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The impact of climate, socio-political and COVID-19 shocks on Tunisia's potential growth

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Abstract

This study estimated Tunisia's potential growth with a Cobb-Douglas production function using an unobservable component model within structural changes context for the period 1989–2023. It investigated the major shocks' effects on the potential growth and its components.

In contrast with most studies, we employed the Beveridge Curve to deduce the natural unemployment rate. In order to obtain a more realistic labor trend. We developed a methodology with which we created an indicator of working hours that considers a representative distribution of employment, in particular by sector, location, and gender.

We performed the study in an uncertain environment. Structural changes have an important impact on the major macroeconomic trends. We manipulated these changes using a variety of econometric time series techniques. We performed the Bai-Perron test to detect slight shifts.

The results show that for the last 40 years, Tunesia has not been able to maintain high potential production growth rates. The country could not halt the significant deceleration of potential output that began in the 2010s or avoid the negative potential growth differentials by 2020–23. Total factor productivity was insufficient to avoid a permanent slowdown that had become more severe with each shock. Additionally, labor declined in response to decelerating demographic trends and persistent structural unemployment. These issues may remain significant in the future.

Keywords: Potential Growth, Production Function, Unobserved Components Model, structural changes, shocks

JEL: E22, E23, E24, E27, C82

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Abbreviations

COVID-19: COronaVIrus Disease of 2019
EU: European Union
FDI: Foreign Direct Investment
GAP: Difference between two values
GDP: Gross Domestic Product
INS: National Institute of Statistics
IT: Information Technology
NAWRU: Non-Accelerating Wage Rate of Unemployment
R&D: Research and Development
TFP: Total Factor Productivity
SME: Small and Midsize Enterprise
TND: Tunisian Dinar
UCM: Unobservable Component Model
y-o-y: ((a year value - the precedent year value) / the precedent year value) x 100

Introduction

Over the past four decades, the Tunisian economy has experienced fluctuating growth levels that align, occasionally, closely with its long-term trajectory, while at other times, they diverge. These changes have become notable in recent years. An unfavorable economic environment (investment, unemployment, productivity, etc.) and few exogenous shocks affect actual growth.

The relationship between the pace of economic growth and its influencing factors is unclear and complex.

Understanding the dynamics of growth in Tunisia and the level of economic development achieved can help identify the factors preventing higher and more sustained economic growth.

On the one hand, growth cannot answer issues such as determining the utilization rate of medium- and long-term sustainable capacities, labor productivity, monetary policy diagnosis, policy mix evaluation, and identifying the economy's position within the growth cycle.

However, changes in growth levels are associated with short-term shocks. Consequently, they exhibit a cyclical impact. Other changes have also been linked to long-lasting reforms. Therefore, they have a significant structural impact. Additionally, supply, transient, and permanent shocks interact in ways that affect the economy. These shocks can lead to unsustainable or structural changes. Thus, analyzing the drivers of economic growth can provide a deeper understanding of the underlying dynamics of the economy and enhance economists' analyses.

It is challenging to accurately determine the economy's precise standing in relation to its potential[1], as it constantly fluctuates between expansion, stagnation, and recession.

Growth must be examined for Tunisia's economic policies; however, it is more crucial to focus on its trends, cyclical components, and underlying causes. Analyzing the deduced growth allows economists to evaluate the influence of its drivers and calculate their relative contributions to its dynamics. Through growth decomposition, economists can assess the effects of the subtracted growth drivers and determine their roles in their dynamics, possible solely through identifying and analyzing long-term economic trends and the impact of crises on their dynamics.

Such analysis is atypical in Tunisia, which regularly raises concerns about the necessity of assessing the position and trajectory of the economic cycle and the effectiveness of macroeconomic policy.

Impact studies on various shocks and crises can help avoid their damaging effects on the economy. Some of these factors lead to changes in growth pathways and their determinants. Therefore, the structural shifts or deviations in their tendencies must be identified and assessed. These studies helped estimate changes in the slope and inclination of the growth path and its contributing

[1] Potential output was introduced by Okun (1962) as the level of output that is consistent with a level of employment that results in a non-accelerating rate of inflation.

variables. Moreover, such literature can help provide long-term insights, which are crucial when making economic decisions.

This study aims to address these concerns to understand better the long-term growth dynamics of gross domestic product (GDP) and its factors and to analyze the effect of the crisis on its path. By constructing a production function, we combine the structural approach with the potential output using econometric modeling based on unobserved component models. Additionally, we estimated unknown break dates and tested them for structural changes.

By analyzing several macroeconomic relationships, this study enabled the estimation, assessment, and forecasting of potential growth until 2030. This approach facilitated the estimation and evaluation of each production factor in equilibrium and determined their relative contributions to potential growth.

Our work contributed to the literature that studies the impact of shocks on potential growth and output gap. This study also helped identify, evaluate, and investigate the effects of various shocks (including climate, socio-political, economic, pandemic, and security shocks) on structural changes in potential growth and its factors, as well as their interactions to assess the sustainability of each structural change. Additionally, this investigation can help understand fundamental economic trends in Tunisia, providing long-term perspectives on economic patterns. Finally, reformulating quantitative analyses of monetary and fiscal stability increases decision-making efficacy.

The study makes several contributions to the literature. First, we introduced a comprehensive database to measure Tunisia's potential growth and output gap. We included novel and representative quarterly data, notably the hours worked. Second, this work is the first to combine parametric and nonparametric methods to derivate the production function. We used Unobservable Component Models (UCM) to estimate the trends and the Beveridge Curve to determine the natural unemployment rate. Third, this research is novel because it investigates the impact of shocks on the potential growth and its factors by using a new approach that compares actual and forecasted data after the shocks.

In terms of content, the paper is laid out as follows: Section 1 provides an overview of the methodology. In addition to the estimation results and the determination methodology of the natural unemployment, the data investigation is presented in Section 2 with an emphasis on the hours worked compilation. Section 3 is devoted to the analysis and discussion of the results. The last section is avoided to the concluding remarks of the paper.

Section 1: Methodology for calculating potential rates and output gap

1.1 Overview of the methodology

Early works of Hodrick and Prescott (1981, 1997), Beveridge and Nelson (1981), King and Rebelo (1993) and Baxter and King (1999) were mostly engaged in the application of univariate filters. The estimates coming out of these filters reject several statistical features (Blagrave et al., 2015). In addition, the use of these filters in real time are constrained by their sensitivity to ex-post adjustments to the results (Adams & Coe, 1990; Laxton & Tetlow, 1992 and Apel & Jansson, 1999). Specifically, the estimates of the present output gap change retroactively as new data become available (Beneš et al., 2010 and Melolinna & Tóth, 2016). The use of univariate statistical models to discern potential outputs is also controversial. Owing to the method's lack of an economic theory foundation, such results may be perceived as statistical trends rather than potential outputs.

Because of these limitations (Hamilton, J. (2018)), numerous multivariate statistical approaches have been developed, including adding additional data to the statistical methods used for the trend-cycle decomposition. Camba-Mendez et al. (2003) demonstrate that multivariate models reduce revisions during the sample period end when compared with univariate techniques.

Unobservable Component Models (UCM; Harvey, 1989) produce an output gap comparable to standard business cycle indicators. Laxton (1992) and Kuttner (1994) were constructing unobserved components models to estimate potential output al-ready in the early 1990s. Furthermore, UCMs can be augmented by incorporating lag structures or additional observable variables. Borio et al. (2014) and Melolinna et al. (2016) also propose including financial indicators to miti-gate the end-of-sample problem. Alichi et al. (2017, 2015) demonstrate that, among other measures, introducing the capacity-utilization rate that contains additional information on the amount of slack in the economy is effective in reducing the ex- post revision of results when estimating potential output and slack in the economy. Alichi et al. (2018) augment their UCM with a monetary policy rule to further improve the reliability of the potential output estimates. By integrating this estimation technique with the production function methodology, we can account for macroeconomic relationships more effectively.

Hence, this study employed UCMs. First, we apply this technique to estimate potential growth and output gap (Tóth, M. (2021)). The subsequent phase is to identify structural changes in Tunisian economic activity and investigate the impact of recent shocks on the level and trend of the GDP (Abiad, A., D. Furceri, and P. Topalova, 2016; Acevedo, S., M. Mrkaic, N. Novta, E. Pugacheva, and P. Topalova, 2018; Binici, M., S. Centorrino, S. Cevik, and G. Gwon, 2022; De Winne, J., and G. Peersman, 2018; Heinen, A., J. Khadan, and E. Strobl, 2019; Bodnár, K., Le Roux, J., Lopez-Garcia, P. and Szörfi, B. (2020)). In the linear regression models estimated by least squares, we applied the Bai-Perron tests of numerous structural changes occurring at unknown times; the test of L+1 breaks through to L breaks (Bai and Perron, 1998).

We employ a combination of the structural approach of potential output and econometric modeling. The structural method is based on the "Cobb–Douglas" production function model (Cobb and Douglas, 1947). This function incorporates components such as capital, labor, and total productivity. It also incorporates constant-scale returns based on the share of wages in GDP as the elasticity of output regarding labor.

In this structural approach, we estimated the trends in the capital, labor, and total production variables using unobserved component models.

The unobserved component technique is based on decomposing seasonally adjusted time series into trends and cyclical components. To estimate the various components, we employed state-space form and Kalman filter (Harrison and Stevens 1976; Harvey 1989; Young et al. 1999; Durbin and Koopman 2012).

For unemployment, we used the Beveridge curve (Christopher Dow and Dicks-Mireaux, 1958) to determine its natural rate. Although the Beveridge curve is a nonparametric method, it provides more accurate results than the Phillips curve, demonstrating its inadequacy in comparison to the performance of the Beveridge curve. The Phillips curve does not provide robust estimates, because it does not account for a firm's response to unemployment.

The empirical results include estimates for potential output and its factors, as well as natural unemployment calculated using the Beveridge curve.

Furthermore, identifying unknown break dates included in the potential output is based on tests that allow inferences regarding the presence of structural changes and the number of breaks. In a linear regression model estimated by least squares, we employed the Bai-Perron tests of numerous structural changes occurring during uncertain periods.

