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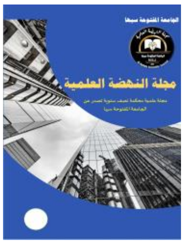

قياس نمو الإنتاجية الكلية لعوامل الإنتاج في الاقتصاد الليبي خلال الفترة الزمنية (1990–2024)

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الملخص

تهدف هذه الدراسة إلى تحليل ديناميكيات نمو إجمالي عوامل الإنتاج (TFP) في الاقتصاد الليبي خلال الفترة (1980–2024)، مع تقييم المساهمات النسبية لرأس المال والعمل والإنتاجية في النمو الاقتصادي، و تعتمد هذه الدراسة على إطار نظرية النمو الكلاسيكية الجديدة، وتستخدم تحليل محاسبة النمو (Growth Accounting)لتفكيك مصادر النمو وقياس تطور الإنتاجية الكلية عبر الزمن. تشير النتائج إلى أن النمو الاقتصادي في ليبيا كان مدفوعًا أساسًا بتراكم رأس المال (%12.46) مقارنة بمساهمة محدودة للعمل (%0.41)، في حين بلغ نمو الناتج (%1.3)، كما سجلت الإنتاجية الكلية نموًا ضعيفًا (%0.61) مع تقلبات ملحوظة وفترات انكماش، مرتبطة بعدم الاستقرار السياسي والصدمات الاقتصادية وضعف الأطر المؤسسية، مما يعكس انخفاض كفاءة استخدام الموارد. تؤكد النتائج أل أن هناك حاجة إلى إصلاحات هيكلية تشمل إصلاح قطاع النفط، وتنويع الاقتصاد، وتعزيز رأس المال البشري، وتحسين جودة التعليم والمؤسسات، بما يدعم التحول نحو نمو قائم على الإنتاجية، و بهذا تقدم الدراسة تحليلًا طويل الأجل لتطور الإنتاجية في ليبيا، وتسلط الضوء على القيود الهيكلية التي تعيق تحقيق نمو اقتصادي مستدام في اقتصاد ريعي.

الكلمات المفتاحية: إجمالي عوامل الإنتاج، النمو الاقتصادي، ليبيا، محاسبة النمو، رأس المال البشري.

Measuring the Growth of Total Factor Productivity in the Libyan Economy over the Period (1990–2024)

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Abstract

This study aims to analyze the dynamics of total factor productivity (TFP) growth in the Libyan economy over the period 1980–2024, with a focus on assessing the relative contributions of capital, labor, and productivity to economic growth. The analysis is grounded in the neoclassical growth theory framework and employs a growth accounting approach to decompose the sources of growth and track the evolution of aggregate productivity over time. The findings indicate that economic growth in Libya has been driven primarily by capital accumulation (12.46%), while the contribution of labor

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remains limited (0.41%), and overall output growth averages only 1.3%. Moreover, TFP growth is modest (0.61%) and characterized by significant volatility and periods of contraction, largely associated with political instability, economic shocks, and weak institutional frameworks, reflecting low efficiency in resource utilization. The results underscore the need for comprehensive structural reforms, including reforming the oil sector, diversifying the economic base, strengthening human capital, and improving the quality of education and institutions, in order to support a transition toward productivity-led growth. This study provides a long-term assessment of productivity dynamics in Libya and highlights the structural constraints hindering sustainable economic growth in a resource-dependent economy.

Keywords: Total Factor Productivity, Economic Growth, Libya, Growth Accounting, Human Capital.

1.Introduction:

One way to look at economic growth reveals more than just labor and machines at work. Rooted in older theories, the idea waited decades before gaining clarity during the 1930s. Over time, researchers began relying on it heavily when measuring how efficiently resources combine to create value. Hidden within numbers is something unmeasured, yet powerful, that pushes result higher. Not captured by counting hours worked or tools used, this element often stems from innovation. Instead of treating advancement as separate pieces added together, it shows how people, equipment, understanding, and abilities interact in ways that multiply outcomes unexpectedly. Because of such dynamics, output shifts even when inputs stay flat.

Economic growth over time depends heavily on how efficiently resources are used, since productivity shows how well labor, capital, and knowledge become output (Solow, 1957). To assess what each input contributes, researchers often rely on measuring productivity. Though Smith discussed related ideas in 1776, the idea of total factor productivity (TFP) first appeared in Tinbergen's work from 1942, setting the stage for later analysis (Ciccone & Dimaria, 2006). Rather than isolating one resource like labor, TFP accounts for how all inputs work together - revealing insights about technology, institutions, and new methods. Because it combines multiple influences at once, this metric goes beyond simpler measures that track only individual components.

Productivity shapes how nations differ economically, according to neoclassical growth ideas and later versions like the Solow model (1956) along with theories by Romer (1990) and Aghion & Howitt (1992). Instead of focusing only on machines or education, newer thinking points to innovation, shared knowledge, and strong institutions as vital forces behind lasting output gains. Evidence increasingly shows that stable politics, effective governance, and resilient systems matter deeply - especially where countries rely heavily on resources or face development challenges (Acemoglu & Robinson, 2012; World Bank, 2020). Because these factors influence incentives, investment climates shift when rules become predictable. When leaders act consistently, firms adapt faster. Institutions shape behavior quietly yet powerfully over time.

Though rich in resources, Libya's economy centers on oil, making it sensitive to outside pressures and domestic unrest. Following 2011, ongoing political turmoil and broken institutions began undermining economic results and output levels. Data now show that limited government effectiveness, poor handling of assets, along with continuous safety issues, led to capital being used poorly while worker efficiency dropped. As a result, total factor productivity plays only a minor role in driving expansion (International Monetary Fund, 2023; World Bank, 2022; African Development Bank, 2021).

