumulation K, labour efforts L and natural resources NR (Chambers and Guo 2009) as follows:

$GDP_t = A_t K_t L_t R_t e^{u_t}$ ….. (14)

Where:$R_t$ stands for the natural resources endowments extracted and converted directly into continuing revenues to fund different expenditures rather into inputs through the economic process.

For estimating purposes to eliminate statistical problems such as multicollinearity, reduce heteroscedasticity, and to impose CES assumed previously, one can suppose:

$\alpha + \beta = 1$

To do so, and following many studies(Abu-Qarn and Abu-Bader 2007),equation will be reduced to an estimable form dividing both sides by L, then taking logarithms of all termsas follows:

$ln\ (Y_t/L_t) = lnA + \alpha ln\ (K_t/L_t) + u_t$ ..... (15)

Equation (15) above has been estimated for the period 1970-2014, and different types of data for all factors has been employed as shown in appendix (1).

The annual number of workers and annual compensation spent on labour factorhave been employed as L factor. Skilled-adjusted labour also has been engaged following many studies (Abu-Qarn and Abu-Bader 2007), (Senhadji 2000), as in the equation below:

$ln\ (Y_t/LH_t) = lnA + \alpha ln\ (K_t/LH_t) + u_t$ ..... (16)

After obtaining $\alpha, \beta$will be calculated easily according to the previous assumption of CES.

Studied period will start in 1970 up to the year of available data (2014), data are available at both local and international institutions for variables of interest, Y (GDP) is represented in and real values, data on L labour is available at local publishes in a number of workers, total annual labour compensations and total labour supply and even total population. Where H presents human capital by the average years of schooling for people aged above 15 as demonstrated in (Barro and Lee 2010).

Similar to labour and human capital, data on physical capital stock Kobtained in annual capital income, total capital stock and annual depreciation (used capital)at each year as well from local publishing of national accounts prepared by Economic Science Research Centre (ESRC) [2] for the period (1962-2006), for confirmation, depreciation rate has been calculated for the whole period to calculate K for the last eight years (2007-2014),and found equal to5%,whichcompatible with

[2] Economic Science Research Centre (ESRC) at Garyounis University had published outcomes of national accounts for the period (1962-2006) and the study will depend on these data as they considered reliable data as it had been done by academic team, data on rest of years obtained from annual investments shown in periodicals of Central Bank of Libya.

previous studies for MENA region as in (Abu-Qarn and Abu-Bader 2007), then it is easy to calculate physical capital stock for the whole period following perpetual inventory method (PIM) (Berlemann and Wesselhöft 2012) according to common following form (17),results calculated and obtained were very close.

$K_t=(K_{t-1}-\delta K_{t-1})+I_t$ …… (17)

Stationarity test for all variables shows that most of them are on-stationary at level as demonstrated in appendix (A2).

Growth in GDP can be broken down into contribution of total factor productivity and contribution of the rest of other factors K and L according to the following equation:

$\frac{Y}{Y}=\frac{A}{A}+\propto\frac{K}{K}+(1-\propto)\left(\frac{L}{L}\right)$ . . . . . (18)

Where: $(1-\propto)=\beta$

Then:

$(T\dot{F}P/TFP)=\dot{Y}/Y-[\alpha(\dot{K}/K)+\beta(\dot{L}/L)]$ …… (19)

Variables with dot are deferential with respect to time as usual in economics parlance.

$(T\dot{F}P/TFP)$ or $\frac{A}{A}$ denote the growth rate in TFP and referred to as the *Solow Residuals*.

The next step is to estimate output function using STATA$_{14}$ and EVIEWS$_{8}$.

**4-Structure of Libyan economy and input factors:**

Before going through the study let us review in brief some related characters of Libyan economy.

**4-1-The characteristics and growth of GDP:**

Being oil based economy since the sixties, funds became available for investment, and Libyan authority has to choose the appropriate path to achieve the desired economic development. Libyan economy in that time was in fact one of the most underdeveloped economies in the world (Higgins 1968). In general, and despite such a decision was not easy to be taken (Hirschman 1959), Libyan economy was subjected to many economic plans, which reflected in a kind of economic growth and development over time. As a result, Libya witnessed some improvements; however, there were negative growth in many years. Through these plans, it can be noticed that growth in non-oil GDP was greater than in oil one, although both of them are still highly related to the changes in oil shocks rather than to any other economic effects (Ahmouda 2014). In other words, in spite of remarkable economic growth during the study period, this growth was hardly sustained during the global oil shocks and uncertainty, as most of the economic growth was attributed to oil revenues (Ruhaet 2013).

Table (1) illustrates the growth rates in Oil, total and per capita GDP over the studied period. It can be observed that growth in per capita oil GDP was greater than non-oil up to the mid-nineties when the growth in non-oil GDP had exceeded the growth in oil GDP, however, this growth seems to be attributed also to the oil, as it fallen down suddenly due to decreasing in oil production in 2011.

Table 1

GDP growth ratios related to the periods of plans in 1997 prices

| Period | Compared with | Total GDP gr. rate | Non-oil GDP gr. rate | Per capita growth rate of | | |
|---|---|---|---|---|---|---|
| | | | | non-oil GDP | oil GDP | total GDP |
| Five-year plan 1963-1968 | 1962/1969 | 38.2 | 13.9 | 9.6 | 44.7 | 33.1 |
| Three-year plan 1973/1975 | 1973/1976 | 23 | 18.3 | 13.2 | 26.4 | 17.7 |
| Transformation plan 1976/1980 | 1976/1981 | 0.1 | 10.9 | 6.2 | -10.5 | -4.2 |
| Transformation plan 1981/1985 | 1986/1991 | -1.1 | -0.9 | -2.1 | -1.5 | -2.3 |
| Five-years plan 1986/1991 | 1991/1996 | 2.3 | 0.4 | -2.0 | 5.8 | -0.2 |
| Trio-programme 1994/1996 | 1994/1997 | 2.0 | 3.0 | 1.2 | 0.2 | 0.2 |
| Economic policies 98-2001/2006 | 1998/2007 | 4.7 | 5.8 | 4.0 | 2.4 | 3.0 |
| Transformation plan 2006/2010 | 2006/2010 | 5.1 | 7.4 | 4.2 | -1.1 | 2.0 |
| Developing programme 2008/2012 | 2008/2010 | 1.9 | 3.3 | 0.0 | -2.2 | -1.1 |
| Transition period 2014 | 2010 | -47.5 | -46.4 | -50.3 | -62.6 | -58.2 |

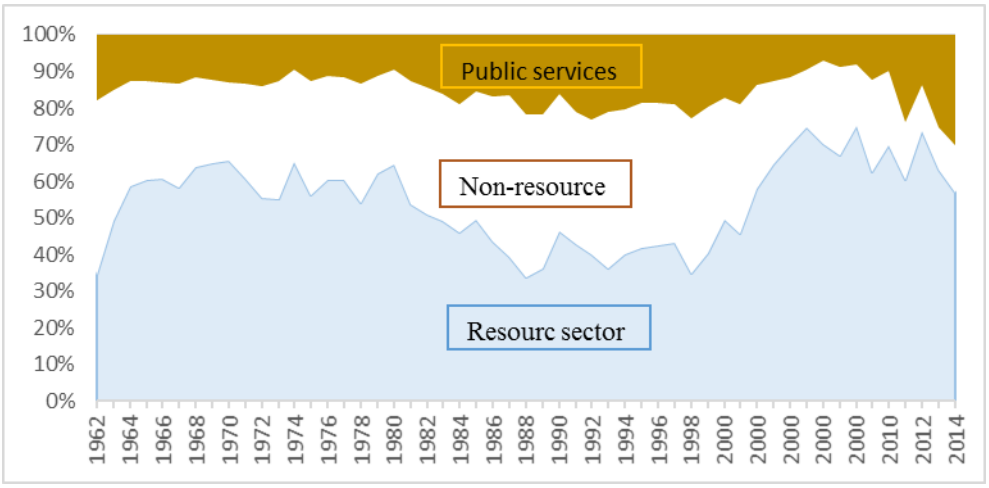
Source: Merza (2012)

## 4-2-The role of oil in Libyan economy:

It can be seen that oil has played a major role in the aggregate economic process, as shown in figure (1), the ratio of oil-based GDP has risen quickly-suddenly after oil discovering to 70%, and kept at almost upper than 50% over a prolonged period, until the fall down of oil prices in the begging of the eighties. Meanwhile, non-resource sector contribution declined from 50% in 1962 (*beginning of the oil stage*) to around 27% after just three years. Despite the long period of suffering from this condition, the authority could not resist the upward trend of oil prices again in 2000. As a result, this rate reached 70% once again after 2000.Within years of resource sector declining from 1981 to 2000, there was expansion of public and government owned sector, which in turn depended on oil revenues. Traditionally in Libyan economy, public sector played a pivotal role benefited mainly from oil revenues (Ruhaet 2013).Libyan economy along with oil rich countries is still highly depending on oil, however, it fluctuated over the last thirty years (Akli and Kim 2014,(Bhattacharyya and Blake 2010), and still majorly reliant on oil and its products, it taps more than 90% of total revenues from oil, and 95% of earned income is oil based (Ahmouda 2014).However,it should be considered as an opportunity for growth as stated in(Solarin and Ozturk 2016), Sachs concluded that almost resource-abundant countries -particularly that mineral-intensive ones- have stagnated in economic growth (Sachs and Warner 2001).