1.2 Empirical specifications

The gap between observed and trend GDP does not adequately explain or identify the factors influencing the dynamics of potential output. Furthermore, the results often lack economic significance and tend to be less robust towards the end of the sample period.

The structural method improves upon these limitations by incorporating growth factors into models and accounting for their effects. Furthermore, this approach makes assumptions based on economic theory and multivariate modeling, such as structural vector autoregression models, dynamic stochastic general equilibrium models, and production functions.

We selected the production function from the above methods to determine the potential output and its variables. Based on economic theory, the production function estimates and evaluates the maximum output level an economy can produce when capital, technical progress, and labor align with their respective tendencies. Several specifications, such as the Cobb-Douglas function, constant elasticity of substitution, and the simple product of hours worked by hourly productivity, have been developed to design and estimate the production function. Among other things, it is based on estimating potential GDP using the elasticity of substitution of factor, the simple product of hours worked by hourly productivity, or the Cobb-Douglas function. To estimate the total output of the Tunisian economy (Y), we utilize a Cobb-Douglas production function that incorporates the stock of physical capital (K), total Factors productivity (G), and labor (L).

$$Y_t = G_t \, L_t^{\alpha} K_t^{1-\alpha} \quad (1)$$

The parameters α_t and $(1 - \alpha_t)$ represent the values of the production-labor and production-capital elasticity over time. In other words, the elasticity of labor and capital returns. These parameters estimate the proportion of production income supplied by labor and capital by imposing certain criteria related to capital and labor.

In our specification, the labor component (L) is represented by the average number of hours worked by a unique individual during a quarter (H) multiplied by the working population (N):

$$L_t = N_t H_t \quad (2)$$

$$N_t = P_t^{age} A_t^{act}(1 - U_t) \quad (3)$$

P_t^{age} : Working age population between 15 and 60 years in t.
A_t^{act} : Total population activity rate in terms of age in t.
$P_t^{age} A_t^{act}$: Active population in t; It will, henceforth, be designated P_t^{act}.
U_t : Labor-force unemployment rate.
$1 - U_t$: Labor force participation rate.

As a result of this relationship:

$$L_t = P_t^{age} A_t^{act}(1 - U_t) H_t \quad (4)$$

Equation (1) is therefore written as:

$$Y_t = G_t (P_t^{age} A_t^{act}(1 - U_t) H_t)^{\alpha} K_t^{1-\alpha}$$

Postulating that $y_t = \log(Y_t)$, $g_t = \log(G_t)$, $p_t^{age} = \log(P_t^{age})$, $a_t = \log(A_t)$, $u_t = -\log(1 - U_t)$, $h_t = \log(H_t)$, $k_t = \log(K_t)$, the linear decomposition of the previous equation yields

$$y_t = g_t + \alpha(p_t^{age} + a_t^{act} - u_t + h_t) + (1 - \alpha)k_t \quad (5)$$

From this equation, we deduce, by similarity, the relation between the potential production Y^* and the potentials G^*, P^{act^*}, A^{act^*}, U^*, H^* and K^*, respectively, of G, P^{act}, A^{act}, U, H and K.

In our framework, the total population is an exogenous variable whose potential is considered to be equal to the observable: $P^{age*} = P^{age}$.

According to Equation (5), the potential production is obtained by summing the various trend components related to labor, capital, and total factor productivity (TFP).

In practice, we assume that the elasticities of production-labor and production-capital are time-invariant. We calibrated the elasticity of production-labor as equal to the share of wages in value-added between 1990 and 2017. This share was equal to 0.415.

We allocate an UCM for each production factor, whose estimation allows us to determine the unmeasurable fundamental component of the factor.

1.2.1 Capital trend

The capital trend k_t^* is modeled according to the following UCM:

$$\begin{cases} k_t = k_t^* + \varepsilon_t^k \\ k_{t+1}^* = k_t^* + k_t^{*\cdot} \\ k_{t+1}^{*\cdot} = k_t^{*\cdot} + \varepsilon_t^{k^{*\cdot}} \end{cases} \quad (6)$$

vectors k_t^* and $k_t^{*\cdot}$ are auxiliary variables indicating capital trends and their variations. ε_t^k and $\varepsilon_t^{k^{*\cdot}}$are the errors of the k and $k^{*\cdot}$ equations. ε_t^k and $\varepsilon_t^{k^{*\cdot}}$are represent independently distributed Gaussian error terms with mean zero and variance $\sigma_{\varepsilon^k}^2$ and $\sigma_{\varepsilon^{k^{*\cdot}}}^2$ respectively. Smaller the variance $\sigma_{\varepsilon^{k^{*\cdot}}}^2$, compared to the variance $\sigma_{\varepsilon^k}^2$, better the quality of the smoothing of $k_t^{*\cdot}$. Let $q_{k^{*\cdot}}$ be a quotient such that $q_{k^{*\cdot}} = \frac{\sigma_{\varepsilon^{k^{*\cdot}}}^2}{\sigma_{\varepsilon^k}^2}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable. Thus, we obtain the unobservable variables, k_t^* and $k_t^{*\cdot}$.

1.2.1.1 Capital-trend productivity

The efficiency of the capital trend, ${K_p}_t^*$ is measured as the value of potential production divided by the amount of capital trend utilized.

$${K_p}_t^* = \frac{Y_t^*}{K_t^*} \quad (7)$$

1.2.1.2 Utilization rate

Capital input (K_t) is obtained by multiplying the actual capital stock (K_t^{actual}) by the utilization rate (U_t) as explained in the above equation:

$$K_t = U_t K_t^{actual} \quad (8)$$

The same equation is useful for calculating the capital trend input K_t^* as a product of the actual capital stock K_t^{actual} and average utilization rate U_t^*.

$$K_t^* = U_t^* K_t^{actual} \quad (9)$$

By dividing both sides of Equations (8) and (9), we obtain:

$$\frac{K_t}{K_t^*} = \frac{U_t}{U_t^*}$$

Subtracting 1 from both sides of the previous equation, we obtain:

$$\frac{K_t - K_t^*}{K_t^*} = \frac{U_t - U_t^*}{U_t^*}$$

As the above equation shows, the capital input gap $\frac{K_t - K_t^*}{K_t^*}$ is equal to the capital utilization rate gap.

We can obtain this result using the linear form by taking the logarithm of both sides of equations (7) and (8) and subsequently taking the difference between them.

$$k_t - k_t^* = u_t - u_t^* \quad (10)$$

As shown in Equation (9), the capital input gap $k_t - k_t^*$ is the difference between the actual utilization rate and the average utilization rate, namely, the utilization gap $u_t - u_t^*$.

1.2.2 Labor trend

To estimate labor according to our specification based on the production function approach, the labor factor is measured as the number of hours worked per quarter by the employed population.

1.2.2.1 Working age population trend

The working-age population trend is an unobservable factor, estimated using the following UCM:

$$\begin{cases} p_t^W = p_t^{W*} + \mu D_t^{W2019} + \varepsilon_t^{p^W} \\ p_{t+1}^{W*} = p_t^{W*} + p_t^{W*.} \\ p_{t+1}^{W*.} = p_t^{W*.} + \varepsilon_t^{p^{W*.}} \end{cases} \tag{11}$$

Vectors p_t^{W*} and $p_t^{W*.}$ are auxiliary variables indicating working-age population trends and their variations. $\varepsilon_t^{p^W}$ and $\varepsilon_t^{p^{W*.}}$are the errors of the p_t^W and $p_t^{W*.}$ equations. $\varepsilon_t^{p^W}$ and $\varepsilon_t^{p^{W*.}}$ represent independently distributed Gaussian error terms with mean zero and variance $\sigma^2_{\varepsilon^{p^W}}$ and respectively. Smaller the variance of $\sigma^2_{\varepsilon^{p^{W*.}}}$, compared to the variance $\sigma^2_{\varepsilon^{p^W}}$, better the quality of the smoothing of $p_t^{W*.}$. Let $q_{p^{W*.}}$ be a quotient such that $q_{p^{W*.}} = \frac{\sigma^2_{\varepsilon^{p^{W*.}}}}{\sigma^2_{\varepsilon^{p^W}}}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable. D_t^{W2019} is a dummy variable that takes the value 1 for the period 2019Q2–2020Q1, and 0 otherwise.

Thus, we obtain the unobservable variables $p^{W^*}$and $p^{W^{*.}}$.

1.2.2.3 Activity rate trend

The activity rate trend is an unobservable factor estimated using the following UCM:

$$n_t = p_t^{age} + a_t^{act} - u_t$$

$$\begin{cases} a_t^{act} = a_t^{act*} + \alpha D_t^{act2014} + \beta D_t^{act2021} + \varepsilon_t^{a^{act}} \\ a_{t+1}^{act*} = a_t^{act*} + a_t^{act*.} \\ a_{t+1}^{act*.} = a_t^{act*.} + \varepsilon_t^{a^{act*.}} \end{cases} \tag{12}$$

The vectors a_t^{act*} and $a_t^{act*.}$ are auxiliary variables indicating capital trends and their variations. $\varepsilon_t^{a^{act}}$ and $\varepsilon_t^{a^{act*.}}$are the errors in the a^{act} and $a^{act*.}$ equations. $\varepsilon_t^{a^{act}}$ and $\varepsilon_t^{a^{act*.}}$ represent independently distributed Gaussian error terms with mean zero and variance $\sigma^2_{\varepsilon^{a^{act}}}$ and $\sigma^2_{\varepsilon^{a^{act*.}}}$ respectively. Smaller the variance $\sigma^2_{\varepsilon^{a^{act*.}}}$, compared to the variance $\sigma^2_{\varepsilon^{a^{act}}}$, better the quality of the smoothing of $a_t^{act*.}$. Let $q_{a^{act*.}}$ be a quotient, such that $q_{a^{act*.}} = \frac{\sigma^2_{\varepsilon^{a^{act*.}}}}{\sigma^2_{\varepsilon^{a^{act}}}}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable. $D_t^{act2014}$and $D_t^{act2021}$ are two dummy variables taking 1 for 2014 Q2 and for the period 2021Q3–2023Q3, respectively, and 0 otherwise.

Thus, we obtain the unobservable variables $a^{act^*}$and $a^{act^{*.}}$.