Across the world, between 1981 and 2024, deep shifts reshaped how nations interact economically - globalization picked up speed during these decades. Information and communication tools spread fast, yet outcomes differed widely because digital markets grew unevenly. A financial meltdown hit in 2008, then a pandemic disrupted activity years later, each leaving distinct marks. Productivity responses varied: richer countries often gained more from innovation due to existing infrastructure. In contrast, poorer regions struggled under limits like weak institutions or low investment access. Structural barriers blocked consistent gains even when technology became available elsewhere. Evidence shows this gap persisted despite global integration trends (OECD, 2021; World Bank, 2020).

With this context in mind, looking into what drives productivity in Libya's economy matters greatly, less due to abstract theory, more because it reveals where growth comes from and where deep-rooted problems lie, especially those tied to fragile governance and ongoing unrest. Because of this reality, studying how total factor productivity shifts over time opens a window into how well resources are used, how much each input like machinery, workers, or innovation actually adds, offering insights that can shape realistic policy choices focused on lasting improvements rather than quick fixes.

2.Research Problem:

Even though productivity sits at the heart of economic thinking, agreement is scarce about exactly what drives changes in total factor productivity as countries advance. Research so far zooms in on particular areas or brief periods, rarely capturing how investment, worker skills, and innovation shape one another over extended times. Because shifts like digitization, evolving rules, and worldwide disruptions have gained momentum, fresh insight becomes vital - one that traces patterns since the early 1980s.

Objectives of the Study:

This study aims to:

- Measure and analyze the evolution of productivity factors from 1981 to 2024.
- Assess the relative contribution of capital, labor, and technology to overall productivity growth.
- Examine the role of global shocks, institutional dynamics, and digital transformation in shaping TFP.
- Provide evidence-based insights that can inform economic policy design to enhance long-term growth.

3.Significance of the Study:

This study helps us understand what makes productivity happen by looking at both the theory and the facts. It's a big deal because it can inform policymakers on how to boost innovation, make labor more efficient, and use resources in a way that's good for the planet. By studying productivity over 40 years, we can learn a lot and make better plans for the future, especially since the world is changing so fast. This research can also add to what we already know about economics and help us make sure we're using our resources in a way that will last.

4.Literature Review:

The concept of productivity has undergone significant changes over the past seven decades, driven by advancements in theory and empirical research across various economies. It all started with the neoclassical growth model developed by Solow in the 1950s, which introduced the idea that productivity is a key driver of long-term economic growth. Solow's framework revealed that while capital and labor are essential for growth, their impact eventually decreases, and long-term growth relies on technological progress. This breakthrough led to the development of total factor productivity (TFP), a measure of output growth that cannot be explained by observable inputs. Building on Solow's work, researchers in the 1960s and 1970s focused on breaking down growth into its components, including the contributions of residual inputs and productivity. However, the neoclassical model faced criticism, and subsequent studies have continued to refine our understanding of productivity. Today, we recognize that productivity is a complex and multifaceted concept that plays a crucial role in shaping economic growth and development. By examining the evolution of productivity research, we can gain a deeper understanding of the factors that drive economic growth and identify areas for future improvement. The study of productivity has become increasingly important, as it helps us understand how economies can sustain long-term growth and improve living standards. By analyzing the contributions of different inputs, such as capital, labor, and technology, researchers can identify areas where productivity can be improved, leading to more efficient use of resources and increased economic output. Furthermore, understanding the drivers of productivity is essential for policymakers, as it enables them to design effective policies that promote economic growth and development. In conclusion, the concept of productivity has come a long way since Solow's pioneering work, and its study continues to be an active area of research. By building on the foundations laid by Solow and other researchers, we can gain a deeper understanding of the complex factors that drive economic growth and develop strategies to improve productivity, ultimately leading to more prosperous and sustainable economies.

The old way of thinking about economics had a big problem, it couldn't explain why some countries are better at coming up with new technology than others, or why some places grow faster than others. This led to some new ideas in the late 1980s and early 1990s, thanks to people like Romer, Aghion, and Hoyt. They said that innovation, sharing knowledge, and building up human capital are all important for making productivity better in the long run. Romer's idea was that doing research and developing new things can lead to big returns, and that this can help countries grow. Aghion and Hoyt, on the other hand, talked about how new technologies can replace old ones, which they called "creative destruction". This process can be really important for helping countries stay competitive and keep growing. By looking at these things, we can start to understand why some countries are better at growing and innovating than others. Many studies have looked at how productive different countries are and why some are better than others. For example, Hall and Jones found out in 1999 that the main reason some countries are more productive is because of their social infrastructure, this means things like government policies and institutions that help businesses thrive. Similarly, Barro and Sala-i-Martin discovered in 2004 that having a well-educated workforce and good institutions is crucial for countries to catch up with each other in terms of growth. More recently, it's been shown that being part of a global economy and trading with other countries can help spread new technologies and make businesses more efficient, according to the OECD in 2023. The World Bank has also found that when countries invest in their people's skills and come up with new ideas, their productivity tends to increase. This suggests that there are many factors that can affect how productive a country is, and that investing in people and institutions can be a key part of driving growth and success. By looking at all these different studies, we can get a better understanding of what makes some countries more productive than others, and how we can help countries that are struggling to catch up.

Despite these contributions, the literature has also documented a slowdown in productivity growth in advanced economies since the mid-2000s. Gordon (2016) argued that the pace of transformative technological innovations has declined relative to earlier industrial revolutions. Conversely, Brynjolfsson and McAfee (2014) contended that digital technologies and artificial intelligence have not yet fully materialized in productivity statistics due to measurement lags and diffusion delays. Moreover, global crises, including the 2008 financial crisis and the COVID-19 pandemic, introduced new complexities, as they disrupted labor markets, capital flows, and global value chains, thereby affecting productivity dynamics in unprecedented ways. Regional studies further illustrate heterogeneity in productivity performance. For instance, developing economies often struggle with institutional weaknesses, skills mismatches, and low innovation capacity, which hinder their ability to catch up with advanced economies (Caselli, 2005). Conversely, some emerging economies, particularly in East Asia, have leveraged technology transfer, industrial upgrading, and human capital investment to achieve remarkable productivity growth (World Bank, 2024). These diverse trajectories underline the importance of context-specific factors in shaping productivity outcomes.