Figure (1)

GDP by sectors in percentagesin Libya overthe studied period




**-Source: Author work. - Resource sector includes primary sectors such as agriculture, oil extracting and mining.- Non-resource sector includes industries, transportation, electricity, trade, retails and constructions.- Public services sector includes government funded services such as education, health, security and defence.*

### 4-3-Real Physical capital:

As shown in table (1) there was a significant impact of oil revenues vibration on real physical capital. The average growth rate of physical capital over the period was (11.3%) [In real values was 6.9%] and for labour force was (4.24%), both grew greater than GDP per worker which was just (4.20%). Per worker GDP and per worker physical capital, both showing a similar trend, in which they both were affected by two reasons:

Table (1)

Growth rates in input factors per five year periods in Libya (1970-2014)

| Period | Physical Capital* | Human capital** | Labour Force* | Population* |
|---|---|---|---|---|
| 1970-1974 | 23.63 | 7.21 | 7.97 | 4.05 |
| 1975-1979 | 22.52 | 11.62 | 5.43 | 3.98 |
| 1980-1984 | 16.97 | 11.61 | 4.23 | 4.09 |
| 1985-1989 | 4.62 | 9.14 | 1.47 | 2.86 |
| 1990-1994 | 3.80 | 7.32 | 2.94 | 2.27 |
| 1995-1999 | 3.77 | 9.53 | 3.79 | 1.82 |
| 2000-2004 | 6.77 | 7.81 | 2.80 | 1.53 |
| 2005-2009 | 15.93 | 6.56 | 4.62 | 2.39 |
| 2010-2014 | 3.67 | NA | 4.96 | 2.18 |

Source: * Author work, ** Barro and Lee(2010).

One because of the dramatic fall down of oil revenues in the beginning of the eighties which was larger than authority in Libya can capable with, the second is the rising in participated workers in a aforementioned period, due to the intervention policies adapted during the eighties, and

unprecedented governmental actions in 1984 and 1985, seen in the deportation of thousands of foreign workers which led to decrease in the numbers of engaged workers by 20% and 3% for these years respectively (Ahmida 2001), (Tress, Rabinovich et al. 1988), and in turn increase of physical capital per worker despite reducing in investments. On the other hand, increased human capital per worker followed by slightly decreasing after 1995 can be explained in the long run effect of insufficient investment in education which suffered from quality as Humphrey stated (Humphreys, Sachs et al. 2007). This also can be seen in figure (2), where real GDP/worker and real physical capital/worker, both developed almost as similar as the oil revenues per worker over the studied period.

Figure (2A)

Log of real GDP per worker $GDP/L$ in Libya

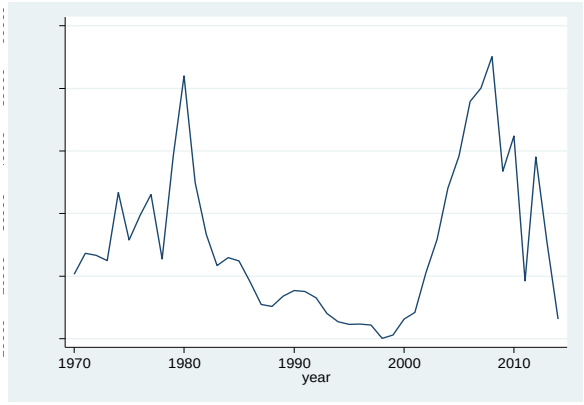



Figure (2B)

Log of real physical capital per worker $K/L$ in Libya

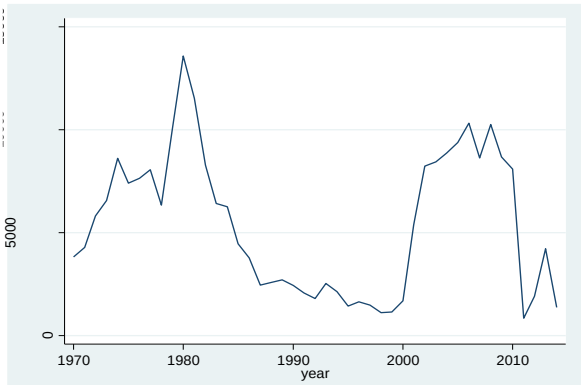



Figure (2C)

Log ofhuman capital per worker $H/L$in Libya

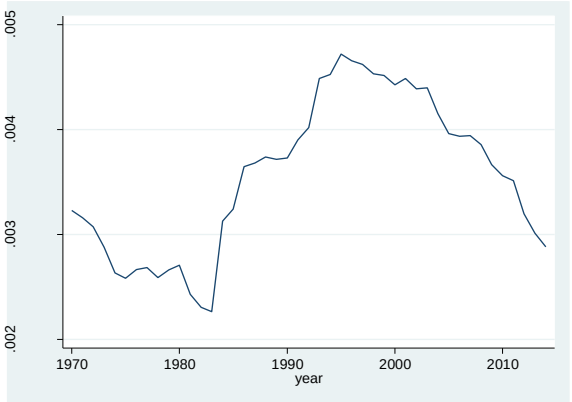
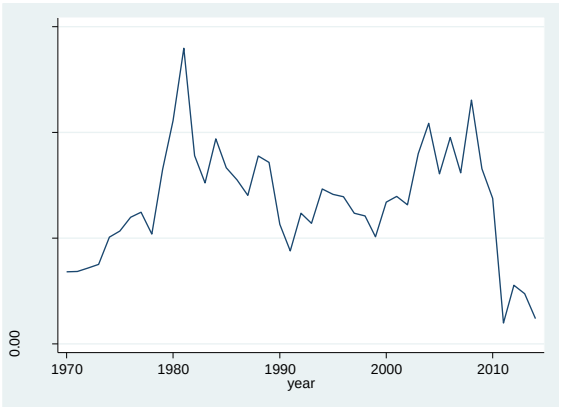



Figure (2D)

Log of oil revenues per worker $R/L$ in Libya

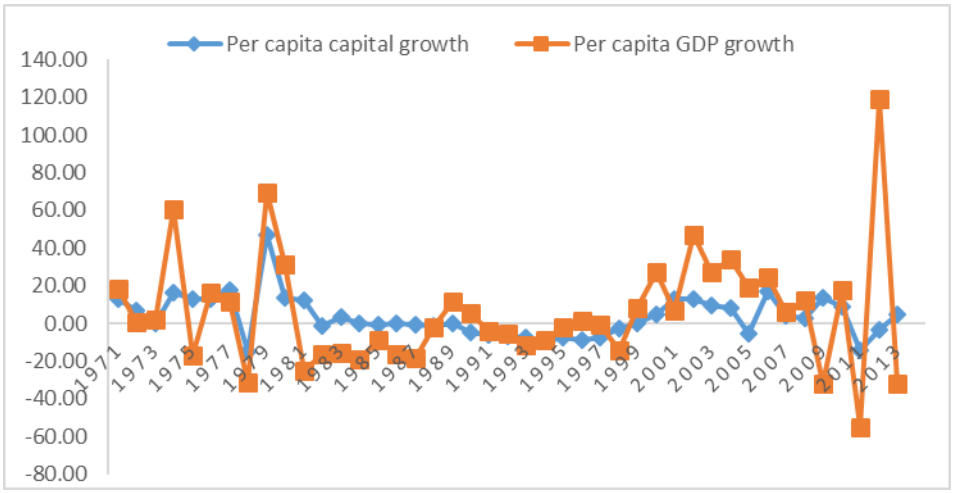



*Source: Author work, and all values are in Libyan currency and current values.*

Although, per capita capital grew more than per-capita-GDPin some years, the first decreased over the period, as seen figure (3). However, this trend should be questioned regarding to the way and type of investment which allocated to fill the gap in basic infrastructure[3] rather to build productive economic structure. This may explain the declining in real physical capital per worker between 1983 and 2000.

Figure (3)

Per capita GDP and Per capita capital in Libya over the period studied (Libyan Dinars)

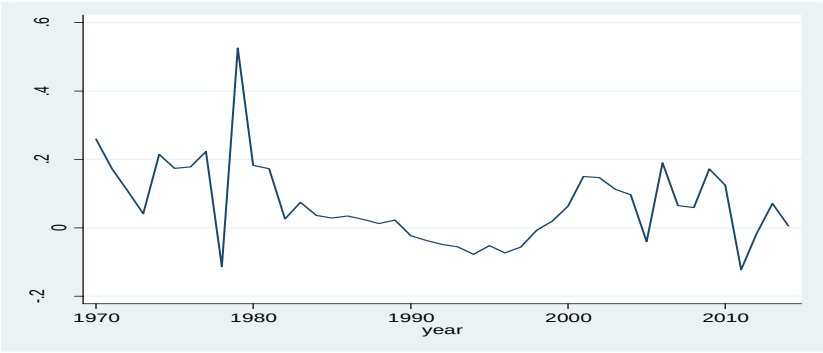



Source: Author work

This is also can be seen in figure (4) for the annual growth rate of capital, which witnessed decreasing through the period and even negative growth in nineties showing consumption-favoured in allocation of oil revenues.