1.2.2.4 Discouraged workers

If we consider the discouraged workers effect λ via the negative impact of the unemployment rate (u_t) on the activity rate (a_t^{act}), according to the following linear equation:

$$a_t^{act} = a_t^{act.} - \lambda u_t + \varepsilon_t^{a^{act}} \quad (13)$$

λ is the opposite of the unemployment-activity rate elasticity.

$a_t^{act.}$ Is the activity rate trend.

Using the following UCM, the discouraged workers rate (the number of discouraged workers in the unemployed population divided by the total unemployed population) can be estimated by

$$\begin{cases} a_t^{act} = a_t^{act.} - \lambda u_t + \varepsilon_t^{a^{act}} \\ a_{t+1}^{act.} = a_t^{act.} + a_t^{act..} \\ a_{t+1}^{act..} = a_t^{act..} + \varepsilon_t^{a^{act..}} \end{cases} \quad (14)$$

The vectors $a_t^{act.}$ and $a_t^{act..}$ are auxiliary variables indicating capital trends and their variations (slopes). $\varepsilon_t^{a^{act}}$ and $\varepsilon_t^{a^{act..}}$are the errors in the a^{act} and $a^{act..}$ equations. $\varepsilon_t^{a^{act}}$ and $\varepsilon_t^{a^{act..}}$ represent independently distributed Gaussian error terms with mean zero and variance $\sigma^2_{\varepsilon^{a^{act}}}$ and $\sigma^2_{\varepsilon^{a^{act..}}}$ respectively. Smaller the variance $\sigma^2_{\varepsilon^{a^{act..}}}$, compared to the variance $\sigma^2_{\varepsilon^{a^{act}}}$, better the quality of the smoothing of $a_t^{act..}$. Let $q_{a^{act..}}$ be a quotient, such that $q_{a^{act..}} = \frac{\sigma^2_{\varepsilon^{a^{act..}}}}{\sigma^2_{\varepsilon^{a^{act}}}}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable.

1.2.2.5 Natural unemployment rate

This study used a non-parametric method based on the Beveridge Curve to determine the Natural Unemployment Rate. Another multivariate parametric approach based on the Phillips curve was used to demonstrate the superiority of the Beveridge curve.

a. Nonparametric approach: Beveridge curve

The prevailing theory is the search and matching paradigm, wherein employees and businesses conduct extensive searches that result in random matching. The Beveridge curve represents the model’s steady state, where inflows into unemployment generated by matching processes are balanced by outflows. The economy’s position on the curve provides insight into the labor market’s conditions. Hence, we use this method to determine and analyze the dynamics of the natural unemployment rate and its structural changes.

b. Parametric approach: Phillips curve

According to economic analyses, the estimated equilibrium unemployment rate determined by the Phillips curve may reflect the natural unemployment rate. However, this approach has recently lost prominence and has become controversial. We employ this method to compare its results with the nonparametric approach.

Our Phillips Curve accounts for long-term demand shocks by introducing the differential of unemployment with respect to the modeled equilibrium unemployment $(u_{t-1} - u^*_{t-1})$, as an unobservable state variable one quarter before, and short-term supply shocks by introducing the dinar exchange rate against the major currencies $(NEER_{t-1})$, one quarter before, and the Brent Crude Oil Price $(BRENT_t)$ in the same quarter.

$$\begin{cases} \Delta p^C_t = \beta_1 \Delta p^C_{t-1} + \beta_2 \Delta p^C_{t-2} + \beta_3 \Delta p^C_{t-3} + (1 - \beta_1 - \beta_2 - \beta_3)\Delta p^C_{t-4} \\ -\beta_4(u_{t-1} - u^*_{t-1}) + \beta_5 \Delta NEER_{t-1} + \beta_6 \Delta BRENT_t + \varepsilon^{\Delta p^c}_t \\ u^*_{t+1} = u^*_t + u^{*\cdot}_t \\ u^{*\cdot}_{t+1} = u^{*\cdot}_t + \varepsilon^{u^{*\cdot}}_t \end{cases}$$

The vectors u^*_t and $u^{*\cdot}_t$ are auxiliary variables that indicate capital trend and its variation. $\varepsilon^{\Delta p^c}_t$ and $\varepsilon^{u^{*\cdot}}_t$ are the errors in the Δp^C_t and $u^{*\cdot}$ equations. ε^k_t and $\varepsilon^{k^{*\cdot}}_t$ represent independently distributed Gaussian error terms with mean zero and variance $\sigma^2_{\varepsilon^{\Delta p^c}_t}$ and $\sigma^2_{\varepsilon^{u^{*\cdot}}}$ respectively. Smaller the variance $\sigma^2_{\varepsilon^{u^{*\cdot}}}$, compared to the variance $\sigma^2_{\varepsilon^{\Delta p^c}_t}$, better the quality of the smoothing of $u^{*\cdot}_t$. Let $q_{u^{*\cdot}}$ be a quotient such that $q_{u^{*\cdot}} = \frac{\sigma^2_{\varepsilon^{u^{*\cdot}}}}{\sigma^2_{\varepsilon^{\Delta p^c}_t}}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable.

Thus, we obtain the unobservable variables u^*_t and $u^{*\cdot}_t$.

1.2.2.2 Number of hours worked trend

Considering one worker from the Tunisian employed population, we designed h_t as the number of hours worked by the worker during a quarter. The number of hours worked, h^*_t is an unobservable factor estimated with the following UCM:

$$\begin{cases} h_t = h^*_t + \varepsilon^h_t \\ h^*_{t+1} = h^*_t + h^{*\cdot}_t \\ h^{*\cdot}_{t+1} = h^{*\cdot}_t + \varepsilon^{h^{*\cdot}}_t \end{cases} \qquad (15)$$

The vectors h^*_t and $h^{*\cdot}_t$ are auxiliary variables that indicate hours trend and its variation. ε^h_t and $\varepsilon^{h^{*\cdot}}_t$ are the errors in the h and $h^{*\cdot}$ equations. ε^h_t and $\varepsilon^{h^{*\cdot}}_t$ represent independently distributed Gaussian error terms with mean zero and variance $\sigma^2_{\varepsilon^h}$ and $\sigma^2_{\varepsilon^{h^{*\cdot}}}$ respectively. Smaller the variance $\sigma^2_{\varepsilon^{h^{*\cdot}}}$, compared to the variance $\sigma^2_{\varepsilon^h}$, better the quality of the smoothing of $h^{*\cdot}$. Let $q_{h^{*\cdot}}$ be a quotient such that $q_{h^{*\cdot}} = \frac{\sigma^2_{\varepsilon^{h^{*\cdot}}}}{\sigma^2_{\varepsilon^h}} \frac{\sigma^2_{\varepsilon^{h^{*\cdot}}}}{\sigma^2_{\varepsilon^h}}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable.

Thus, we obtain the unobservable variables h^*_t and $h^{*\cdot}_t$.

1.2.2.3 Labor force trend

a- working population trend

Working population n_t is derived from Equation (3) through a logarithmic transformation as follows:

$$n_t = p_t^{age*} + a_t^{act} - u_t$$

Using this formula, n_t^*; the tendency of the working population (which is referred to as the number of active and non-unemployed people).

$$n_t^* = p_t^{age*} + a_t^{act*} - u_t^*$$

b- Hours worked trend

The linear version of Formula (2) was used to calculate the logarithmic labor force trend, l_t^*:

$$l_t^* = n_t^* + h_t^*$$

The multiplicative equation provides the relationship between the labor force trend and the total number of hours worked by the employed population during a quarter:

$$L_t^* = N_t^* H_t^*$$

1.2.2.4 Labor force productivity trend

Almost all economists label potential output per worker or potential output per hour as productivity (trend). Increases in potential output per worker or per hour are labeled productivity growth (trend).

$$L_{p_t}^* = \frac{Y_t^*}{L_t^*}$$

We conclude with three potential ways to increase productivity by replacing Y_t^* with its expression concerning the Cobb-Douglas function:

- Improving the efficiency trend with which the inputs are used.
- Increase in capital trend per worker or per hour.
- Increase in the number of workers or hours.

a- Labor productivity trend by employees

Calculating the labor productivity trend involves comparing a given potential production and the quantity of labor trends necessary for this potential production. This was calculated using the following formula:

$$L_{p_t}^* = \frac{Y_t^*}{N_t^*}$$

b- Labor productivity per hour of working time

The above measure excludes the labor duration trend, which is contingent on workers' performance and length of time. Consequently, it is necessary to calculate hourly labor productivity (trend).

$$L_{p_t}^* = \frac{Y_t^*}{N_t^* H_t^*}$$

1.2.3 Total productivity factor trend

Data on TFP G are unavailable. This variable is calculated by subtracting the contributions of capital and labor components from total production in logarithmic terms, according to equation (5).

$$g_t = y_t - (1-\alpha)k_t - \alpha(p_t^{tot} + a_t^{act}\, u_t + h_t)$$

The potential productivity g_t^* is modeled according to the following unobservable component model:

$$\begin{cases} g_t = g_t^* + \varepsilon_t^g \\ g_{t+1}^* = g_t^* + g_t^{*\cdot} \\ g_{t+1}^{*\cdot} = g_t^{*\cdot} + \varepsilon_t^{g^{*\cdot}} \end{cases} \quad (16)$$

The vectors g_t^* and $g_t^{*\cdot}$ are auxiliary variables that indicate capital trend and its variation. ε_t^g and $\varepsilon_t^{g^{*\cdot}}$ are the errors in the g and $g^{*\cdot}$ equations. ε_t^g and $\varepsilon_t^{g^{*\cdot}}$ represent independently distributed Gaussian error terms with mean zero and variance $\sigma_{\varepsilon g}^2$ and $\sigma_{\varepsilon g^{*\cdot}}^2$ respectively. Smaller the variance $\sigma_{\varepsilon g^{*\cdot}}^2$, compared to the variance $\sigma_{\varepsilon g}^2$, better the quality of the smoothing of $g^{*\cdot}$. Let $q_{g^{*\cdot}}$ be a quotient such that $q_{g^{*\cdot}} = \frac{\sigma_{\varepsilon g^{*\cdot}}^2}{\sigma_{\varepsilon g}^2}$. This quotient was set to be sufficiently small to preserve the smoothing of each variable.

Thus, we obtain the unobservable variables g_t^* and $g_t^{*\cdot}$.