5.Research Gap:

Even though the empirical literature is substantial, several important gaps persist. To begin with, existing studies tend to examine either short-run disturbances or long-run patterns in isolation, with limited efforts to integrate both horizons within a single analytical framework. Furthermore, there is a scarcity of long-term, multi-decade investigations that systematically track how the relative roles of physical capital, labor, human capital, and technological progress evolve in the context of ongoing global transformations. In addition, a significant portion of the literature focuses primarily on advanced economies, resulting in an incomplete understanding of productivity dynamics in developing and transition economies. Bridging these shortcomings calls for a comprehensive analysis spanning the period from 1980 to 2024, one that simultaneously accounts for structural shifts and external shocks.

6.Formalization of the Total Productivity Factors (TFP):

The first formal articulation of Total Factor Productivity (TFP) emerged within the framework of neoclassical production theory, which posits that the aggregate production function can be expressed as a combination of capital and labor inputs. A commonly used representation is the Cobb–Douglas production function:

$$Y_t = A_t * f(K_t, L_t)\ldots\ldots\ldots\ldots\ \ldots\ldots\ldots (1)$$

Where:

Y denotes total output, K represents capital, L stands for labor, α\alphaα is the output elasticity of capital, and A captures the level of total factor productivity, reflecting technological progress and efficiency improvements beyond mere input accumulation.

From this production function, the Solow residual is derived as an empirical measure of Total Factor Productivity (TFP). It is obtained by calculating the portion of output growth that cannot be explained by the weighted contributions of capital and labor inputs. Formally, the Solow residual is expressed as:

$$\boldsymbol{\frac{\dot{A}}{A} = \frac{\acute{Y}}{Y} - \alpha\left(\frac{\check{K}}{K}\right) - (1-\alpha)(\frac{\acute{L}}{L})\ldots\ldots\ldots\ \ldots\ldots\ldots (2)}$$

where : $\frac{\dot{A}}{A}$ denotes the growth rate of TFP, $\frac{\acute{Y}}{Y}$ is the growth rate of output, $\frac{\check{K}}{K}$ represents the growth rate of capital, and $\frac{\acute{L}}{L}$ is the growth rate of labor, with α reflecting the capital share of income. Thus, the Solow residual captures improvements in efficiency and technological progress beyond what can be attributed to the accumulation of inputs (Hornstein & Krusell, 1996).

Considering a Cobb–Douglas production function that relates output (Y) to inputs namely physical capital (K) and labor (L) under the assumption of returns to scale denoted by γ, the functional form can be expressed as follows (World Bank, 2000):

$$Y_t = A_t * ({K_t}^{\alpha}.{L_t}^{1-\alpha})\gamma\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

- Y denotes total output (GDP);
- A is total factor productivity (TFP), capturing technological progress and efficiency;
- K represents capital input;
- L represents labor input;
- α is the output elasticity of capital, indicating the proportionate contribution of capital to output;
- β = 1 − α is the output elasticity of labor, reflecting labor's share in output.

To account for returns to scale, we may express the generalized form as:

$Y_t = A_t * ({K_t}^{\alpha}.{L_t}^{\beta})\gamma$……..(4)

Here, γ measures the degree of returns to scale:

- γ = 1 implies constant returns to scale (CRS);
- γ > 1 indicates increasing returns to scale (IRS);
- γ < 1 suggests decreasing returns to scale (DRS).

In the special case where γ = 1, the function simplifies to the standard Cobb-Douglas form with constant returns to scale:

Equation (4) may be conveniently reformulated in the following manner[1]:

$$\frac{\acute{Y}_t}{Y_t} = \frac{\dot{A}_t}{A_t} + \alpha_t * \frac{\acute{K}_t}{K_t} + \beta_t * \frac{\acute{L}_t}{L_t}\ , \quad \alpha_t + \beta_t = 1 \ldots\ldots\ldots\ldots\ldots(5)$$

in which , $\alpha_t$and β_t correspond to the respective contributions of capital and labor costs to total costs.

Typically, information onY_t , K_t ,and L_t is accessible or computable from other indicators, making Ȧ/A the sole unknown. This can, however, be obtained residually from Equation (5):

$$\frac{\dot{A}_t}{A_t} = \frac{\acute{Y}_t}{Y_t} - \alpha_t * \frac{\acute{K}_t}{K_t} - \beta_t * \frac{\acute{L}_t}{L_t} \quad \ldots\ldots\ldots\ldots\ldots..(6)$$

This process is often described as computing the Solow residual. When working with actual data, the corresponding discrete version of the equation is:

$$\frac{\Delta\dot{A}_t}{A_{t-1}} = \frac{\Delta\acute{Y}_t}{Y_{t-1}} - \alpha_t * \frac{\Delta\acute{K}_t}{K_{t-1}} - \beta_t * \frac{\Delta\acute{L}_t}{L_{t-1}} \quad \ldots\ldots\ldots\ldots\ldots..(7)$$

Where Δ denotes the first difference operator. In this framework, α and β represent the shares of capital and labor in national income, respectively. Under the standard assumptions of the neoclassical model, these shares sum to one (α + β = 1). For simplicity, time subscripts have been omitted.

In empirical applications, this version of the equation has long served as the standard approach for calculating total factor productivity, as utilized by Solow in his foundational work.