Figure (4)

Annual Growth rate in real capital stock in Libya over the period



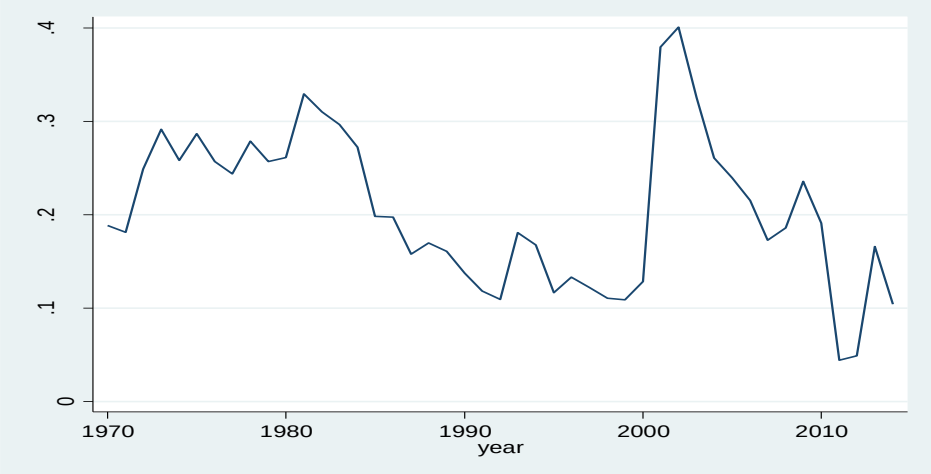

[3]In the seventies the government adapted a plan covered the whole country to fund roads, housing, high voltage electricity net and alike, however these investments theoretically are part of physical capital, many of them are out of usage or unreliable due to the way they located in a such large country.

Source: Author work

Meanwhile, although physical capital stock grew at average of 6.8% over the studied period, which exceeds that of MENA countries (Nehru and Dhareshwar 1993), the declining in investment can be observed obviously in investment-output ratio as seen in figure (5), itfluctuated,andshowed decreasing trend regarding to fluctuated oil revenues in the seventies and dwindled revenues during eighties, and showed increasing at oil prices boom years.

Figure (5)

Investment output ratio in Libya




Source: Author work

Compared with MENA countries Libya had a similar trend of physical capital growth as they share same source of funds, it has greater rate at seventies, however, capital growth showed dramatic decreasing towards nineties when it became negative, before it rose again after 2000. The negative growth rate during nineties summarizes the situation of investment and planning policies in Libyan economy, and explains why productivity changes sharply over the studied period.

Table (2)

Average annual growth in capital for Libya compared with some MENA countries

| Country | Sub-periods | | | | | Whole Period | |
|---|---|---|---|---|---|---|---|
| | 70-80 | 80-90 | 90-98 | 00-10 | 10-14 | Average growth | Years |
| Egypt* | 8.31 | 7.56 | 2.03 | - | - | 6.71 | 1960-98 |
| Algeria* | 9.65 | 4.72 | 0.69 | - | - | 5.5 | 1960-98 |
| Tunisia* | 7.42 | 4.25 | 3.75 | - | - | 5.83 | 1960-98 |
| Iran* | 12.36 | 2.35 | 2.70 | - | - | 6.91 | 1970-98 |
| **Libya**** | **17.85** | **6.14** | **-4.11** | **10.15** | **12.14** | **6.96** | **1970-2014** |

*Source: Abu-qurn 2007. ** Calculated depending on World Bank data.

Likewise MENA countries, incremental capital output ratio ICOR[4], displayed unstable trend, however it witnessed low level compared with other MENA countries through most of the period as in table (3):

Table (3)

Incremental Capital Output Ratio (ICOR) in MENA countries compared with Libya

| Country | Sub-periods | | | | | Whole Period | |
|---|---|---|---|---|---|---|---|
| | 70-79 | 80-89 | 90-99 | 00-10 | 11-14 | Rate | period |
| Egypt* | 2.42 | 3.61 | 1.24 | - | - | 2.72 | 1960-98 |
| Algeria* | 5.00 | 7.29 | 1.84 | - | - | 5.70 | 1960-98 |
| Tunisia* | 2.96 | 3.72 | 2.48 | - | - | 3.14 | 1960-98 |
| Iran* | 3.20 | 2.79 | 2.86 | - | - | 4.69 | 1960-98 |
| **Libya**** | **1.45** | **1.64** | **-11.12** | **1.44** | **0.13** | **0.21** | **70-2014** |

* Source: Abu-qurn 2007, ** Calculated for Libya.

The high value of the ICOR ratio during seventies and eighties (*low marginal productivity of capital*) should be taken cautiously for many reasons, that may indicate to declining in GDP - due to the oil prices fall down thus, relatively high investment level- rather than to capital productivity.

Finally, it might be noticed here that negative sign of ICOR which should not be like that, this in along with the previous comments lightens the absence of investment criterion in the economic process in Libya, and clarifies the role of investment allocation from 1969 to 2003 which focus on social needs rather than productivity (Merza 2012) .

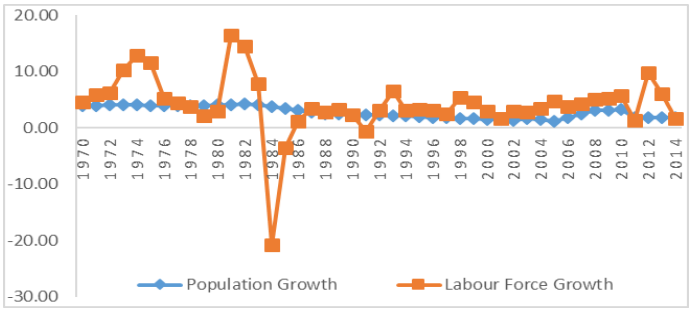
### 4-4-Labour factor:

On the other hand, labour factor growth compared to that of population, clarifies that labour force grew –except in some years- at more than the population did, which indicates the increasing jobs demand while the growth rate of capital was declining. This, leads in turn to a decreasing in per worker-capital ratio, and greater capital productivity relatively. This trend of expansion in youth and labour force featured most of the underdeveloped countries, and has been treated within the expansion of employment in the public services at the expense of productivity.

[4] Incremental capital output ratio (ICOR) is the share of investment in GDP divided by the rate of growth of GDP, the higher the ICOR the lower the productivity of capital, also ICOR can be calculated as follows: $K_t=\alpha_1 + \alpha_2 Y_t$

Figure (6)

Growth in population and labour force in Libya(1970-2014)




Source: Author work

Also, this explains the fact of diminishing in labour productivity through time. Which in turn denotes the low significance of labour factor in the economic process as stated by World Bank:

Table (4)

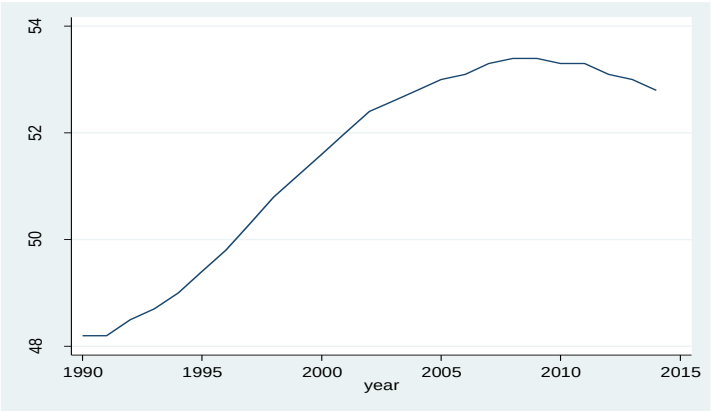
Productivity per worker in Libya and growthof output per worker in MENA countries

| Labour productivity Libyain us Dollars* | Growth in output per worker (MENA)** |
|---|---|
| 37261 (1980) | 0.9 (1970-80) |
| 25692 (1990) | -0.1 (1980-86) |
| 18363 (2000) | 0.1 (1986-92) |

Source: * (World Bank 2006), **(Pritchett 1999)

The participation rate is also displays low level. However, available data are just for twenty-five years, it shows two negative characters, both of them are not featuring any of MENA countries, it witnessed a declining after 2008, and it was less than any oil-based country except Algeria and Iraq, as shown in table (5) and figure (6) below.

Figure (7) Labour force participation Rate in Libya




Source: World Bank.

In this context, it would be needless to say that trend in participation rate was due to governmental decisions rather than to the market movements, these decisions were often made to tackle the employment rather than to economic criteria (Abuhadra and Ajaali 2014).

Nevertheless, it is clearly seen in table (5) that Libya has the lowest participation rate among oil surplus countries (except Iraq and Algeria), which indicates the labour engagement dilemma in the Libyan economy.

Table (5)

Labour participation rate in some MENA countries

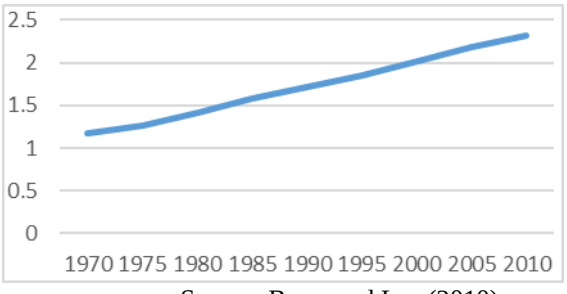
| Country | 2000 | 2006 | 2009 | 2014 |
|---|---|---|---|---|
| **Libya** | **51.6** | **53.1** | **53.4** | **52.8** |
| Algeria | 43.7 | 42.8 | 42.8 | 44.2 |
| Bahrain | 65.7 | 67.1 | 70.1 | 69.9 |
| Egypt | 46.1 | 46.7 | 48.3 | 49.3 |
| Iraq | 41.2 | 41.5 | 41.8 | 42.4 |
| Jordan | 41.9 | 40.5 | 42.9 | 41.8 |
| Kuwait | 67.6 | 67.6 | 67.5 | 68.5 |
| Qatar | 75.5 | 82.4 | 86.0 | 86.6 |
| Saudi | 48.6 | 51.0 | 51.1 | 55.2 |
| Tunisia | 47.7 | 46.3 | 46.9 | 47.7 |

Source: World Bank.