1.2.4 Potential output and output gap

1.2.4.1 Potential output

Knowing g_t^*, k_t^*, a_t^{act*}, h_t^* and u_t^* we obtain y_t^* by applying equation (5).

$$y_t^* = g_t^* + (1-\alpha)k_t^* + \alpha\left(p_t^{age} + a_t^{act*} - u_t^* + h_t^*\right) \quad (17)$$

1.2.4.2 determinants of growth

The growth rate of Y_t is denoted as V_t^{Y}. This can be defined as $V_t^{\mathrm{Y}} = \frac{1}{Y_t}\frac{dY_t}{dt}$. We can characterize as a function of V_t^{Y} the growth rates of labor, capital, and technology by differencing production function with respect to time. The product rule of differentiation implies the following.

$$\begin{aligned} \frac{Y_t}{dt} &= \frac{dG_t L_t^\alpha K_t^{1-\alpha}}{dt} \\ &= L_t^\alpha K_t^{1-\alpha}\frac{G_t}{dt} + G_t K_t^{1-\alpha}\frac{dL_t^\alpha}{dt} + G_t L_t^\alpha \frac{dK_t^{1-\alpha}}{dt} \\ &= L_t^\alpha K_t^{1-\alpha}\frac{G_t}{dt} + \alpha G_t L_t^{1-\alpha} K_t^{1-\alpha}\frac{dL_t}{dt} + (1-\alpha)G_t L_t^\alpha K_t^{-\alpha}\frac{dK_t}{dt} \end{aligned}$$

Dividing by $G_t L_t^\alpha K_t^{1-\alpha}$; this equation becomes:

$$V_t^Y = V_t^G + \alpha V_t^L + (1-\alpha)V_t^K \quad (18)$$

The growth rate of output equals the growth rate of technology term plus a weighted average of capital growth and labor growth, where the weight is determined by the parameter α.

The growth rate of the potential output was calculated similarly. It is the average of capital trend growth and labor trend growth, where the weight is determined by the parameter α.

$$V_t^{Y*} = V_t^{G*} + \alpha V_t^{L*} + (1-\alpha)V_t^{K*} \quad (19)$$

We can calculate the GDP, labor, and capital. The TFP G_t is not directly observable. If we determine the value of α, we could figure out the growth rate of G_t by considering it as Solow residual (Solow, 1957). Robert Solow considered α as the share of GDP paid to workers and capital.

$$V_t^{G} = V_t^{Y} - \alpha V_t^{L} - (1-\alpha)V_t^{K} \quad (20)$$

V_t^{G*} is obtained by the same way of equation (20):

$$V_t^{G*} = V_t^{Y*} - \alpha V_t^{L*} - (1-\alpha)V_t^{K*} \quad (21)$$

1.2.4.3 Output gap

The output gap is the differential between actual output (Y_t) and potential output Y_t^* as follows: obtained from the following equation:

$$output\ gap_t = (Y - Y_t^*)/Y_t^*$$

Assuming ln $(1 + z_t) \approx\ z_t$ if z is close to zero, the above equation will be written as $1 +\ gap_t = Y_t/Y_t^*$ and taking the logarithm of both sides of the equation provides the following relationship:

$$output\ gap_t = y_t - y_t^*$$

Where x= ln X; hereinafter, it is the same.

Note that $y_t$and y_t^*obtained from the linear version of the Cobb-Douglas equation can be written as follows:

$$y_t = g_t + (1-\alpha)k_t + \alpha l_t \quad (22)$$

$$y_t{}^* = g_t^* + (1-\alpha)k_t{}^* + \alpha l_t^* \quad (23)$$

By subtracting the equation (22) from (21), we obtain:

$$y_t - y_t{}^* = (g_t - g_t^*) + (1-\alpha)(k_t - k_t{}^*) + \alpha(l_t - l_t^*) \quad (24)$$

Where $g_t - g_t^*$ is the TFP noise, including measurement errors. The replacement of l_t with its components yields the following equation, which is useful for calculating a more detailed output gap decomposition.

$$y_t - y_t{}^* = (g_t - g_t^*) + (1-\alpha)(k_t - k_t{}^*) + \alpha\left(\left(p_t^{age} - p_t^{age*}\right) + \left(a_t^{act} - a_t^{act*}\right) - (u_t - u_t{}^*) + (h_t - h_t{}^*)\right) \quad (25)$$

1.2.5 Uncertainties and structural changes

Discussions on GDP fluctuations have evolved into more insightful and impartial discussions. The potential for variations and interruptions in the GDP relief trend renders the computation of the economy’s underlying trends insufficient. Discussions contend on the identification, econometric, and economic explanations of changes in GDP and their potential, with varying theories and conclusions. Initially, the “segmented” trend technique helped analyze variations and provided information on breaks. Econometric analysis of nonstationary variables suggests using a stochastic trend to model GDP trends. However, this approach relies on an econometric model that assumes a deterministic trend. Furthermore, the break tests analysts use to determine the various variations are based on temporal intervals purportedly known beforehand by point identification. The selection and number of breakpoints are determined beforehand, and these choices can vary depending on the analysts’ backgrounds, perspectives, and political inclinations. Various available options may produce distinct results. According to Doz, Raboult, and Sobczak (1995), this approach has been criticized for other reasons.

Econometric analysis of structural changes can answer queries regarding the existence, number, and timing of potential ruptures. The segmented trend filtering approach is enhanced by employing contemporary break tests that do not require prior knowledge of the number and dates of these breaks. It enables the estimation of potential GDP, identification of its variations, and detection of trend break dates and their frequency. Consequently, we can analyze the impact of significant shocks and crises on the level and trajectory of Tunisia’s potential output regarding the break dates and structural changes.

1.2.6 Limitations of the study

The method does not incorporate multivariate UCMs that consider a comprehensive specification for the TFP. Explanatory variables such as R&D efforts, speed of adoption of inventions, and creative destruction are important and may improve the study (Fernald (2014); Anzoategui, Comin, Gertler, and Martinez (2016)). Schmöller and Spitzer (2018) find that the decrease in R&D intensity explains the TFP slowdown that started in the early 2000s.

The study lacks a sectoral focus and perspective that are crucial for analyzing how shocks affect potential growth and the output gap per sector. Without desagregation at the sectoral level, the shocks' channels of transmission between sectors remain unknown.

The process of converting capital data into a quarterly series leads to uncertainty concerning the accuracy of the data.

The primary limitation of the model is the "endpoint" problem, which creates a considerable ambiguity around trend and cycle levels. This kind of uncertainty poses a significant disadvantage to policymakers, as their primary concern is the current estimate of the output gap.

It's also unclear how structural change will be determined. Economic, security, pandemic, and socio-political shocks are a few that are already well-known. Even with statistical analysis, it is incredibly challenging to detect others. There is disagreement over the coherence of shocks' existence, number, magnitude, and duration.

Section 2: Data and estimation results

2.1 Data

We used quarterly data ranging from 1990Q1 to 2023Q3. The statistics were obtained from the National Institute of Statistics (INS), the Central Bank of Tunisia, and World Development Indicators (World Bank). The seasonally adjusted real GDP is provided by the INS. We seasonally adjusted for other time series. Capital stock and number of hours are yearly data. The price indices were based on a base of 100 for 2010. These data were transformed into a quarterly time series.

Capital stock is substantially correlated with investments. These two series of movements are similar. Investments may be an excellent indicator of capital stock. Both the Denton and Chow-Lin methods generated series approximate to the natural series. The same approach was employed to transform the number of hours into a quarterly time series with the working population as an indicator.

The following time series are gathered for this study: Real GDP base 2010 seasonally adjusted, Capital Stock, Employment, Population over 15 years old, Unemployment, Active Population, Nominal Effective Exchange Rate, Brent Oil Prices in US Dollars, Consumer Price Index Base 2010, and Import Price Index, Base 2010.

We constructed the number of hours using monthly, quarterly, and yearly time-series data. These data were collected from TSI publications: the 2014 General Population and Housing Census, Business Employment and Salary Surveys, National Population and Employment Surveys, Tunisia's statistical yearbooks, and Tunisia's employment and unemployment indicators. The series is as follows:

- Number of working people who are self-employed, employees, receive family support or are undeclared.
- Number of people employed in each sector (agriculture, fishing, manufacturing, and services).
- Number of people working in formal and informal jobs.
- Number of people working in stated and undeclared jobs.
- The proportion of the working population that is overworked, has a full-time job and is under-employed.
- Net job creation
- Job applications, labor applications, and job offers. These series were categorized as follows: gender, satisfied, dissatisfied, and unsatisfied with the first job.
- Unemployment rates. These series were categorized by gender and level of study (higher degree, secondary, basic, and without level).

The TSI survey provides the number of people who worked specific days during the previous year. The number of days is distributed as follows: [1–30; 31–60; 61–90; 91–180; 181–270; 271–365].

The survey also provided information about the activity sector (agriculture, manufacturing, non-manufacturing, and services), gender (male or female), communal or non-communal membership, and regional membership (Great Tunis region, North-Est, North-West, Center-Est, Center-West, South-Est, South-west). The survey results cover 2010, 2011, and 2014.

For the years 1989–2009, we respected the distribution of the employed labor force given by the 2010 survey (by interval of number of hours worked, sector etc.) and applied it to the available distribution of the real employed labor force for each year.

For 2012, 2013, and 2014, we followed the same strategy, using the 2014 survey distribution. The hours worked have a persistent behavior.

2.2 Estimation results

We present the estimation results of the models below, which are backward-looking unobserved component models with a state-space form and Kalman filter decomposition.

We used the Cobb-Douglas function, as previously presented. Productivity is determined from the Solow residual (Solow, 1956), which explains technical progress and elements not captured by Capital and Labor. The capital trend is specified from national accounts, whereas the labor trend is measured by the number of hours worked per quarter by the employed population by estimating its components, working-age population, natural unemployment rate, number of working hours, and activity rate.

The potential GDP was obtained by integrating the estimated production factors into the production function to calculate the growth in potential GDP and the output gap and the contribution of factors to both potential growth and the output gap. Once the structural breaks were detected, a period-by-period analysis was performed.