6.1Alternative Method for Empirical Investigation:

While the Solow model offers a clear understanding of the interconnections between variables under the assumption of continuous data, real-world economic measurement typically relies on discrete observations. The transformation in Equation (7) merely approximates the continuous form, which can result in imprecise outcomes. For discrete datasets, the trans-logarithmic form of the production function, introduced by Diewert,(1976) is generally more appropriate:

$$lnY_t = \alpha_0 + \alpha_K * lnK_t + \alpha_L * lnL_t + \alpha_t + \frac{\beta_{KK}}{2}[lnK_t]^2 + \frac{\beta_{LL}}{2}[lnL_t]^2 + \frac{\beta_t}{2}.t^2 + \beta_{KL}lnK_t * lnL_t + \beta_{Kt}lnK_t * t + \beta_{Lt}lnL_t * t \ldots\ldots\ldots\ldots..(8)$$

Where:

$$\alpha_K + \alpha_L = 1$$
$$\beta_{KK} + \beta_{KL} = 0$$
$$\beta_{LL} + \beta_{KL} = 0$$
$$\beta_{Kt} + \beta_{Lt} = 0$$

Under the assumption of competitive labor and capital markets, we have:

$$\alpha_t = \frac{\partial lnY_t}{\partial lnK_t} = \alpha_K + \beta_{KK}lnK_t + \beta_{KL}lnL_t + \beta_{Kt}t \ldots\ldots..(9)$$

$$\alpha_t = \frac{\partial lnY_t}{\partial lnL_t} = \alpha_L + \beta_{LL}lnL_t + \beta_{KL}lnK_t + \beta_{Lt}t \ldots\ldots..(10)$$

When working with discrete data, the variables' rates of change are computed using the first differences of their logarithms. Specifically, in our analysis, this is expressed as:

$$\Delta lnY_t = \frac{1}{2}[\alpha_t + \alpha_{t-1}] * \Delta lnK_t + \frac{1}{2}[\beta_t + \beta_{t-1}] * \Delta lnL_t + \Delta lnA_t \ldots\ldots(11)$$

The total factor productivity growth rate can be obtained directly from the preceding equation.

$$\Delta lnA_t = \Delta lnY_t - \frac{1}{2}[\alpha_t + \alpha_{t-1}] * \Delta lnK_t + \frac{1}{2}[\beta_t + \beta_{t-1}] * \Delta lnL_t \ldots\ldots(12)$$

Despite the greater technical accuracy of the latter equation, the Solow framework presented in Equation (7) will be applied here to demonstrate the calculation of total factor productivity. Alternative Method for Calculation of TPF (Appendix1).

7.Estimating the Capital Stock:

The capital stock (K) is typically constructed using the perpetual inventory method, which provides a systematic way to estimate the accumulated value of capital over time by

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[1] The applied transformations, along with the relevant assumptions, are outlined in Appendix 1.

continuously updating the previous period's capital stock with new investment while accounting for depreciation. The basic formula is given by[2]:

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

where:

- K_t = capital stock at time t,
- δ = depreciation rate of capital,
- K_{t-1} = capital stock in the previous period (t−1),
- I_t = gross investment during period t.

This approach assumes that capital depreciates at a constant rate δ, and new investment increases the capital stock accordingly. By applying this formula recursively from a base year, researchers can construct a time series of capital stock values, which is essential for analyzing productivity and growth.

This method has been extensively used in empirical research to estimate capital stock, as outlined by Nehru and Dhareshwar (1994), who developed a comprehensive dataset on physical capital stock using this methodology. Their work provides a reliable framework for measuring capital accumulation, particularly in cross-country growth and productivity studies:

$$\frac{K_t - K_{t-1}}{K_{t-1}} = \boldsymbol{\delta} + \frac{I_t}{K_{t-1}} = \boldsymbol{g}\ldots..\mathbf{(14)}$$

Hence:

$$\boldsymbol{K_{t-1}} = \frac{I_t}{g+\delta}\ldots\ldots\ldots\ldots\ldots..\mathbf{(15)}$$

Building a time series for capital stock encounters the challenge of determining the initial capital value, denoted as K_0. This issue can be addressed through various approaches, including estimating the capital stock for the base year (K_0) or calibrating the depreciation rate parameter δ.

8.Processing and Sources of Data:

In this study, we utilized statistical data from the World Bank's World Development Indicators (WDI). The gross domestic product (GDP) serves as the measure for Y_t, while the number of employed individuals represents L_t. Gross investment is denoted by I_t, and δ stands for the depreciation rate. For gross investment, we use the indicator known as "gross fixed capital formation."

A key challenge lies in determining the initial value of capital stock (K_0) for the model. Our method to estimate the initial capital stock involves assumptions related to the depreciation rate. Since the literature presents a variety of depreciation values, we adopt a depreciation rate of δ=5%, implying that capital fully depreciates over a period.

Consequently, the capital stock series is influenced by the initial capital stock K_0, which itself depends on parameters such as the depreciation rate δ and the average annual growth rate g. In this analysis, δ is treated as an exogenous parameter set at 5%, consistent with rates observed in industrialized countries, while g varies depending on the timeframe under consideration. It is worth emphasizing that all aggregate values are expressed in millions of Libyan Dinars, whereas employment figures are reported as the number of individuals. The entire dataset is presented in constant prices, covering the period from 1980 to 2024.

9.Empirical Results:

It should be noted that all macroeconomic aggregates are measured in millions of Libyan dinars, while employment is recorded as the total number of persons. The dataset is compiled in real (constant-price) terms and spans the period from 1980 to 2024.

9.1. Capital Stock Calculation:

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[2] We use a Perpetual Inventory Method (PIM) is a widely used approach to estimate the capital stock over time by continuously updating the previous period's capital stock with net additions from new investments, while accounting for depreciation. This method allows researchers to construct a time series of capital stock based on investment data.

This methodology provides a coherent and theoretically sound framework for estimating the capital stock over the entire study horizon (1980–2024). The first step involves determining the initial level of physical capital in the base year.

9.1.1.Estimate Initial Capital Stock (K_0):

In this study, the capital stock series is constructed using the Perpetual Inventory Method (PIM). The procedure starts with estimating the initial capital stock (K0), which serves as a key benchmark for building a reliable and internally consistent time series. This initial value is derived based on equation (15); accordingly, the following expression is applied:

$$\boldsymbol{K_0 = \frac{I_0}{g+\delta}}$$

Suppose:

- Investment in 1979 was 1,955.3 million (LYD),
- Average annual growth rate of investment = 2% (g =0.02)[3],
- Depreciation rate δ=0.05.