### 4-5-Human capital:

Regarding human capital, however the rarity of data and studies on human capital in Libya, Barro and Lee provided a series of five year period starting from1950 up to2010 of human capital index (HCI). This index might be unsuitable for regression purposes, never the less, it provides a reliable indicator for such factor as shown in figure (8):

Figure (8) Human capital index in Libya (1970-2010)



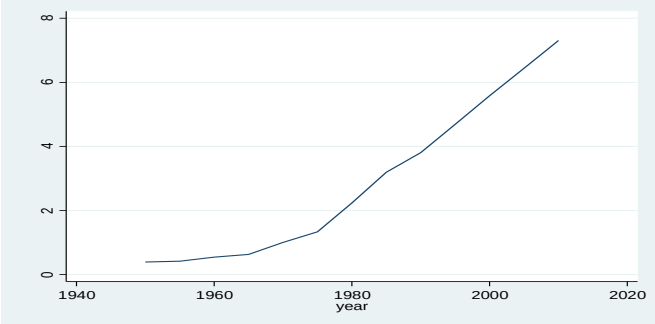

Source: Barro and Lee (2010)

Moreover, alternative considered proxy for human capital, which widely employed is the average years of schooling, for our case this proxy has been improved steadily over the period as shown in figure (9), and Libya has been pointed along with most of MENA countries- among the fastest 20 countries in expansion of schooling growth during 1960-2000(Pritchett 1999)(Barro and Lee 2011), and the sixth among 145 countries in increasing in average years of schooling from 1.5 years in

1970 to 8.2 years in 2010, which in fact is the studied period[5].This proxy has been criticised empirically because it overstates the growth in human capital in underdeveloped countries with relative low initial levels of education (Collins, Bosworth et al. 1996), some studies have even found that it is difficult to detect a significant impact of the changes in years of schooling on economic growth (Collins, Bosworth et al. 1996), and even controversial (Rauch and Meier 2000), (Pritchett 1999).And according to Campante and Chor, there was no obvious correlation between change in schooling years and the unemployment rate in most of the oil-rich countries (Campante and Chor 2012).

Figure (9)

Average years of schooling in Libya




Source: Barro. http://www.barrolee.com/data/dataexp.htm

Meanwhile, in spite of the crucial role of human capital in economic growth as many studies showed(Fang and Chang 2016, Teixeira and Queirós 2016), and the importance of complementarity between human and physical capital in highly performing economies (Bhattarai 2004), the role of human capital is still under investigations for under developing countries, as others found that for 17 Latin American countries for the period 1975 to 2004, which hold similar characters of Libyan economy, there is no significant effect of overall resource dependence on physical nor human capital but there is a significant negative impact of oil export dependence on human capital (Blanco and Grier 2012), (Bhattacharyya and Collier 2013).

In addition, contrary to the common view, previous studies also revealed that there was no significant relationship between investment in education and economic growth for a sample of 9 Arab countries for the period 1960-1985. (Ali 2003), even more, other researchers have found that more involvement in education does not help in economic growth, especially in low development countries (Basu and Bhattarai 2012). This outcome explains some of the human capital problem and

[5] Arab Monetary Fund, united Arab bulletin, 2015, p 251.

the fact that these countries - due to funding availability- are still focusing on quantity rather than quality in terms of investing in education and human capital.

To conclude, it can be stated here, that human capital -as an input factor- still under reasonable doubts in terms of its role in economic growth, regards to the proxy variable that has been used especially in developing countries due to the lack of data. In this context, average years of schooling has been included in the production function as (HC) variable, however, adjusted-human capital to return to schooling is preferred over the basic average mean years of schooling (Barro, Robert and Jong-Wha Lee, 2013).

### 4-6-Total Factor Productivity TFP in oil-based economies:

Total factor productivity TFP in MENA countries witnessed decreasing trend through the period after seventies as shown below in table (6) (Pritchett 1999),

Table (6)

TFP growth in the Middle East and North Africa region

| Pritchett 1999* | | Senhadji 2000** | |
|---|---|---|---|
| Periods | growth rate | Periods | growth rate |
| 1960-70 | 2.2 | 60-73 | 0.86 |
| 1970-80 | -2.4 | 74-86 | -0.54 |
| 1980-96 | -1.6 | 87-94 | -0.64 |
| 1986-92 | -0.2 | 60-94 | -0.03 |

* Source: (Pritchett 1999). ** (Senhadji 2000).

Abu-Qarn and Abu-Badr also found that TFP in MENA countries is insignificant and often detrimental for the period 1960 to 1998.Anew study found that TFP is fluctuated widely within some of MENA countries, and even contributed negatively in some of themas shown below in table(7):

Table (7)

TFP contribution to GDP in some of MENA countries

| **Country** | **TFP contribution %** |
|---|---|
| Egypt | 2.9 |
| Iran | -158.7 |
| Morocco | 14.07 |
| Qatar | -15.43 |
| Saudi Arabia | 130.87 |

Source: (Ali, 2016)

### 5-Source of economic growth:

In economic literature, sources of economic growth has been studied according to two approaches: one is national accounts approach which, calculates the input shares depending on national accounts data, assuming the competitiveness in input market, and considering each factor share equal to corresponding elasticity with respect to output. he other approach: regression approach, estimates factor shares applying regression method(Kaüger, Cantner et al. 2000).However, some researchers have criticised this method due to its critical influence on results (Park and Ryu, 2006). In this

section, we will investigate the source of growth following national accounts method briefly, then regression approach will be done, applying Cobb-Douglas production function.

**5-1-Labour and capital income over the studied period:**

The table (8) and the graph later show the labour compensation over the studied period, compared with oil-based countries. It displays an almost similar level and even pattern, and shows increased trend related with oil revenues, as the latter decreased in the eighties the labour income increased. After 2000, labour income went down as oil prices went up. This explains the rental nature of such economies where the absorption capacity is not able to absorb the increasing revenues. Which reflects in saving and capital accumulation then in capital income. On the other hand, in both non-oil and industrial economies labour income – and in turn capital income fluctuated steadily. For Libya, factor incomes fluctuated more than other similar economies, probably due to the government inference in the input market, which, reflected in annual labour compensation. The unusual to be noticed here, is that labour compensation rose up dramatically after 2012 to an unprecedented rate (0.78in 2014) due to expansion in employment and decreasing in capital accumulation because of instability which lead to assimilation of most of income in salaries for public sector, and makes 2014 an outlier value.

Table (8)

Labour compensation in GDP in Libya for 4 year periods compared with some other economies

| Country / Year | Oil-based economies | | | | | | Non-based economies | | | Indus. econ. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Libya | Saudi | Iran | Iraq | Qatar | Kuwait | Jordan | Tunisia | Egypt | Average* |
| 1970 | **0.209** | 0.32 | 0.33 | 0.15 | 0.33 | 0.23 | 0.47 | 0.55 | 0.39 | 0.66 |
| 1974 | **0.222** | 0.32 | 0.33 | 0.15 | 0.33 | 0.23 | 0.50 | 0.55 | 0.39 | 0.67 |
| 1979 | **0.243** | 0.32 | 0.33 | 0.15 | 0.33 | 0.23 | 0.45 | 0.55 | 0.39 | 0.67 |
| 1984 | **0.356** | 0.32 | 0.33 | 0.15 | 0.32 | 0.23 | 0.48 | 0.55 | 0.39 | 0.63 |
| 1989 | **0.392** | 0.32 | 0.33 | 0.15 | 0.32 | 0.23 | 0.47 | 0.55 | 0.39 | 0.63 |
| 1994 | **0.375** | 0.32 | 0.33 | 0.15 | 0.32 | 0.23 | 0.48 | 0.52 | 0.39 | 0.62 |
| 1999 | **0.373** | 0.32 | 0.36 | 0.12 | 0.29 | 0.23 | 0.50 | 0.52 | 0.41 | 0.61 |
| 2004 | **0.242** | 0.29 | 0.29 | 0.23 | 0.20 | 0.23 | 0.45 | 0.50 | 0.37 | 0.59 |
| 2009 | **0.253** | 0.27 | 0.31 | 0.32 | 0.20 | 0.22 | 0.48 | 0.48 | 0.33 | 0.60 |
| 2014 | **0.783** | 0.27 | 0.26 | 0.29 | 0.19 | 0.24 | 0.48 | 0.50 | 0.37 | 0.60 |

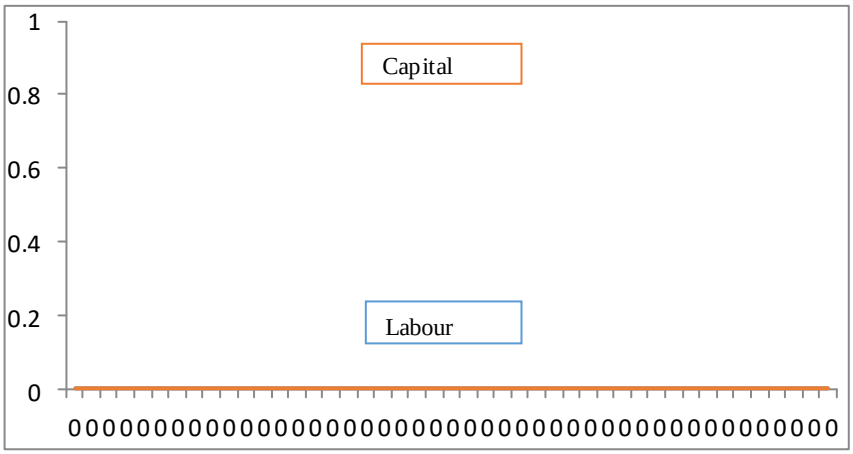
Source: - Calculated only for Libya, the rest are obtained from Pen World Table PW 9.0, at www.rug.nl/research/data/pwt/pwt-pwt-9.0

- * Average calculated for 7 industrial countries (USA, UK, France, Germany, Canada, Japan and Italy) depends on the same source.