2.2.1 Capital

First, we estimated the capital trends over the entire study period (1989Q1–2023Q4). The results of this estimation are econometrically robust but do not consider structural breaks. An estimation by period can address this limitation. For each period, estimation was performed for data from 1989Q1 to the end of that period.

The capital series analysis shows two breaks, 2002Q1 and 2011Q1, noting that the COVID-19 shock in 2020 was not significant as a structural break for capital. This allowed us to divide the overall period studied into three sub-periods: 1989Q1–2001Q4, 2002Q1– 2010Q4, and 2011Q1–2023Q4.

Table 1 shows the estimated results by sub-period.

Table 1: Estimation results of Capital models

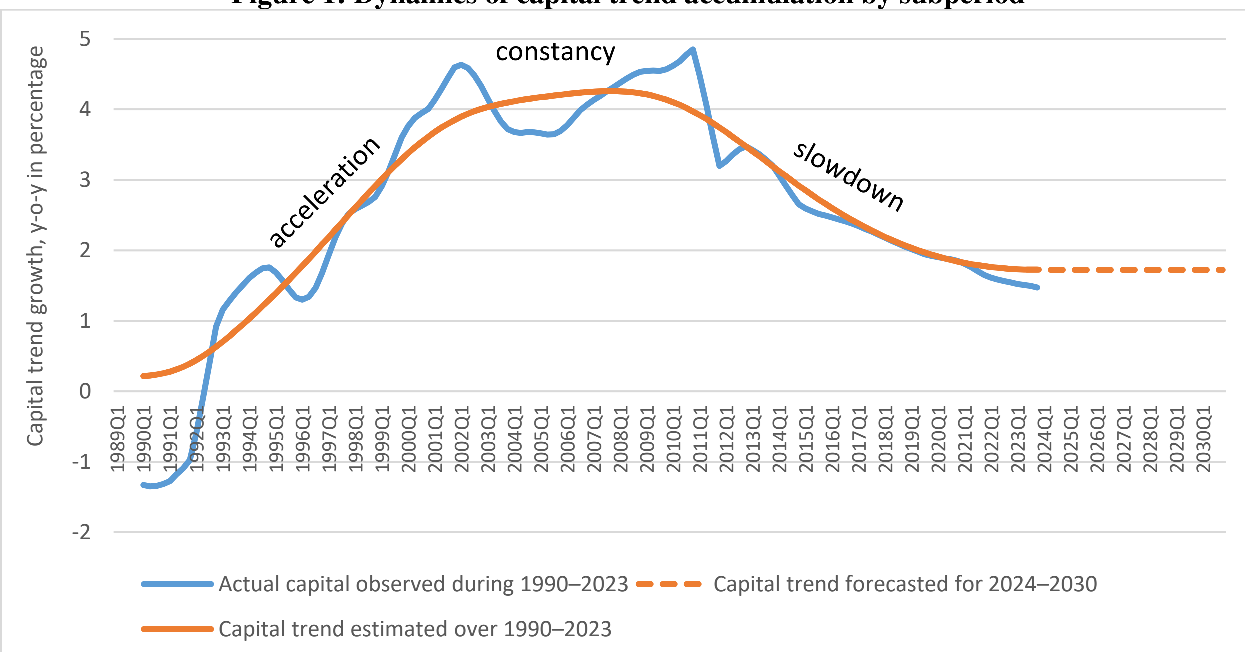
Variables	Parameters	1989Q1–2001Q4	2002Q1–2010Q4	2011Q1–2023Q4
Dependent variable : k				
ε_t^k	$\sigma^2_{\varepsilon^k}$	0.39 (-20.6)	0.21 (-40.3)	0.16 (52.3)
$\varepsilon_t^{k^{*\cdot}}$	$q_{k^{*\cdot}}$	1/7000	1/7000	1/7000

* The figures in parentheses represent the Z-statistics of the estimated parameters.

We obtain the capital trends for each period. The capital trend over the entire period is obtained by aggregating the capital trend series by period.

Figure 1 confirms the annual increase in capital and capital trend for the subdivision of the study period into three sub-periods with diverse rates of change: the first acceleration period, the second period of stability at a high level, and the third period of slowdown.

Figure 1: Dynamics of capital trend accumulation by subperiod

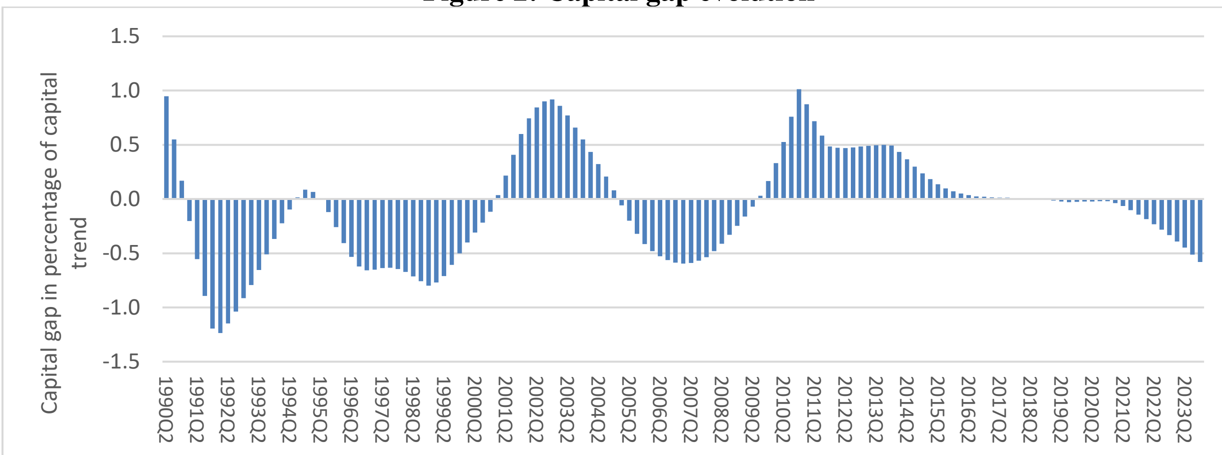


Source: INS and author calculations

Thus, during the first sub-period (1989Q1–2001Q4), capital accumulation was fairly rapid in correlation with the reforms undertaken since the 1980s. During the second period (2002Q1–2010Q4), the pace of capital accumulation stabilized at a high level. In the third period, following the shock of the revolution, the capital trend underwent a structural change with a change in level and a downward trend in growth.

Figure 2 illustrates the evolution of the capital gap.

Figure 2: Capital gap evolution



Source: INS and author calculations

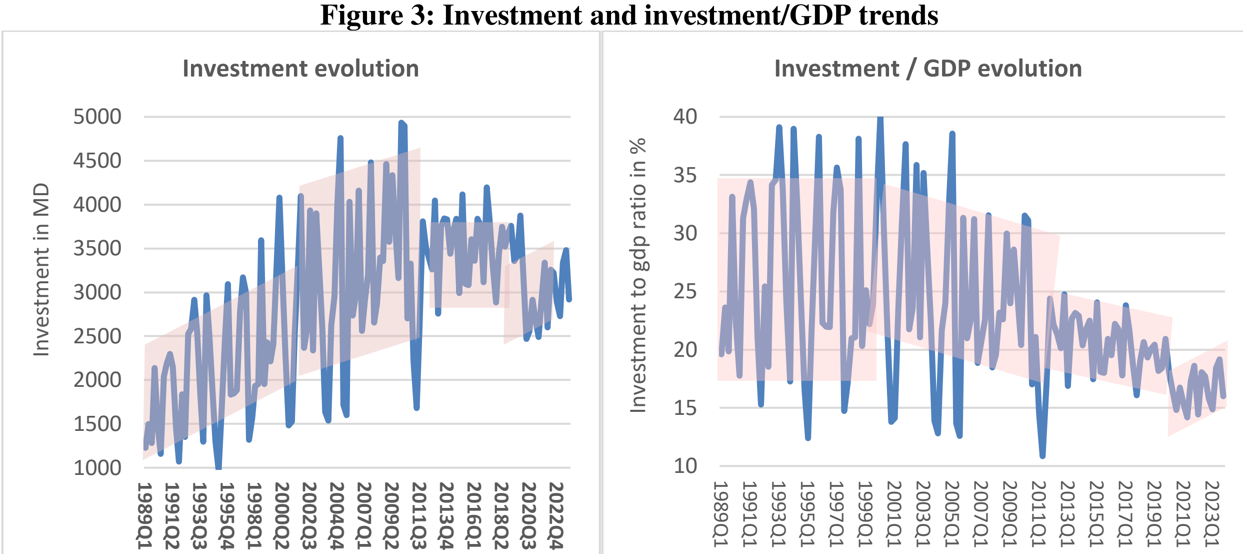
During the first sub-period (1989Q1–2001Q4), the capital gap was negative. The pace of capital accumulation helped close the gap only in 2001.

During the second sub-period (2002–2010), the capital gap remained positive until 2004, before turning negative again between 2005 and 2008.

In the third sub-period (2011–2023), the gap has continued to be positive, albeit at a slower pace, before declining significantly since the onset of COVID-19

Figure 3 confirms the seasonally adjusted investments as a percentage of the GDP for the three phases of capital accumulation.

Figure 3: Investment and investment/GDP trends

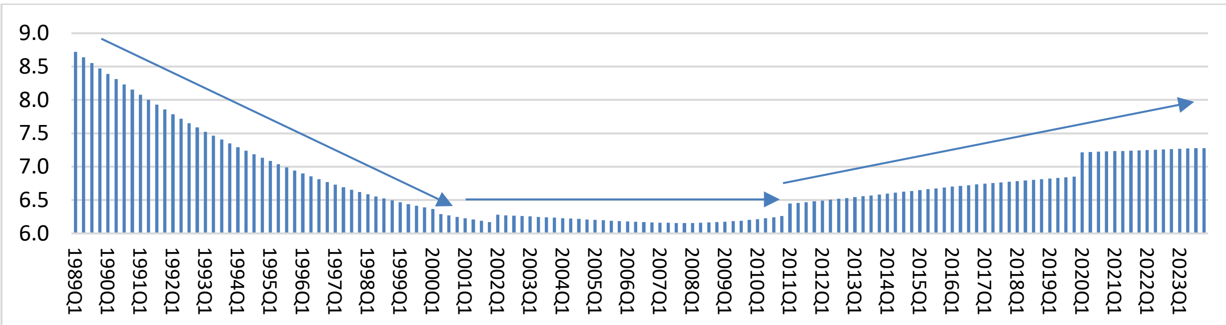


Source: INS and author calculations

The first phase of capital accumulation reflects high levels of investment as a percentage of the GDP, ranging from 12% to 40%, depending on the quarter. These levels, whose dispersion decreased during the second period, followed a downward trend, which explains the deceleration in capital accumulation. In the third period, investment rates decreased despite a slight upturn in the post-COVID-19 period, resulting in a decline in capital accumulation and potential.