Then:

$$K_0 = \frac{1{,}955.3}{0.02+0.05} = \frac{1{,}955.3}{0.07}$$ = 27,932.85 million LYD[4].

9.1.2. Calculate Capital Stock for Subsequent Years (K_t):

This specification rests on the assumption that investment follows a stable growth path over time, while capital stock declines at a constant depreciation rate. In line with common practice in the literature and evidence from comparable economies, the depreciation rate is fixed at 5 percent annually (δ=0.05). The average growth rate (g) is estimated from historical investment data for Libya over the study period. After establishing the initial capital stock (K0), the capital series for subsequent years is generated iteratively using equation (13). Accordingly, the following expression is employed:

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

Then:

$$K_{1980} = (1-0.05).K_{1979} + I_{1980}$$
$$K_{1980} = (0.95)27{,}932.85 + I_{1980}$$

9.1.3. Estimating Capital and Labor Shares (α and β) in Libya: A Practical Approach:

To obtain estimates of the parameters α and β in the Cobb–Douglas production function for Libya, this study employs a hybrid approach that integrates both growth accounting techniques and econometric estimation. These parameters play a central role in quantifying the respective contributions of capital and labor to real output, and in deriving Total Factor Productivity (TFP). The conventional Cobb–Douglas production function can be expressed as follows:

$$Y_t = A.K_t^{\alpha}.L_t^{\beta}$$

Taking natural logarithms of both sides:

$$lnY_t = lnA + \alpha.lnK_t + \beta.lnL_t + \varepsilon_t \ldots\ldots\ldots\ldots (16)$$

Where:

- Y: Real Gross Domestic Product (GDP).
- K: Real capital stock (gross fixed capital formation, investment, or capital services).
- L: Labor input (number of employed persons or hours worked).
- A: Total Factor Productivity.
- ε: Error term

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[3] g can be estimated by accounted the average annual investment growth rate during the period (1980-1990), by this equation $g = 1 - \left[\frac{I_n}{I_0}\right]^{\frac{1}{n}}$.

[4] Notes that, we Repeat this process for each year up to 2024.

9.2. Growth Accounting (Direct Estimation via Income Shares):

When detailed data on factor incomes are unavailable, it is standard practice to rely on benchmark parameter values grounded in neoclassical theory and evidence from comparable economies. As indicated in the empirical literature:

- α (capital's share) typically ranges between 0.30 and 0.40
- β (labor's share) typically ranges between 0.60 and 0.70
- Under the assumption of constant returns to scale: α + β = 1[5].

Therefore, estimating α and β for Libya will follow this technique:

- β = (Compensation of Employees) / GDP
- α = (Gross Operating Surplus) / GDP

"According to Libya's national accounts, labor compensation accounts for 65% of GDP, while the operating surplus represents the remaining 35%. Therefore:"

- α = 0.35
- β = 0.65

10. Econometric Estimation:

Once time-series data for Y, K, and L are collected, the log-linear form of the production function can be estimated using multiple linear regression:

$$lnY_t = C + \alpha . lnK_t + \beta . lnL_t + \varepsilon_t$$

Where:

- c = ln(A), the constant term representing TFP.
- ε = residual or error term

The model can be estimated using Ordinary Least Squares (OLS).

Accordingly, using Equation (16), we derive a time series for A spanning the period 1980 to 2024, with an average value of: (A = 0.16).

Consequently, we obtain the following equation:

Y= 0,16+ 0-34 K+ 0.66 L

The findings suggest that a 1% increase in capital is associated with a 0.34% increase in GDP, whereas a 1% increase in labor corresponds to a 0.66% rise in GDP.

The table below reports the yearly growth rates of output (Y), capital (K), and labor (L) over the 1981–2024 period. These figures highlight key patterns in productivity performance and the accumulation of production factors, which are essential for interpreting the long-term evolution of economic growth over the past forty years.

Table (1): Decomposition of Economic Growth

Years	Growth (in %)			Years	Growth (in %)		
	Output (y)	Capital (K)	Labor (L)		Output (y)	Capital (K)	Labor (L)
1981	-19.2	37.53	16.46	**2003**	13.0	49.11	2.35
1982	2.8	3.65	14.48	**2004**	4.5	-3.80	2.46
1983	-2.5	-3.88	7.92	**2005**	11.9	94.24	2.50
1984	-5.0	-9.35	-20.73	**2006**	6.5	58.33	3.12
1985	8.3	-16.36	-3.55	**2007**	6.2	68.40	3.68
1986	-11.4	-26.00	1.17	**2008**	-0.2	9.11	3.60
1987	-14.7	-12.88	3.55	**2009**	-4.4	27.20	3.44
1988	7.6	-28.95	2.81	**2010**	5.0	-16.89	3.24
1989	7.2	10.49	3.35	**2011**	-50.3	4.62	-3.01
1990	3.7	9.29	-88.24	**2012**	86.8	-46.10	-3.50
1991	15.7	-2.35	4.01	**2013**	-18.0	70.19	2.67
1992	-2.7	-8.48	4.01	**2014**	-23.0	-12.54	2.38
1993	-3.8	0.91	4.01	**2015**	-0.8	2.76	1.83

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[5] Solow, R. M. (1957).

1994	1.9	45.14	3.99	**2016**	-1.5	-29.74	1.74
1995	-2.2	5.56	3.90	**2017**	32.5	16.85	1.91
1996	2.1	-20.30	3.76	**2018**	7.9	12.23	2.05
1997	5.2	29.16	3.58	**2019**	-11.2	8.66	1.93
1998	-3.6	1.35	3.38	**2020**	-29.5	-22.64	0.60
1999	0.7	-15.54	3.29	**2021**	28.3	-45.02	2.71
2000	3.7	12.84	2.64	**2022**	-8.3	176.61	1.49
2001	-1.8	43.19	2.05	**2023**	10.2	17.12	1.44
2002	-1.0	-1.39	2.20	**2024**	-0.6	55.84	1.17
Period of Analysis: 1981-2024					**1.3**	**12.46**	**0.41**

Note: The table was designed by the researcher.