Also, it can be seen in the graph below that both factors income witnessed fluctuations over prolonged stage, with continuous increase in labour income till 2002, when oil revenues increased due to oil prices, this reflected in capital income due to increased saving however, labour compensation had not been decreased in current values.

Figure (10)

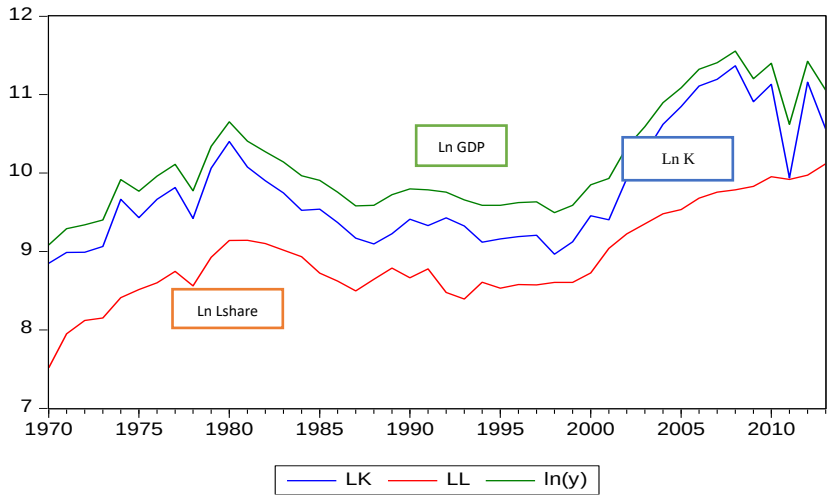
Capital and labour shares in GDP in Libya




As seen in figure (11) both of labour and capital compensations fluctuated in tandem with the changes in GDP, however, capital income is more related to GDP movements. And both of them showed a non-stationary pattern.

Figure (11)

GDP, labour and capital shares over (1970-2013)




**5-2-Regressionresults:**

To estimate factors parameter for Libyan production function, many variables have been employed as defined in Appendix (A1),unit root test also has been done because non-stationary variables may lead to spurious regression, and results illustrated in Appendix (B2).Most of variables are found stationary at first difference-technically known as *I (1)*, hence, it can be concluded that all variables

of interest are integrated of order1.Different combinations of physical capital, human capital and labouring many proxies and factor income have been regressed against GDP in many forms[6].

Trying to define the model at best, two dummy variables also have been engaged, one for socialistic policies that adapted from 1980 to 1989 named D(Soci), and the other for regime change in 2011 named D(ReCh). To avoid the outlier observation affects, regression made two times for two periods, one from (1970-2014), the second for just (1970-2013).Results that statistically and theoretically acceptable are summarised in appendix (B1) and (B2) respectively.

**5-3-Some features can be summarised:**

1. As shown in mentioned tables, all estimated formulas showed autocorrelation problem.
2. Dummy variable for governmental interference D(Soci) is insignificance, therefore, it has been ignored, while dummy variable for regime change D(ReCh) is significant to.
3. Human capital plays less role in economic process as seen in low elasticities to GDP even negative in some cases, this consists with many studies on similar economies as well.
4. Using per-capita or per-worker GDP does not seem to affect the results substantially neither significance of estimators.
5. The constant (A), varied largely, and it is more than unity in some cases.
6. Under the assumption of Hicks-neutral, the sum of $\alpha$ and $\beta$ obtained was also almost 1 which leads to CRS assumption and Harrod-neutral as well.
7. Using capital investment or capital stock as a proxy for Kshows low elasticity forcapital. And capital elasticities-as seen in the tables- varied between 0.23 and 0.60, depends on independent variable associated, and capital proxy employed (per-worker or per-capita). When capital and labour compensations employed, the results changed dramatically, and enhanced statistically in which capital became more important than labour.

As seen in appendix (B) the autocorrelation problem exists in most of estimated models, except for model (12) in table (B2), and it needs to be removed.

One-way to deal with autocorrelation is that Prais-Winsten regression method (Kadiyala 1968), following Cochrane-Orcutt iterative process as illustrated in appendix (D).

The results obtained are summarised in the appendix B table (1 and 2) for periods (1970-2014) and (1970-2013) respectively. Where can be note statistical improvement, however, elasticity of K still less than that of L, this supports previous results in table (1and 2) of appendix A.

[6] GDP has been represented in real values, per-capita GDP, GDP per worker and GDP per adjusted skilled worker, while capital represented in capital stock in each year, capital income, per worker capital, and capital per person. Labour has been represented in labour force (number of workers), labour compensation each year as shown in Appendix (A1).

Reviewing all results and according to statistical and theoretical criteria, it can be noticed that model 12 in both tables 1 and 2 in appendix (B) shows better indicators more than any estimated model. Accordingly, this model for the period (1970-2013) will be the chosen one for our task.
To be sure for this selection, autocorrelation and co-integration tests have been done.In this context Breusch-Godfrey serial correlation (LM test) is also applicable (Johnston 1984). Results are shown in the table (9):

Table (9)
Breusch-Godfrey serial Correlation LM test

| Test | Calculated value | P. value | |
|---|---|---|---|
| F-statistic | 0.635 | Prob. F(2,39) | 0.5354 |
| Obs* R-squared | 1.387 | Prob. Chi-Square(2) | 0.4997 |

*Null hypothesis: the model has no serial correlation*

According to result, it can be stated that our desirable hypothesis (no autocorrelation) cannot be rejected, and the model (12) is free[7] of autocorrelation. Also, Correlogram-Q statistic - autocorrelation function (ACF) -denotes rejection of serial correlation as illustrated in appendix C.

Moreover, due to stationarity of variables of interest, co-integration test and results are displayed in table (10). Tests indicated that while there is no co-integration relationship for the period (1970-2014), there is one co-integration equation in the period (1970-2013).Therefore, there is a long-run relationship between variables under consideration, and regression is not spurious.

Table (10)
Johansen Co-integration Test for Model estimated

| Model tested | Hypothesis | Trace Test | | | Maximum Eigen Value Test | | |
|---|---|---|---|---|---|---|---|
| | | $\lambda$ | 5% critical | Prop | $\lambda$ | 5% critical | Prop |
| Model No. 12 2014 | $H_0$ | 21.57 | 29.80 | 0.32 | 16.72 | 21.14 | 0.19 |
| | $H_1$ | 4.85 | 15.50 | 0.82 | 4.80 | 14.26 | 0.77 |
| | $H2$ | 0.05 | 3.84 | 0.82 | 0.05 | 3.84 | 0.82 |
| Model No. 12 2013 | $H_0$ | 36.64 | 29.80 | 0.007 | 30.44 | 21.13 | 0.002 |
| | $H_1$ | 6.20 | 15.49 | 0.67 | 5.76 | 14.26 | 0.64 |
| | $H_2$ | 0.44 | 3.84 | 0.51 | 0.44 | 3.84 | 0.51 |

To give robustness to the regressed model, error correction model (ECM) is built to investigate the long run relationship as follows.

**Error Correction Model:**

Results below support what have been stated previously about parameters of L and K.

[7] See Attia, A. Modern Econometrics. Pp. 650-653.

Table (11)

ECM for production function for Libyan economy (1970-2013)

| Variables | Cons | ΔlK | Δll | $e_{t-1}$ | R2 | F | D-W | | |
|---|---|---|---|---|---|---|---|---|---|
| Δln(Y) -.002 | | 0.68*** | 0.34*** | -0.913*** | | 0.99 | 6914 | 1.89 | |
| | (-0.80) | | (120.9) | (25.23) | | (-6.11) | | | |

*Note: T-statistics in parentheses* *** p<0.01, ** p<0.05, * p<0.1

As seen in the table, elasticities of both L and K still almost at the same level, and both are significant, while the parameter of the term $e_{t-1}$is equal to 0.91 which indicates the speed of correction to converge towards steady state level.

**5-3-1-Discussion:**

Accordingly, it can be claimed that the coefficients of model 12 in appendix B table 2 are valid to calculate the source of growth in the Libyan economy for the studied period. Depending to Harrod-neutral or Hicks-neutral as assumed previously elasticities of capital and labour which will be applied are 0.69 and 0.31 respectively to calculate the sources of growth in Libyan economy.

In general, although it is difficult to compare these results with others due to the lack of such studies on Libyan economy, taking into account economies that share similar features (such as MENA countries),where capital formation plays a substantial role in economic growth rather than labour and TFP(Altaee, Al-Jafari et al. 2016), and capital share in income is about 0.4 or more, which compatible with these results.

**5-4-Shares of input factors in economic growth:**

Shares of each input factor are calculated, according to Harrod-neutral assumption, also TPF contribution to economic growth calculated accordingly, and illustrated below in table (12) in percentage for periods of five years each.