The buffet indicator's[2] progress is illustrated in Figure 4. The above statistic links capital trend to potential GDP.

Figure 4: Evolution of Buffet Indicator



Source: INS and author calculations

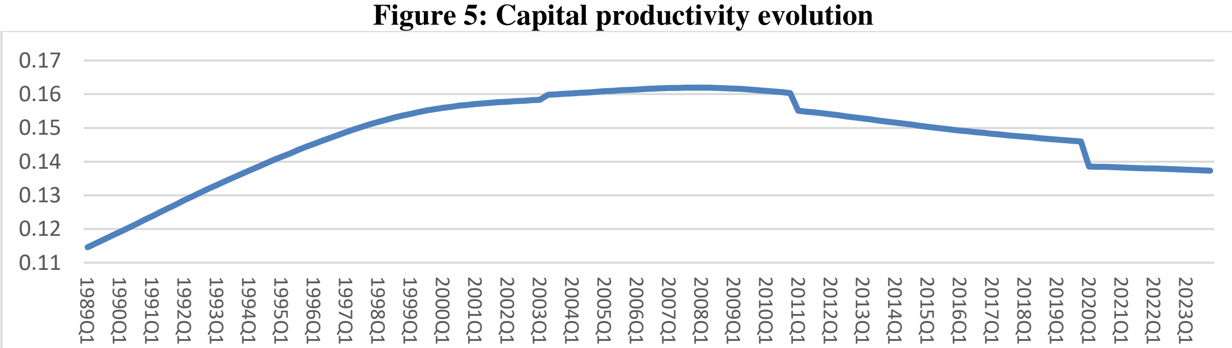
During the first sub-period, capital was at a high level of potential GDP, despite a downward trend reflecting faster growth in potential GDP.

During the second sub-period, the Buffet indicator stabilized at approximately 6.2, the lowest level, indicating a slowdown in the progression of investment over GDP.

In 2011, this indicator rose to approximately 6.8 in 2020 and 7.3 in 2023, aligning with the weakening of potential GDP, reflecting a possible decline in labor input or productivity.

The inverse of the buffet indicator, capital productivity, obtained by dividing potential output by capital trend, was on a rising path until 2003, then stabilized, and has been on a downward trend since 2011, as shown in Figure 5.

Figure 5: Capital productivity evolution



Source: INS and author calculations

[2] Buffet indicator = capital trend / potential GDP

2.2.2 Labor trend

Estimating the labor trend force using formula (2), $l_t^* = n_t^* h_t^*$ needs to define the average number of hours worked by a unique individual during a quarter (H) multiplied by the working population (N), depending on the working age population, activity rate, and unemployment rate.

2.2.2.1 Working age population trend

For the working-age population, instead of using actual data, we used the trend estimated by the UCM to correct for certain fluctuations and abnormal breaks in the series published by INS, notably between 2019Q2 and 2020Q1. Thus, the model incorporates dummy $D_t^{age2019}$ to consider the effects of the break during this period. The results of the model estimations are presented in Table 2.

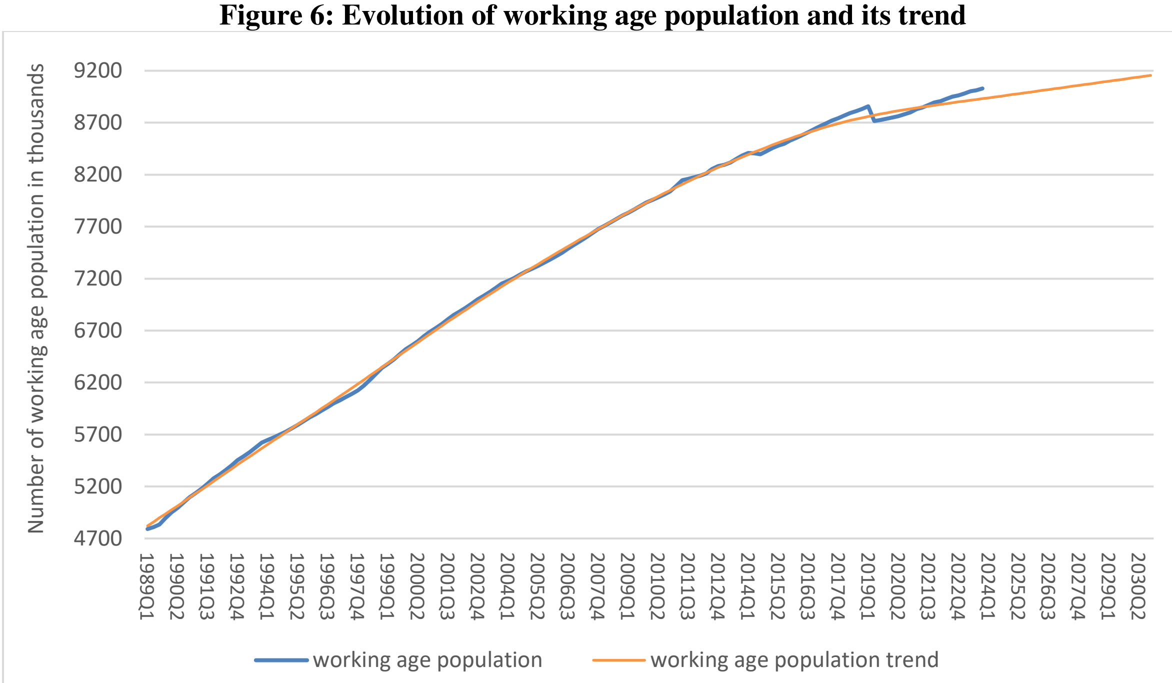
Table 2: Estimation results of working age population models

Variables	Parameters	1989Q1–2023Q4
Model: dependent variable : p^{age}		
$\varepsilon_t^{p^{age}}$	$\sigma^2_{\varepsilon^{p^{age}}}$	0.13 (-77.0)
$\varepsilon_t^{p^{age*.}}$	$q_{p^{age*.}}$	1/7000
$D_t^{age2019}$	μ	0.002 (-4.5)

* The figures in parentheses represent the Z-statistics of the estimated parameters.

Figure 6 depicts the working-age population and its trend, which has recently slowed significantly.

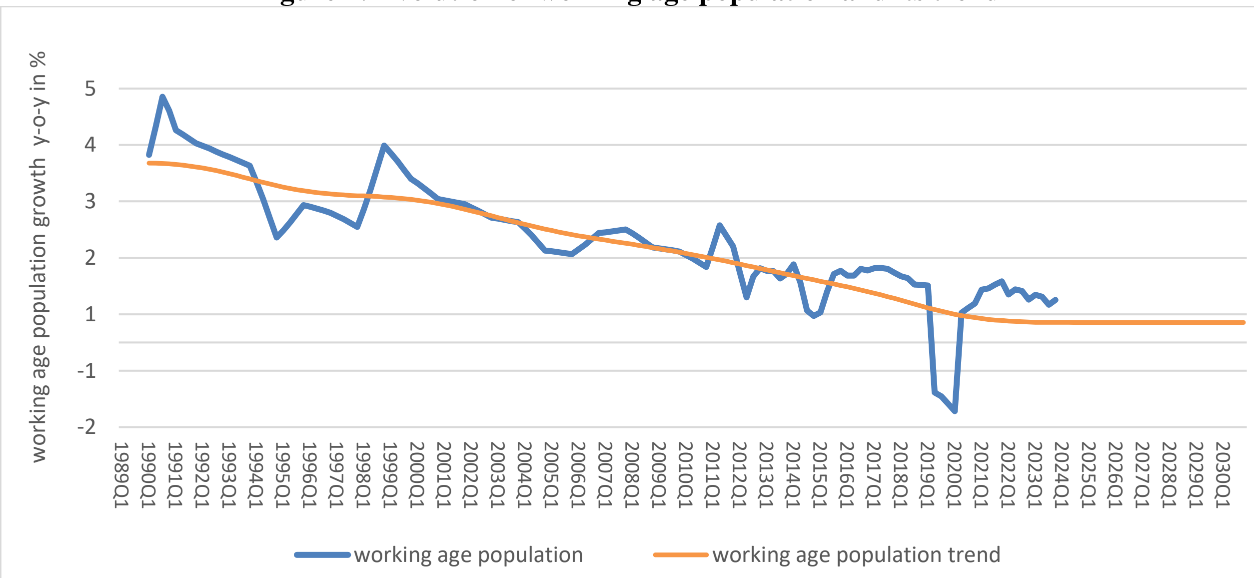
Figure 6: Evolution of working age population and its trend



Source: INS and author calculations

The downward trend in working-age population growth reflects a slowdown in the average growth and aging of the Tunisian population. The contribution of the population aged > 60 years to the total population is increasing. This age group is growing rapidly (3.6% in 2021, compared with an average growth rate of 0.5% for the total population), and this trend may continue over the next few years, as illustrated in Figure 7.

Figure 7: Evolution of working age population and its trend



Source: INS and author calculations

2.2.2.2 Activity rate

The activity rate trend estimated using the UCM incorporates one dummy variable for 2014Q2 and another for 2021Q3 to 2023Q3. The first shock had a transitional effect, and the second shock was also short-term and was not of a structural nature, as the activity rate improved following the gradual recovery post-COVID-19.

The model estimation results are summarized in Table 3.