10.1. General Trends and Volatility:

Over the entire period, average annual output growth stood at approximately 1.3%, compared to a relatively higher average capital growth of 12.46% and a modest average labor force growth of 0.41%. This divergence between capital accumulation and output growth suggests diminishing returns to capital or inefficiencies in capital utilization, which is a classical concern in Solow-type neoclassical growth models (Solow, 1956).

The data reveals periods of extreme volatility, particularly in output growth, with some years (2011: -50.3%) showing dramatic contractions and others (2012: 86.8%) reflecting sharp rebounds. Such fluctuations could be attributed to political instability, global economic shocks, or structural shifts in the economy. Labor and capital also show erratic growth in specific years, further indicating a lack of consistent factor accumulation.

10.2. Capital Accumulation vs Output Growth:

Despite capital input growing at a much higher rate than labor or output in many years (notably in 2005, 2006, 2007, 2022), output growth has not always followed suit. For example, in 2005, capital grew by 94.2%, but output grew by only 11.9%., however, in 2022, capital surged by 176.6%, while output declined by -8.3%.

These instances suggest that capital was not fully productive or that capital deepening did not translate into proportional output gains. From the perspective of Total Factor Productivity (TFP), this reflects a stagnation or even a deterioration in the efficiency of production. According to endogenous growth theory (Romer, 1990), such inefficiencies may stem from lack of innovation, weak institutions, or poor resource allocation.

10.3. Labor Dynamics and Employment Contribution:

Labor growth remained positive but relatively flat throughout the period, averaging 0.41% per year. In several years (1990, 2011, 2012), labor input contracted significantly, which might reflect either demographic transitions, unemployment shocks, or labor market rigidities. This weak labor input contribution to output growth further emphasizes the importance of productivity improvements to sustain long-term growth.

10.4. Structural Breaks and Shocks:

There appear to be structural breaks or economic shocks visible in the data:

- The early 1980s and late 2000s show significant fluctuations in both capital and output.
- The period 2010–2013 is characterized by extremely volatile output and capital growth, suggesting potential financial or political disruptions.
- The 2020–2024 period shows the impact of exogenous shocks such as the COVID-19 pandemic (2020) and its aftermath, reflected in the sharp contraction of output in 2020 (-29.5%) despite the capital contraction (-22.6%) and labor decline.

These fluctuations highlight the vulnerability of output growth to shocks, especially when not backed by solid institutional and technological foundations.

10.5. Estimate Total Factor Productivity (TFP):

The estimation of Total Factor Productivity (TFP) was conducted using Equation (12), with the corresponding results summarized in Tables (2) and (3).

Table (2): Contribution of Production Factors

Years	Contribution in output (In %)		TFP	Years	Contribution in output (In %)		TFP
	Capital (α)	Labor (β)			Capital (α)	Labor (β)	
1981	0.32	0.68	**0.38**	**2003**	0.34	0.66	**3.47**
1982	0.32	0.68	**-0.19**	**2004**	0.33	0.67	**1.92**
1983	0.32	0.68	**-0.25**	**2005**	0.33	0.67	**5.09**
1984	0.32	0.68	**-3.76**	**2006**	0.33	0.67	**3.23**
1985	0.33	0.67	**-0.58**	**2007**	0.33	0.67	**1.93**
1986	0.33	0.67	**-3.61**	**2008**	0.33	0.67	**-18.44**
1987	0.34	0.66	**-0.36**	**2009**	0.32	0.68	**21.63**
1988	0.33	0.67	**-2.82**	**2010**	0.33	0.67	**1.24**
1989	0.33	0.67	**0.99**	**2011**	0.33	0.67	**-4.79**
1990	0.33	0.67	**1.90**	**2012**	0.33	0.67	**3.85**
1991	0.34	0.66	**0.72**	**2013**	0.33	0.67	**-0.57**
1992	0.34	0.66	**0.14**	**2014**	0.32	0.68	**-3.07**
1993	0.33	0.67	**-0.43**	**2015**	0.33	0.67	**-1.03**
1994	0.33	0.67	**1.80**	**2016**	0.33	0.67	**-1.05**
1995	0.34	0.66	**0.70**	**2017**	0.33	0.67	**2.74**
1996	0.34	0.66	**0.41**	**2018**	0.33	0.67	**0.93**
1997	0.34	0.66	**2.21**	**2019**	0.33	0.67	**-0.82**
1998	0.34	0.66	**-1.32**	**2020**	0.34	0.66	**-4.62**
1999	0.34	0.66	**2.01**	**2021**	0.34	0.66	**6.07**
2000	0.34	0.66	**1.75**	**2022**	0.34	0.66	**4.77**
2001	0.34	0.66	**1.36**	**2023**	0.33	0.67	**0.35**
2002	0.34	0.66	**1.93**	**2024**	0.33	0.67	**1.05**
Period of Analysis: 1981-2024					**0.33**	**0.67**	**0.61**

Note: The table was designed by the researcher.

In the table (2), the contributions of capital and labor are given as shares of output, while TFP is the residual that explains the portion of output growth not accounted for by input growth. Sustainable long-term economic growth depends predominantly on enhancements in Total Factor Productivity (TFP) rather than solely on the accumulation of inputs. Over the period from 1981 to 2024, the average contribution of capital to output was 33%, while labor contributed an average of 67%. Meanwhile, the average growth rate of TFP during this timeframe was recorded at 0.61%. This suggests that output growth during the period was primarily driven by the accumulation of inputs, especially labor, rather than by improvements in productivity or technology.