Table (12)

Contributions of TFP and each input factor toeconomic Growth in Libya (1970-2013)

| Year | GDP Growth | TFP | Physical Capital | Labour | A/A |
|---|---|---|---|---|---|
| 1970 | 7.75 | -0.06 | 5.37 | 3.44 | **1** |
| *contribution of each factor in %* | | *(-0.79)* | *(69.27)* | *(31.52)* | |
| 1975 | -13.76 | 0.16 | -9.56 | -4.35 | **-0.25** |
| *contribution of each factor in %* | | *(-1.13)* | *(69.51)* | *(31.63)* | |
| 1980 | 36.69 | -0.43 | 25.51 | 11.61 | **-1.11** |
| *contribution of each factor in %* | | (-1.17) | (69.53) | (31.64) | |
| 1985 | -5.73 | 0.06 | -3.98 | -1.81 | **-0.84** |
| *contribution of each factor in %* | | *(-1.01)* | *(69.42)* | *(31.59)* | |

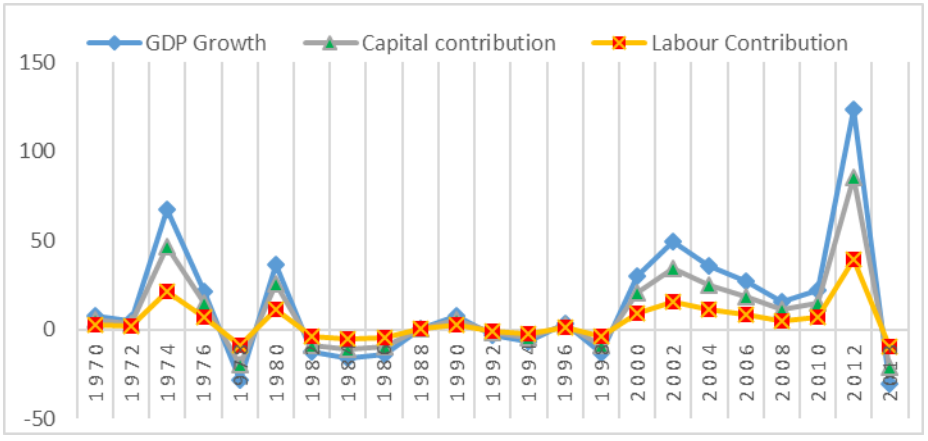
| | | | | | |
|---|---|---|---|---|---|
| 1990 | 7.73 | -0.1 | 5.38 | 2.45 | **-0.61** |
| *contribution of each factor in %* | | *(-1.28)* | *(69.61)* | *(31.67)* | |
| 1995 | -0.10 | -0.002 | -0.07 | -0.03 | **-0.48** |
| *contribution of each factor in %* | | *(1.67)* | *(67.58)* | *(30.75)* | |
| 2000 | 29.61 | -0.36 | 20.6 | 9.37 | **-0.49** |
| *contribution of each factor in %* | | *(-1.21)* | *(69.56)* | *(31.65)* | |
| 2005 | 20.72 | -0.24 | 14.40 | 6.55 | **-2.33** |
| *contribution of each factor in %* | | *(-1.16)* | *(69.52)* | *(31.63)* | |
| 2010 | 21.78 | -0.27 | 15.15 | 6.9 | **-2.77** |
| *contribution of each factor in %* | | *(-1.23)* | *(69.57)* | *(31.66)* | |
| 2013 | -30.77 | 0.35 | -21.39 | -9.73 | **-3.82** |
| *contribution of each factor in %* | | *(-1.15)* | *(69.52)* | *(31.63)* | |
| **Averages** | 8.61 | -0.10 | 5.99 | 2.72 | - |
| **Average in %** | | *(-1.06)* | *(69.46)* | *(31.60)* | - |

*A/A is calculated time trend of TFP following Solow method (Solow 1957)*

Regards to input factors share in economic growth, relatively, there is no high volatility in both of them, capital share was equal to (5.99) in average compared with (2.72) of labour through the period, which compatible with available results of studies on MENA countries that have oil-based economies, furthermore, as seen in table (12) labour contribution is less than capital one. As stated by Senhadji, the contribution to output growth due to TFP depends crucially and reversely on the parameter of capital ($\alpha$) [the share of physical capital](Senhadji 2000), this can be observed in the table as well. This is probably because capital grew faster than labour which in turn, leads to negative correlation between contributions of the two factors, L & TFP. In our case, real physical capital grew by6.9% on average over the period, while labour force, labour supply and population, all grew at an average of 4.25%, 5.06% and 2.7% respectively over the same period, which explains the greater contribution of capital rather than labour. Also, the impact of closed economy policy between 1980 and 2000 on contributions of each factor can be observed in figure (12).

Figure (12)

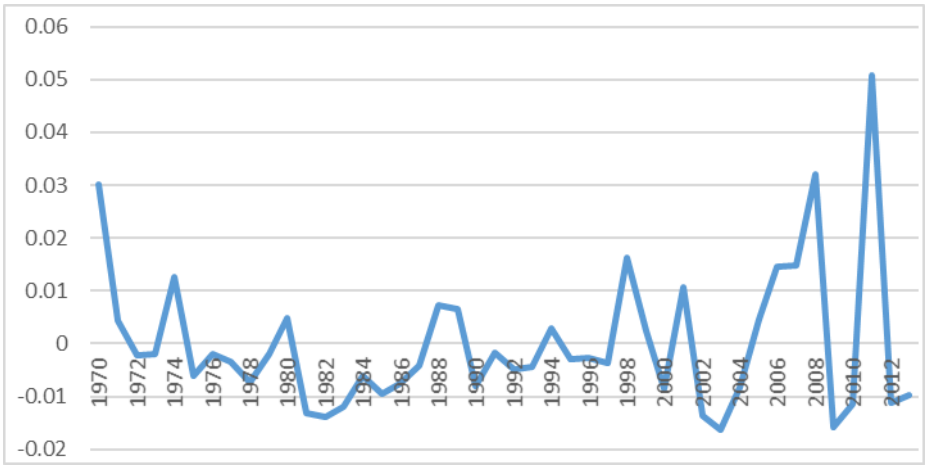
Growth rate of output per worker and contributions of each factor (for two-year periods)



Moreover, regards to total factor productivity TFP, it has been documented did not contribute to economic growth in developing countries as it showed a negative pattern in many studies (Pritchett 1999). In our case, also TFP showed a negative pattern most of the studied period, however, the period from 1981 to 2000 witnessed a relatively less fluctuations in TFP, at this period Libyan economy can be described as a closed economy due to the action taken by the government at the beginning of the eighties and then by the UN sanctions starting in 1992 till 2000 when the borders reopened again. Out of this period Libyan economy usually witness high degree of openness which reflected in high fluctuates in TFP due to oil effects, as seen the figure (11).

Figure (11)

Estimated TFP in Libya (1970-2013)




## 6-Conclusion:

This study is an attempt to determine the key factors of economic growth sources in the Libyan economy, using as best as possible a good and different proxies for input factors, the result shows that economic growth of period under consideration can be explained by capital accumulation rather than TFP or labour, This findings is compatible with previous studies on economies which hold similar features. Moreover, a similar interpretation can be made for the TFP contribution to growth, which is insignificant. These results also point to policies that had been followed for four decades, focusing on capital accumulation to fill the gap of infrastructure and capital. Labour factor has less role in growth rate, which is expected in such capital abundance economy, however declining in its productivity. Human capital has also no significant effect on the economic process, despite the observed progress in education and health services over period of interest. This is unsolved question

not only in Libyan economy, but also in other oil-based MENA countries, which indicates to planning dilemma in education, and absence of cognitive skills in educational systems.

These results on growth along with other ones arise the fact that there is a need for re-thinking of investment policies and allocation of oil revenues.

Appendices:

Appendix: (A) Definitions of variables and unit root tests.

Table (1) employed variables definitions and sources of data

| No. | Var. Name | Definition | Type of data | source |
|---|---|---|---|---|
| 1 | LabCom*(wages)* | Annual labour compensation | Million Dinars | National accounts ESRC |
| 2 | Kshar | Annual capital share in GDP | Million Dinars | calculated |
| 3 | Lshar | Annual labour share in GDP | Million Dinars | National accounts ESRC |
| 4 | LabF | Number of workers | Thousands | Central Bank of Libya |
| 5 | SkilLab | Adjusted skilled labour | | Calculated |
| 6 | K*(TotInvst)* | Annual total investment | Million Dinars | calculated |
| 7 | (K/N) | Per capita annual capital investment | Million Dinars | calculated |
| 8 | GDP | Gross domestic product | Million Dinars | Central Bank of Libya |
| 9 | (Y/N) | Per capita domestic product | Thousand Dinars | calculated |
| 10 | HC | Human capital Index | Mean years of schooling | Barro and Lee 2010 |
| 11 | (Y/L) | Per worker GDP | Current Dinars | calculated |
| 12 | (K/L) | Annual per worker capital | Current Dinars | calculated |
| 13 | (HC/L) | Per worker human capital | Index | calculated |
| 14 | (L/N) | Annual per capita labour compensation | Current Dinars | calculated |
| 15 | D(ReCh) | Dummy variable for regime change in 2011 | 1 from 2011to2014 | - |
| 16 | D(Soci) | Dummy variable for policy adapted (1980-1989) | 1 from(1980 to 1989) | - |

Table (2)