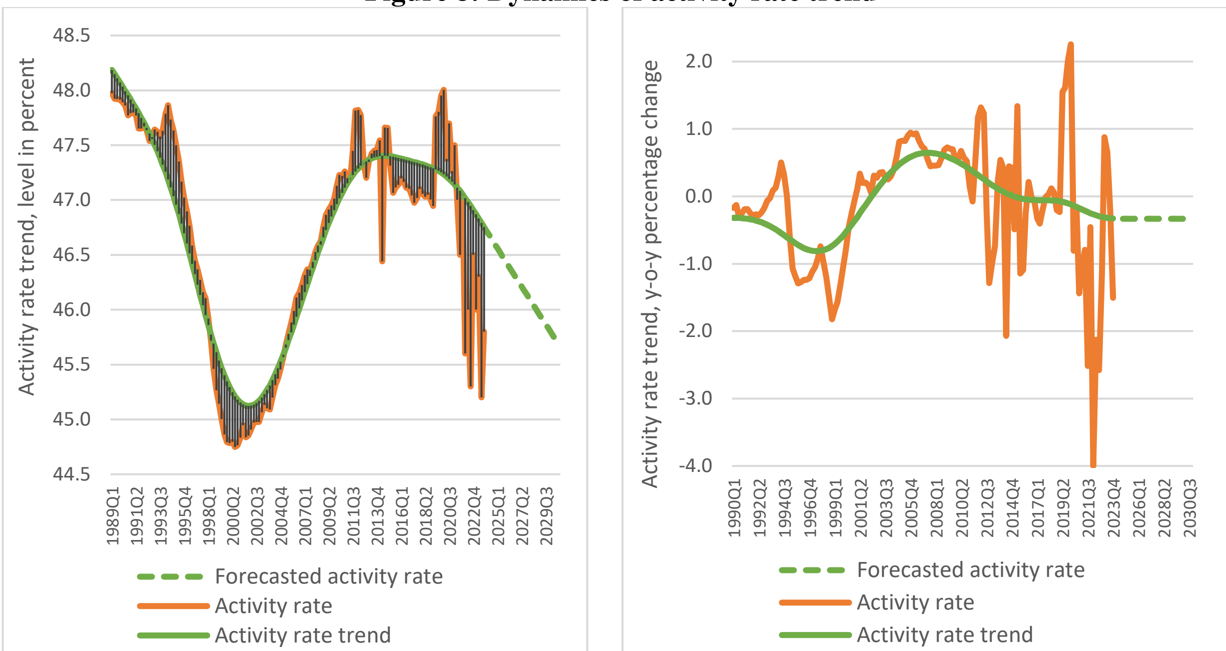
Table 3: Estimation results of working age population models

Variables	Parameters	1989Q1–2023Q4
Dependent variable a^{act*}		
$\varepsilon_t^{a^{act}}$	$\sigma^2_{\varepsilon^{a^{act}}}$	0.14 (-66.9)
$\varepsilon_t^{a^{act*.}}$	$q_{a^{act*.}}$	1/7000
Dummy 2014Q2	α	0.01 (-2.2)
Dummy 2021Q3–2023Q3	β	0.00 (-6.8)

* The figures in parentheses represent the Z-statistics of the estimated parameters.

Figure 8 shows four phases separated by three shocks: 2001–2002, the 2011 revolution 2011 and COVID-19 in 2020 for the activity rate trend dynamics. Structural disruptions were followed by changes in growth trends, with no effect on the levels.

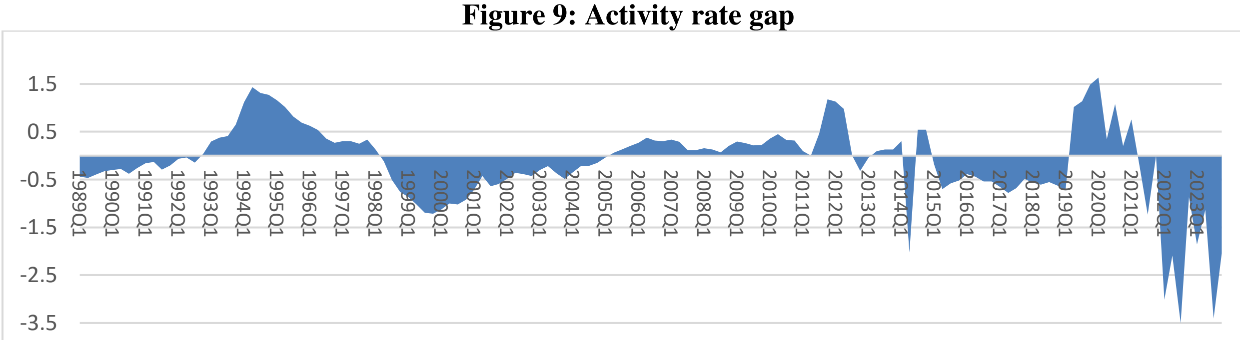
Figure 8: Dynamics of activity rate trend



Source: INS and author calculations

Moreover, the activity rate increased significantly between 2001 and 2010, following a downward trend from to 1990–2000 period. From 2011 onwards, these rates showed a slight downward trend, which became more pronounced after 2020 (Figure 9).

Figure 9: Activity rate gap



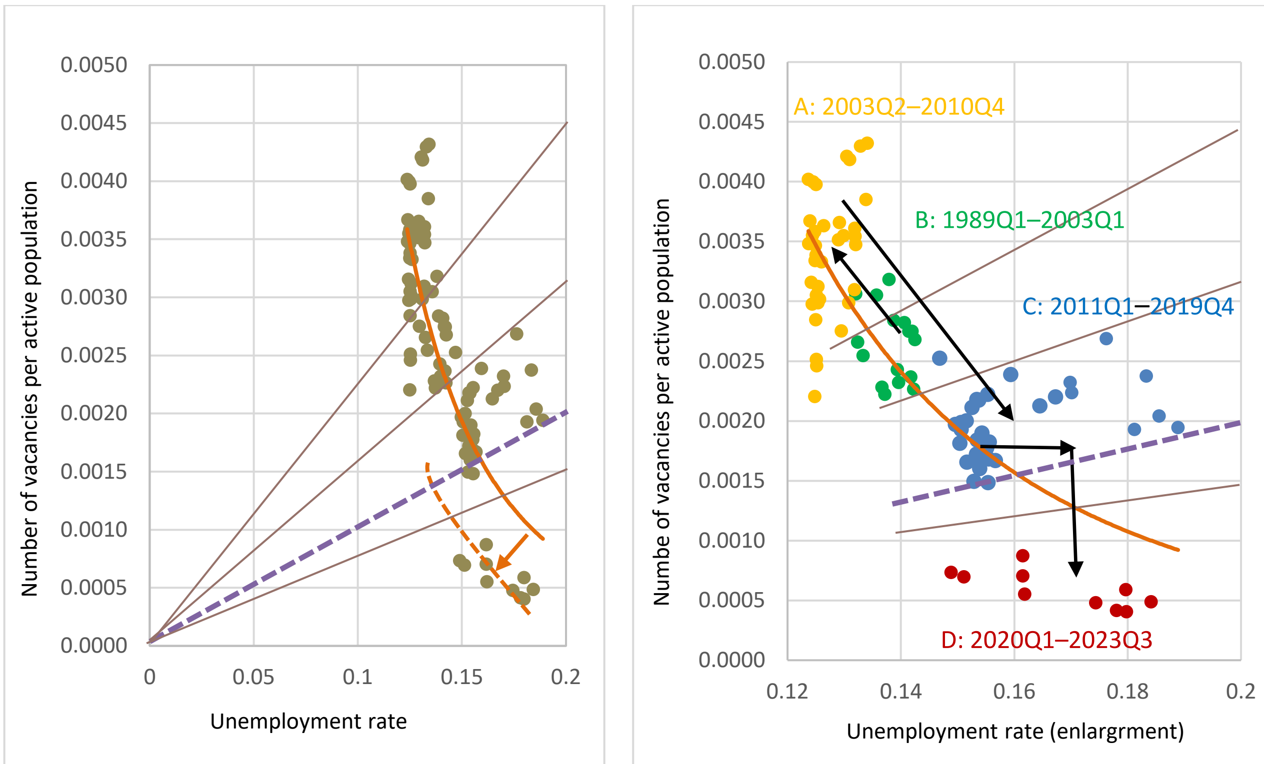
Source: INS and author calculations

The first phase was characterized by an overall positive activity rate gap, which began to weaken. During the second phase, the activity rate remained close to its potential. During the third and fourth phases, the gap was negative, except during the COVID-19 period.

2.2.2.3 Natural unemployment rate

The natural employment rate is determined using the Beveridge Curve, which matches the unemployment rate with the number of vacancies in the labor force, as shown in Figure 10.

Figure 10: Intersection of unemployment and vacancies rates



Source: INS and author calculations

Notes: The violet line represents the 45° angle bisector, and the brown line categorizes the groups.

The matching function represented by the Beveridge curve slopes downward, which is consistent with the theory. This indicates that when there are many job vacancies, unemployment should be relatively low, as unemployed individuals, even some employed workers, can fill the available positions. Conversely, when vacancies decrease, unemployment increases.

The economic situation affects its position on the Beveridge curve. The figure on the right shows the concentration of points per period. The yellow and green points toward the top left of the Beveridge curve reflect expansionary periods, where job openings are high relative to employment, as firms' demand to hire workers is crucial.

Points toward the bottom right, here in blue and red, usually reflect recessionary or recovery periods where firms are not actively hiring, and job openings are low relative to employment.

There is also a shift in the Beveridge Curve to the right, showing decreasing vacancy rates from COVID-19 while maintaining the level of unemployment at levels higher than those in the period 2011–2019. This represents a decrease in matching efficiency after COVID-19 pandemic.

The determination of the structural change in the natural unemployment rate using the Beveridge curve is based on the change in the matching function from one period to the subsequent period for unemployment and vacancy rates.