Table (3): Summary of Results of Decomposition of Economic Growth and Contribution of Production Factors

Period of Analysis	Growth (in %)			Contribution in output (In %)		TFP
	Output (y)	Capital (K)	Labor (L)	Capital (α)	Labor (β)	
1981-1990	-2.3	-3.64	-6.28	0.33	0.67	**-0.83**
1991-2000	1.7	4.83	3.66	0.34	0.66	**0.80**
2001-2010	4.0	32.75	2.86	0.33	0.67	**2.33**
2011-2024	1.6	14.92	1.10	0.33	0.67	**0.27**
1981-2024	1.3	12.46	0.41	0.33	0.67	**0.61**

A period-specific analysis reveals that between 1981 and 1990, Total Factor Productivity (TFP) growth exhibited considerable volatility, oscillating between positive and markedly negative values. Notably, negative TFP growth rates were observed in 1984 (−3.76%), 1986 (−3.61%), and 1988 (−2.82%), reflecting significant inefficiencies and potential macroeconomic or political instability during these years. Conversely, modest positive growth was recorded in 1989 (0.99%) and 1990 (1.90%). This period was marked by economic instability, with weak institutional foundations. Growth was driven by expansion in labor and capital, not efficiency gains.

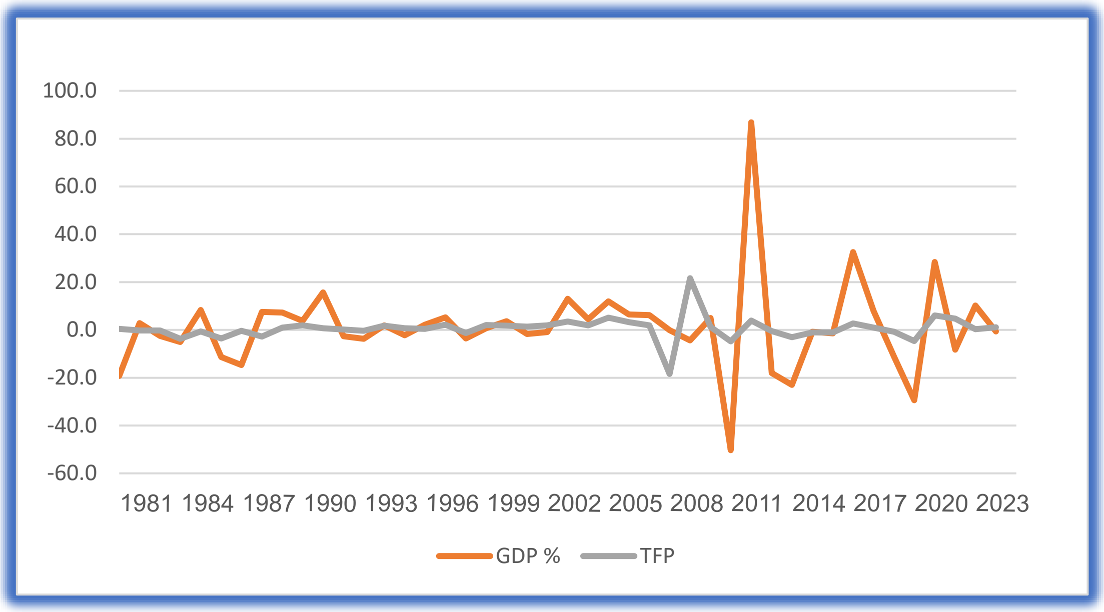

Figure (1): TFP's Contribution to Economic Growth

During the period from 1991 to 2000, Total Factor Productivity (TFP) demonstrated gradual improvement, with notable increases in 1997 (2.21%) and 1999 (2.01%). However, this recovery was uneven and susceptible to setbacks. While early indications of structural reform may have surfaced, economic growth continued to be predominantly driven by input accumulation and remained vulnerable to external and internal shocks.

In regarding to the period 2001–2010, Total Factor Productivity (TFP) experienced significant increases in 2005 (5.09%) and 2006 (3.23%), followed by a pronounced decline in 2008 (−18.44%), which can likely be attributed to the global financial crisis or domestic disturbances. The sharp rebound in 2009 (21.63%) may indicate a recovery from earlier inefficiencies, although such an extreme value requires careful examination. This decade was characterized by both reform initiatives and susceptibility to external shocks, with TFP growth exhibiting promising potential but remaining highly volatile.

During the period 2011–2024, Total Factor Productivity (TFP) continued to exhibit volatility. The year 2021 recorded the highest TFP growth in the series at 6.07%, followed by strong performance in 2022 (4.77%) and more moderate gains in 2023 and 2024. Nonetheless, negative TFP growth persisted in certain years, notably in 2014 (−3.07%) and 2020 (−4.62%), which may be attributed to political instability or public health crises, such as the COVID-19 pandemic. Although recent years show signs of gradual improvement in productivity, the trend remains uneven. This suggests that advancements in technology adoption and institutional reforms may be yielding results, albeit at a slow and inconsistent pace.

The occurrence of negative Total Factor Productivity (TFP) values during several years of the study period reflects a decline in economic efficiency and a suboptimal utilization of productive resources. According to the neoclassical growth framework (Solow, 1956), TFP represents the portion of output growth that cannot be explained by the accumulation of capital or labor. Therefore, negative TFP values indicate that output grew at a slower rate than input usage, suggesting that economic growth during these periods was predominantly factor-driven rather than productivity-led.

This decline in TFP may be attributed to various structural and external factors, including weak institutional quality, inefficient resource allocation, limited technological adoption, and low levels of innovation. Additionally, negative productivity shocks resulting from political instability, economic crises, or global disruptions, such as the COVID-19 pandemic, could further contribute to reduced efficiency. The persistent volatility or decline in TFP highlights the need for comprehensive structural reforms aimed at enhancing technological progress, improving human capital, and strengthening institutional frameworks. Such reforms are essential to shift the growth trajectory from one based on input expansion to one rooted in sustained improvements in productivity[6].

11. Economic Implications:

11.1 Input-driven growth:

The economy has relied heavily on labor-intensive growth, with labor contributing two-thirds to output. This reflects the characteristics of a developing economy with limited capital deepening and moderate technological progress.