Unit-root test for variables under consideration for Libya (1970-2014)

| Variables | ADF | | PP | | With Trend |
|---|---|---|---|---|---|
| | I(0) | I(1) | I(0) | I(1) | |
| L*(wages)* | 6.98*** | | 15.44*** | | No |
| Ln*(wage)* | | -5.92*** | | -5.92*** | No |
| Ln(Kshar) | | -3.85*** | | -9.24*** | No |
| Ln(Lshar) | | -5.82*** | | -5.83*** | No |
| K*(TotInvst)* | | -4.92*** | | -7.5*** | No |
| Ln(K) | | -6.48*** | | -6.48*** | No |
| Ln(K/N) | | -6.46*** | | -6.86*** | No |
| Ln(Kcapital income) | | -6.54*** | | -6.67*** | No |
| Ln(L labour income) | | -5.92*** | | -5.93*** | No |
| GDP*r* | | -9.81*** | | -9.46*** | No |
| Ln(GDP) | | -7.40*** | | -7.40*** | No |
| Ln(GDP/N) | | -7.26*** | | -7.35*** | No |
| HC*(mean yrssch)* | | -4.83*** | | -4.77*** | No |
| Ln(HC) | | -5.96*** | | -5.96*** | Yes |
| Ln(Y/L) | | -8.64*** | | -8.74*** | Yes |
| Ln*(K/LabCom)* | | -6.55*** | | -7.05*** | No |
| Ln*(HC/LabCom)* | | -5.27*** | | -5.31*** | No |
| Ln*(LabCom/N)* | | -5.84*** | | -5.85*** | No |
| Skilled Lab | | -6.33*** | | -6.49*** | No |

**** denote significance at 5% and 1% levels respectively.*

Appendix: (B) Summary of results. Table (1) Summary of estimated models for the period (1970-2014)

| **Model & dep. Vars.** / **Indep.Vars.** | **1** ***Ln (Y/LabCom)*** | **2** ***Ln (Y/LabCom)*** | **3** ***Ln (Y/N)*** | ***4 Ln(Y/N)*** | ***5 Ln(Y/N)*** | ***6 Ln(Y)*** | ***7 Ln(Y)*** | ***8 Ln(Y)*** | ***9 Ln(Y)*** | ***10 Ln(Y)*** | ***11 Ln(Y)*** | ***12 Ln(Y)*** | ***13 Ln(Y)*** | ***14 Ln(Y)*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | FMOLS | FMOLS |
| **Constant** | 10.39** | 1.34*** | 1.12* | 7.18*** | 4.3*** | 1.07** | 0.685 | -2.03 | 1.25** | 3.20*** | 0.99* | 0.37*** | 0.88 | 0.45 |
| | (2.6) | (36) | (1.98) | (12.63) | (10.39) | (2.42) | (1.11) | (-1.38) | (2.2) | (7.71) | (1.77) | (3.08) | (1.62) | (0.56) |
| **Ln(k** annual investment**)** | | | | | | 0.31*** | 0.52*** | 0.47*** | 0.33*** | 0.60*** | 0.30*** | | 0.35*** | 0.58*** |
| | | | | | | (6.39) | (10.47) | (8.74) | (5.85) | (13.33) | (4.62) | | (6.18) | (9.63) |
| **Ln(K**annual capital income in GDP**)** | | | | | | | | | | | | 0.59*** | | |
| | | | | | | | | | | | | (33.48) | | |
| **Ln(L** annual labour income in GDP**)** | | | | | | | | | | | | 0.45*** | | |
| | | | | | | | | | | | | (21.66) | | |
| **Ln (**Labour Compensation**)** | | | | | | 0.72*** | | | 0.68*** | | 0.74*** | | 0.70*** | |
| | | | | | | (11.02) | | | (6.77) | | (7.03) | | (8.91) | |
| **Ln** (Labour Force) | | | | | | | 0.72*** | 1.25*** | | | | | | 0.67*** |
| | | | | | | | (8.02) | (4.54) | | | | | | (5.93) |
| **Ln(K/**Labour Compensation**)** | 0.31*** | 0.31*** | | | | | | | | | | | | |
| | (5.97) | (6.4) | | | | | | | | | | | | |
| **Ln (**per-capita Investment ratio**)** | | | 0.31*** | 0.47*** | 0.58*** | | | | | | | | | |
| | | | (6.16) | (9.65) | (10.9) | | | | | | | | | |
| **Ln (**Labour Compensation/ population**)** | | | 0.72*** | | | | | | | | | | | |
| | | | (7.5) | | | | | | | | | | | |
| **Ln (**Labour Force/population**)** | | | | 1.34*** | | | | | | | | | | |
| | | | | (4.97) | | | | | | | | | | |
| **Ln(**Human Capital/Labour Compensation**)** | 0.005 | | | | | | | | | | | | | |
| | (0.08) | | | | | | | | | | | | | |
| **Ln(**Human Capital**)** | | | | | 0.23*** | | | -0.41* | 0.042 | | | | | |
| | | | | | (2.98) | | | (-2.02) | (0.5) | | | | | |
| **Ln(**Adjusted skilled labour**)** | | | | | | | | | | 0.21*** | | | | |
| | | | | | | | | | | (5.23) | | | | |
| **D(ReCh)** | | | | | | | | | | 0.57*** | -0.08 | | | |
| | | | | | | | | | | (4.18) | (-0.45) | | | |
| **D(Soci)** | | | | | | | | | | | -0.14* | | | |
| | | | | | | | | | | | (-1.92) | | | |
| **Observations** | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| **$R^2$ Adj.** | 0.46 | 0.48 | 0.86 | 0.79 | 0.73 | 0.91 | 0.86 | 0.87 | 0.91 | 0.88 | 0.91 | 0.99 | 0.91 | 0.84 |
| **F** | 20 | 40.99 | 134 | 84.6 | 59.6 | 222 | 137 | 99.5 | 145 | 111 | 117 | 3398 | - | - |
| **D-w** | 1.1 | 1.1 | 1.12 | 0.91 | 0.73 | 1.13 | 0.86 | 0.95 | 1.13 | 1.02 | 1.24 | 1.27 | - | - |

*Note: T-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

Table (2)Summary of estimated models for the period (1970-2013)

| **Model & dep. Vars.** / **Indep.Vars.** | **1** ***Ln(Y/LabCom)*** | **2** ***Ln(Y/LabCom)*** | **3** ***Ln(Y/N)*** | ***4*** ***Ln(Y/N)*** | ***5*** ***Ln(Y/N)*** | ***6*** ***Ln(Y)*** | ***7*** ***Ln(Y)*** | ***8*** ***Ln(Y)*** | ***9*** ***Ln(Y)*** | ***10*** ***Ln(Y)*** | ***11*** ***Ln(Y)*** | ***12*** ***Ln(Y)*** | ***13*** ***Ln(Y)*** | ***14*** ***Ln(Y)*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | FMOLS | FMOLS |
| **Constant** | 0.79 | 1.34*** | 0.45 | 7.5*** | 4.29*** | 0.69 | 0.60 | 0.57 | -3.23* | 3.22*** | 0.84 | 0.52*** | 0.31 | 0.07 |
| | (1.47) | (38.2) | (0.82) | (12.01) | (10.21) | (1.65) | (0.95) | (1.02) | (-2.01) | (8.0) | (1.67) | (16.4) | (0.60) | (0.08) |
| **Ln(k** annual investment**)** | | | | | | 0.26*** | 0.51*** | 0.25*** | 0.44*** | 0.60*** | 0.28** | | 0.27*** | 0.58*** |
| | | | | | | (5.44) | (10.11) | (4.43) | (7.75) | (13.66) | (4.68) | | (4.93) | (8.88) |
| **Ln(K** annual investment**)** | | | | | | | | | | | | 0.70*** | | |
| | | | | | | | | | | | | (110.33) | | |
| **Ln(L**annual labour income in GDP**)** | | | | | | | | | | | | 0.32*** | | |
| | | | | | | | | | | | | (41.15) | | |
| **Ln (**Labour Compensation**)** | | | | | | 0.81*** | | 0.84*** | | | 0.78*** | | 0.84*** | |
| | | | | | | (12.31) | | (8.04) | | | (8.25) | | (10.41) | |
| **Ln (**Labour Force**)** | | | | | | | 0.74*** | | 1.49*** | | | | | 0.73*** |
| | | | | | | | (7.75) | | (4.88) | | | | | (5.69) |
| **Ln(K/**Labour Compensation**)** | 0.23*** | 0.26*** | | | | | | | | | | | | |
| | (4.25) | (5.32) | | | | | | | | | | | | |
| **Ln(**per-capita Investment ratio**)** | | | 0.23*** | 0.45*** | 0.59*** | | | | | | | | | |
| | | | (4.64) | (8.91) | (10.75) | | | | | | | | | |
| **Ln (**Labour Force/population**)** | | | 0.88*** | | | | | | | | | | | |
| | | | (8.88) | | | | | | | | | | | |
| **Ln (**Labour Force/population**)** | | | | 1.49*** | | | | | | | | | | |
| | | | | (5.06) | | | | | | | | | | |
| **Ln(**Human Capital/Labour Compensation**)** | -0.07 | | | | | | | | | | | | | |
| | (-1.06) | | | | | | | | | | | | | |
| **Ln(**Human Capital**)** | | | | | 0.22*** | | | -0.026 | -0.56** | | | | | |
| | | | | | (2.88) | | | (-0.34) | (-2.56) | | | | | |
| **Ln(**Adjusted Skilled Labour) | | | | | | | | | | 0.22*** | | | | |
| | | | | | | | | | | (5.44) | | | | |
| **D(ReCh)** | | | | | | | | | | 0.69*** | 0.04 | | | |
| | | | | | | | | | | (4.72) | (0.24) | | | |
| **D(Soci)** | | | | | | | | | | | -0.13** | | | |
| | | | | | | | | | | | (-2.16) | | | |
| **Observations** | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| **$R^2$ Adj.** | 0.39 | 0.39 | 0.89 | 0.80 | 0.73 | 0.93 | 0.87 | 0.93 | 0.88 | 0.89 | 0.93 | 0.99 | 0.93 | 0.85 |
| **F** | 14.8 | 28 | 171 | 85.7 | 58.1 | 275 | 135 | 179 | 104 | 119 | 149 | 51239 | - | - |
| **D-w** | 1.31 | 1.24 | 1.38 | 0.94 | 0.74 | 1.34 | 0.86 | 1.36 | 1.0 | 1.12 | 1.51 | 1.86 | - | - |