11.2. Weak productivity performance:

Low and volatile TFP values indicate structural inefficiencies. The economy has not yet reached the stage where productivity is a consistent driver of growth.

11.3. Implications for Total Factor Productivity (TFP):

Given that both capital and labor grew faster than output on average, especially in several key periods, we can infer a relatively weak growth in Total Factor Productivity. According to the Solow Residual approach, TFP is the portion of output growth not explained by capital or labor accumulation. Persistent negative or low TFP implies that economic growth is primarily factor-driven rather than productivity-driven, a pattern often observed in resource-based or transition economies.

11.4. Urgent need for productivity-focused reforms:

To enhance long-term sustainable growth, future policy should prioritize:

- Investment in technological infrastructure and digitalization
- Labor market reforms to boost human capital
- Institutional strengthening and governance improvement
- Reforms in education and vocational training systems

12. Conclusion:

This study investigates the evolution of Total Factor Productivity (TFP) in Libya over the period 1980–2024 within the framework of the neoclassical growth model, particularly drawing on the insights of Robert Solow. It evaluates the relative contributions of capital, labor, and productivity to overall output growth. The empirical results point to a growth pattern largely driven by factor accumulation rather than efficiency improvements, with productivity gains remaining both limited and unstable over time.

The findings indicate that average annual output growth reached approximately 1.3%, while capital accumulation expanded at a substantially higher rate of 12.46%, and labor growth remained modest at 0.41%. This pronounced imbalance suggests the presence of diminishing returns to capital and reflects inefficiencies in the allocation of resources, consistent with the theoretical predictions of the Solow growth model.

An important feature of the results is the high volatility of TFP growth across sub-periods, with frequent negative values implying that increases in inputs did not consistently translate into proportional gains in output. Notable declines in productivity occurred in years such as 1984, 1986, 1988, 2008, and 2020, likely associated with macroeconomic instability, political disruptions, external shocks, and institutional constraints. Even during periods characterized by

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[6] See Solow, R. M. (1956).

strong capital expansion, such as 2005 and 2022, output growth did not respond proportionately, further highlighting inefficiencies in capital utilization.

Although certain years, such as 1997, 2005, 2009, and 2021, witnessed temporary improvements in productivity, these episodes were irregular and short-lived. The contribution of labor remained relatively stable but insufficient to offset broader systemic inefficiencies. Overall, the average TFP growth rate of 0.61% over the study period indicates that Libya's long-term economic performance has been predominantly driven by quantitative increases in factor inputs rather than qualitative enhancements in efficiency, innovation, or technological progress.

From a broader perspective, these findings suggest that Libya's growth trajectory reflects the characteristics of a resource-dependent, factor-driven economy that has yet to transition toward productivity-led development. Structural rigidities, weak institutional frameworks, limited technological diffusion, and high exposure to external shocks have collectively constrained the economy's ability to achieve sustained and inclusive growth.

Looking ahead, effective policy reform should prioritize addressing the structural determinants of low productivity. This includes investing in technological infrastructure and digital transformation, improving human capital through education and labor market reforms, strengthening governance and institutional quality, and fostering innovation alongside private sector development.

In conclusion, unlocking Libya's long-term growth potential requires a decisive shift from input-driven expansion toward a productivity-oriented development model. Without such a transformation, future economic growth is likely to remain constrained despite continued increases in capital and labor inputs.

Note: It is important to acknowledge that the artificial intelligence engine (ChatGPT) was utilized to assist in linking and interpreting the methods used to calculate the study variables, as well as to enhance the clarity and academic quality of the English language used in this paper. This support was provided for informational and linguistic purposes only.

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14. Appendices:

14.1. Appendix 1

Calculation of Decomposition of GDP and TFP’s contribution:

Calculation of Decomposition of economic growth and contribution of production factors given a capital share α = 0.35, it generally relies on a standard growth accounting framework based on a Cobb-Douglas production function.

The aggregate production function is often written as:

$$Y = A.K^{\alpha}.L^{1-\alpha}$$

where:

- Y = Output (GDP)
- A = Total Factor Productivity (TFP)
- K = Capital input
- L = Labor input
- α=0.45 = Capital's output elasticity (share)
- 1−α=0.55 = Labor's output elasticity

Growth Rate Decomposition:

Taking logs and then differentiating with respect to time, the growth rate of output can be decomposed as:

$$\frac{\acute{Y}_t}{Y_t} = \frac{\dot{A}_t}{A_t} + \alpha_t * \frac{\acute{K}_t}{K_t} + 1 - \alpha_t * \frac{\acute{L}_t}{L_t}$$

Where: $\frac{\acute{Y}_t}{\boldsymbol{Y}_t}$ is the growth rate of output, $\frac{\dot{A}_t}{\boldsymbol{A}_t}$ is the growth rate of TFP, $* \frac{\acute{K}_t}{\boldsymbol{K}_t}$is the growth rate of capital, $\frac{\acute{L}_t}{\boldsymbol{L}_t}$ and is the growth rate of labor.

Calculate growth rates:

Compute the average annual growth rates (or growth rates over your period of interest) for Y, K, and L using:

$$g_x = \frac{X_t - X_{t-1}}{X_t} \text{ or } lnX_t - lnX_{t-1}$$

Calculate TFP growth (Ag):

Rearrange the growth accounting formula:

$$\boldsymbol{g_A = g_Y - \alpha g_K - (1 - \alpha) g_L}$$

Contribution of each factor to growth:

- Contribution of capital to GDP growth: αg_K
- Contribution of labor to GDP growth: $(1 - \alpha) g_L$
- Contribution of TFP to GDP growth: g_A

Verify:

$$\boldsymbol{g_Y = g_A + \alpha g_K + (1 - \alpha) g_L}$$

For example:

Variable Growth Rate g:

GDP (Y) = 4%
Capital (K) = 6%
Labor (L) = 1%
Given α=0.35
Hence:
Ag = 0.04 – (0.35* 0,06) – (0.65 * 0.01)
0.04 – 0.021 – 0.0065 = 0.0125 (1.25%.