*Note: T-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1.*

Appendix (C): Re-estimated models using Prais-Winsten method:

Table (1)Re-estimation for chosen models (2, 3, 6, 7, 10, and 12) for period (1970-2014) using P-W method

| ***Models*** | ***Model 2*** | ***Model 3*** | ***Model 6*** | ***Model 7*** | ***Model10*** | ***Model12*** |
|---|---|---|---|---|---|---|
| ***Indep. Vars.*** | ***Ln(Y/LabComp)*** | ***Ln(Y/N)*** | ***Ln(Y)*** | ***Ln(Y)*** | ***Ln(y)*** | ***Ln(y)*** |
| ***Constant*** | 1.36*** | 1.93** | 1.66** | 1.75 | 3.72*** | 0.41** |
| | (24.08) | (2.31) | (2.45) | (1.32) | (5.78) | (2.26) |
| ***ln(K****annual Investment****)*** | | | 0.33*** | 0.42*** | 0.52*** | |
| | | | (5.63) | (6.77) | (7.92) | |
| ***ln(K****annual capital income****)*** | | | | | | 0.57*** |
| | | | | | | (29.7) |
| ***ln(L****annual labour income****)*** | | | | | | 0.47*** |
| | | | | | | (18.81) |
| ***ln (L****Labour Force****)*** | | | | 0.69*** | | |
| | | | | (4.12) | | |
| ***ln (L****Labour Compensation****)*** | | | 0.63*** | | | |
| | | | (7.05) | | | |
| ***ln (K/N****Per-capita investment****)*** | | 0.34*** | | | | |
| | | (5.78) | | | | |
| ***ln (****Labour Compensation/N****)*** | | 0.58*** | | | | |
| | | (4.5) | | | | |
| ***ln (K****annual investment/Labour Compensation****)*** | | | | | | |
| ***ln (K*** *per worker investment ratio****)*** | 0.34*** | | | | | |
| | (5.84) | | | | | |
| ***ln (****Adjusted Skilled Labour****)*** | | | | | 0.23*** | |
| | | | | | (3.13) | |
| ***D(ReCh)*** | | | | | 0.42** | |
| | | | | | (2.09) | |
| ***Obs*** | 45 | 45 | 45 | 45 | 45 | 45 |
| ***$R^2$*** | 0.51 | 0.88 | 0.89 | 0.88 | 0.88 | 0.99 |
| ***F*** | 47.3 | 167 | 174 | 169 | 107 | 2228 |
| ***D-W-h*** | 1.78 | 1.82 | 1.81 | 1.87 | 1.91 | 1.78 |

*Note: T-statistics in parentheses* *** p<0.01, ** p<0.05, * p<0

Table (2) Re-estimation for chosen models (2, 3, 6, 7 and 10) for period (1970-2013) using P-W method

| ***Models*** | ***Model 2*** | ***Model 3*** | ***Model 6*** | ***Model 7*** | ***Model 10*** |
|---|---|---|---|---|---|
| ***Indep. Vars.*** | ***Ln(Y/LabComp)*** | ***Ln(Y/N)*** | ***Ln(Y)*** | ***Ln(Y)*** | ***Ln(y)*** |
| ***Constant*** | 1.34*** | 1.00 | 1.04* | 1.60 | 3.68****** |
| | (27.55) | (1.39) | (1.85) | (1.32) | (5.93) |
| ***ln(K*** *annual Investment****)*** | | | 0.27*** | 0.39*** | 0.52*** |
| | | | (4.66) | (5.99) | (8.01) |
| ***ln(L)*** *(Labour Force)* | | | | 0.74*** | |
| | | | | (4.08) | |
| ***ln(L)*** *(Labour Compensation)* | | | 0.76*** | | |
| | | | (9.01) | | |
| ***ln (K/N*** *Per-capita investment****)*** | | 0.26*** | | | |
| | | (4.40) | | | |
| ***ln (****Labour Compensation/N****)*** | | 0.78*** | | | |
| | | (6.31) | | | |
| ***ln (****labour Force /N****)*** | | | | | |
| ***ln (K*** *annual investment/ Labour Compensation****)*** | 0.27*** | | | | |
| | (4.63) | | | | |
| ***ln (K*** *per worker investment ratio****)*** | | | | | |
| **ln (**Adjusted Skilled Labour) | | | | | 0.24*** |
| | | | | | (3.35) |
| **D(ReCh)** | | | | | 0.47*** |
| | | | | | (2.37) |
| ***Obs*** | 44 | 44 | 44 | 44 | 44 |
| ***$R^2$*** | 0.44 | 0.88 | 0.89 | 0.88 | 0.88 |
| ***F*** | 34.1 | 158 | 182 | 168 | 103 |
| ***D-W-h*** | 2.0 | 1.98 | 1.98 | 1.89 | 1.82 |

*Note: T-statistics in parentheses* *** p<0.01, ** p<0.05, * p<0.1

Appendix (D):

Prais-Winsten method process for dealing with autocorrelation.

If $Y_t = \alpha + \beta X_t + \varepsilon_t$

And the error term $\varepsilon_t$ is serially correlated over time followed AR (1)[8] as follows:

$\varepsilon_t = \rho\varepsilon_{t-1} + e_t$ Where: $e_t$ is the withe noise and $|\rho| < 1$

So, estimators can be obtained from the expression:

$$Y_t - \rho Y_{t-1} = \alpha(1-\rho) + \beta(X_t - \rho X_{t-1}) + e_t$$

Then with Prais-Winsten transformed expression (Johnston 1984):

$$\sqrt{1-\rho^2}Y_t = \alpha\sqrt{1-\rho^2} + \beta(\sqrt{1-\rho^2}X_1) + \sqrt{1-\rho^2}\varepsilon_t$$

The last formula can be estimated by OLS, and P-W estimates are much closer to OLS as they described as BLUE (Kmenta 1986).

Appendix (E):

Correlogram of Residuals:

Date: 09/14/16 Time: 13:20
Sample: 1970 2013
Included observations: 44

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \| . \| | . \| . \| | 1 | 0.005 | 0.005 | 0.0010 | 0.975 |
| .*\| . \| | .*\| . \| | 2 | -0.172 | -0.172 | 1.4313 | 0.489 |
| . \|** \| | . \|** \| | 3 | 0.220 | 0.229 | 3.8251 | 0.281 |
| . \| . \| | . \| . \| | 4 | 0.013 | -0.031 | 3.8330 | 0.429 |
| . \| . \| | . \| . \| | 5 | -0.062 | 0.018 | 4.0331 | 0.545 |
| . \| . \| | .*\| . \| | 6 | -0.010 | -0.067 | 4.0388 | 0.671 |
| . \| . \| | . \| . \| | 7 | 0.016 | 0.017 | 4.0520 | 0.774 |
| .*\| . \| | .*\| . \| | 8 | -0.132 | -0.148 | 5.0280 | 0.755 |
| . \| . \| | . \| . \| | 9 | 0.013 | 0.053 | 5.0371 | 0.831 |
| . \|** \| | . \|*. \| | 10 | 0.237 | 0.198 | 8.3782 | 0.592 |
| .*\| . \| | .*\| . \| | 11 | -0.169 | -0.141 | 10.139 | 0.518 |
| . \| . \| | . \| . \| | 12 | -0.060 | 0.018 | 10.363 | 0.584 |
| . \| . \| | .*\| . \| | 13 | 0.058 | -0.106 | 10.585 | 0.646 |
| .*\| . \| | . \| . \| | 14 | -0.070 | -0.009 | 10.913 | 0.693 |
| .*\| . \| | .*\| . \| | 15 | -0.119 | -0.132 | 11.906 | 0.686 |
| .*\| . \| | .*\| . \| | 16 | -0.106 | -0.103 | 12.712 | 0.694 |
| . \| . \| | . \| . \| | 17 | 0.036 | 0.030 | 12.807 | 0.749 |
| . \| . \| | . \|*. \| | 18 | 0.048 | 0.115 | 12.989 | 0.792 |
| . \| . \| | . \|*. \| | 19 | 0.072 | 0.104 | 13.409 | 0.817 |
| . \| . \| | .*\| . \| | 20 | -0.003 | -0.077 | 13.410 | 0.859 |

[8]The term $\varepsilon_t$, described as AR (1) if itserially correlated according to $\varepsilon_t = \rho\varepsilon_{t-1} + e_t$, and as AR (2) if it was according to $\varepsilon_t = \rho_1\varepsilon_{t-1} + \rho_2\varepsilon_{t-2}e_t$ and so on (Johnston, 1984, 306)

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