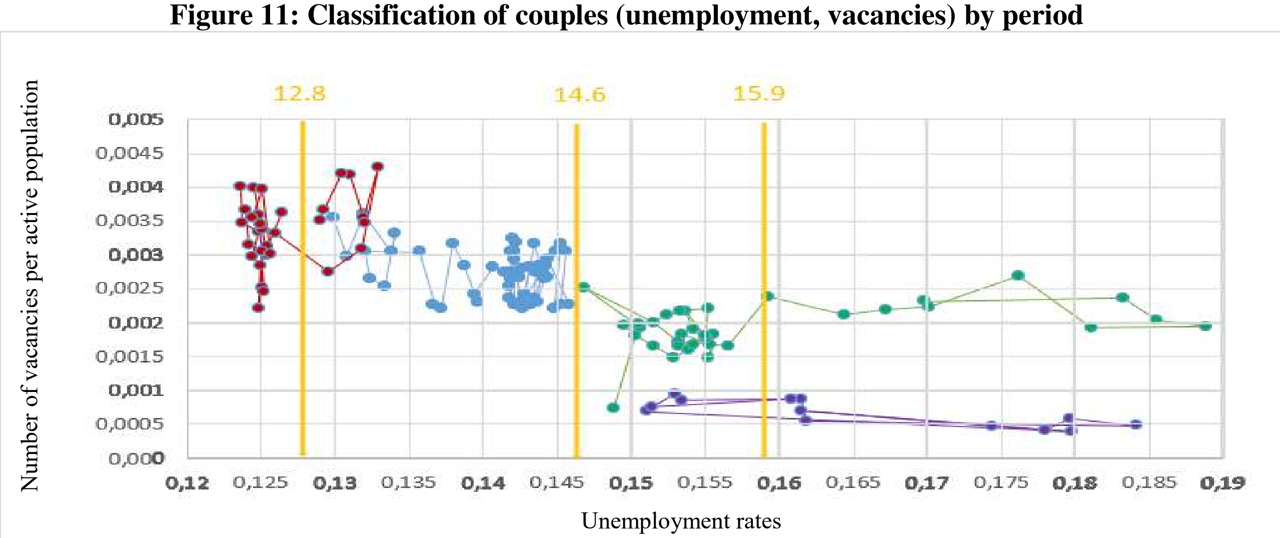
Consequently, the scatter plot in Figure 11 illustrates that the concentration of points in red is located at the top left of the Beveridge Curve, characterized by high vacancy rates varying between 0.0022 and 0.0044 and low unemployment rates between 0.124 and 0.133. The identification of these pairs shows that they relate to the period 2003–2010. The second concentration of points (blue) is characterized by falling vacancy rates in the range of 0.0022–0.0035, and rising unemployment rates between 0.13 and 0.147.

A shift between the pair (0.126; 0.0036) relating to quarter 2003Q2 belonging to the red point cloud and the pair 2003Q1 (0.1298; 0.0035) belonging to the blue point cloud was visually detectable. The unemployment rate separating the two pairs was equal to 12.8. Red points interfering with the blue points were not considered when determining the shift between the two-point clouds. These points relate to the end of the 2008Q4–2010Q4 period, whereas the points near the shift should be approximately 2003. However, they are characterized by a higher unemployment rate than the average of the red cloud.

The other shifts are determined similarly from the Beveridge curve: a shift in 2011Q1 separating the clouds of blue and green points corresponds to an unemployment rate of 14.6. A final shift in 2020Q1 separates the concentration of green points from the scattered points to the right of the Beveridge curve, which is characterized by a higher unemployment rate.

Since the onset of COVID-19, a rise in unemployment (purple points) has been accompanied by a notable decrease in vacancy rates. This exceptional increase was cyclical. The decrease in unemployment levels after COVID-19 suggests that a structural break in the natural unemployment rate is unlikely.

Figure 11: Classification of couples (unemployment, vacancies) by period



Source: INS and author calculations

The natural unemployment rate determination using the Beveridge Curve method reveals a staircase pattern that subdivides the study period into three phases separated by two shocks, as shown in Figure 12.

The first shock in 2003 was followed by a drop in the natural unemployment rate of 2% points compared to the previous period, while the second shock in 2011 resulted in a significant and rapid rise in unemployment, raising natural unemployment to a higher level of 3% points.

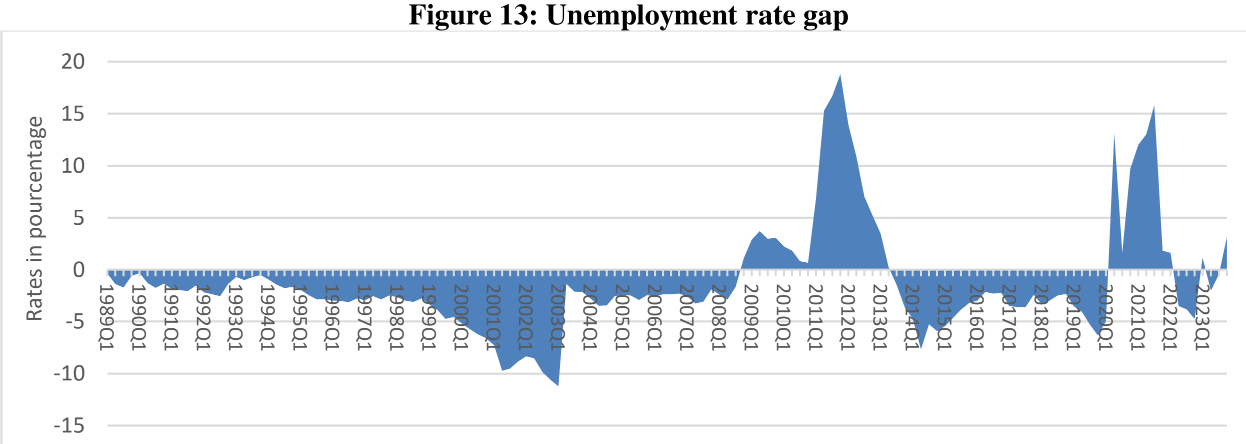
Tunisia's persistently high unemployment rate can be explained by several factors, particularly the steady increase in the active population, including higher education graduates, the mismatch between the demand for labor and the profile of labor supply, and the relative rigidity of the labor market.

Figure 12: Natural unemployment rates

Source: INS and author calculations

In recent decades, trends in the unemployment rate and the natural rate of unemployment have indicated a decline in the economy's capacity for employability and job creation, as shown in Figure 13. Consequently, the economy has not achieved optimal employment levels.

Figure 13: Unemployment rate gap



Source: INS and author calculations

From 1989 to 2002, the unemployment rate decreased and gradually deviated from its natural rate, particularly from 1995.

Discouraged Workers Rates

From 2003 to 2010, the unemployment rate returned to a level approximate to that of full employment. Over the last period, the sharp rise in the unemployment rate resulted in a negative unemployment gap, other than the period of the revolution (2011–2012) and the COVID-19 (2020–2021), when unemployment levels far exceeded their natural level.

As the participation and unemployment rate series are not linear, we estimate the equation (equation number) over intervals wherein these two series do not show any structural changes, as shown in Table 4. The dates of the previously studied structural changes were 2003Q3 and 2011Q1.

The following table shows the estimation results for the first period:

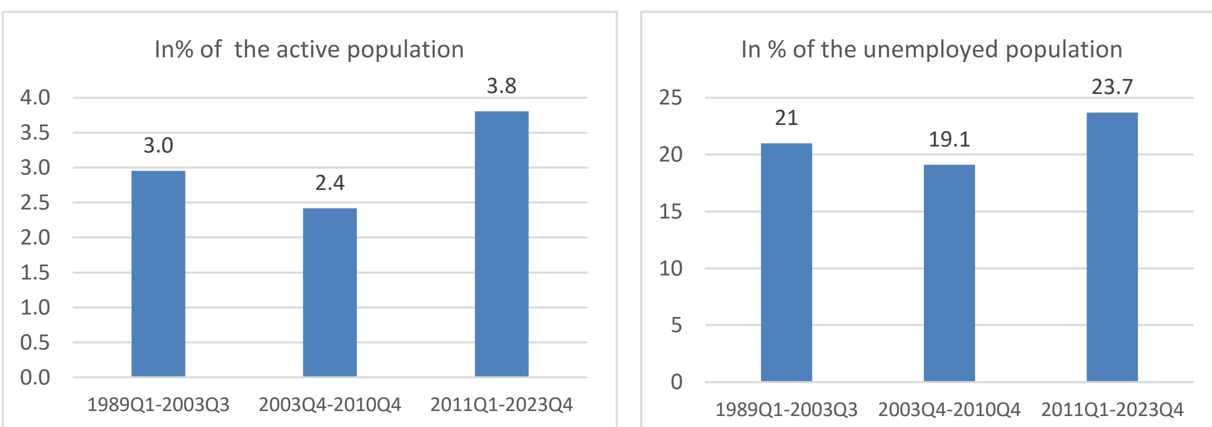
Table 4: Estimation results of discouraged workers population models

Variables	Parameters	1989Q1–2003Q3
Dependent variable : a^{act*}		
$\varepsilon_t^{\mathrm{d}}$	$\sigma^2_{\varepsilon^{\mathrm{d}}}$	0.26 (-37.82)
$\varepsilon_t^{d^{\cdot\cdot}}$	$q_{d^{\cdot\cdot}}$	1/7000

* The figures in parentheses represent the Z-statistics of the estimated parameters.

The estimation results over the period 1989Q1–2003Q3 show a rate of discouraged workers among the unemployed population of 21%.

Figure 14: Discouraged workers' rate



Source: INS and author calculations

The same estimates for the periods 2003Q4–2010Q4 and 2011Q–2023Q4 show percentages of 19.1% and 23.7%, respectively (Figure 14). As a proportion of the active population, discouraged workers' rates declined from 3% to 2.4% before rising to 3.8% in 2011.

2.2.2.4 Working hours per worker trend

The standard measure of labor input in national accounts is total hours worked. However, accurately measuring this has proven challenging owing to the growing importance of the service sector, the increase in self-employment, and the emergence of several new, and frequently irregular working patterns. Their inclusion in the production function (PF) approach was delayed owing to these measurement difficulties. Despite these issues, working hours were calculated using different national and international databases, primarily INS labor surveys.

The observation of trends in the number of hours per worker showed a structural change, mainly in level, following the 2011 shock, which divided the period into two phases. However, no structural changes were observed after the 2002 and 2020 shocks. The impact of the 2002 shock was negligible, and the effect of the 2020 shock, which resulted in abnormally meagre work hours, was linked to the economic outlook caused by the COVID-19 pandemic. The levels of hours worked before and after the COVID-19 shock changed but are considered the same because of their economic outlook and progressive increase.

The trend in the number of hours was estimated separately for each period, and the results are summarized in Table 5.

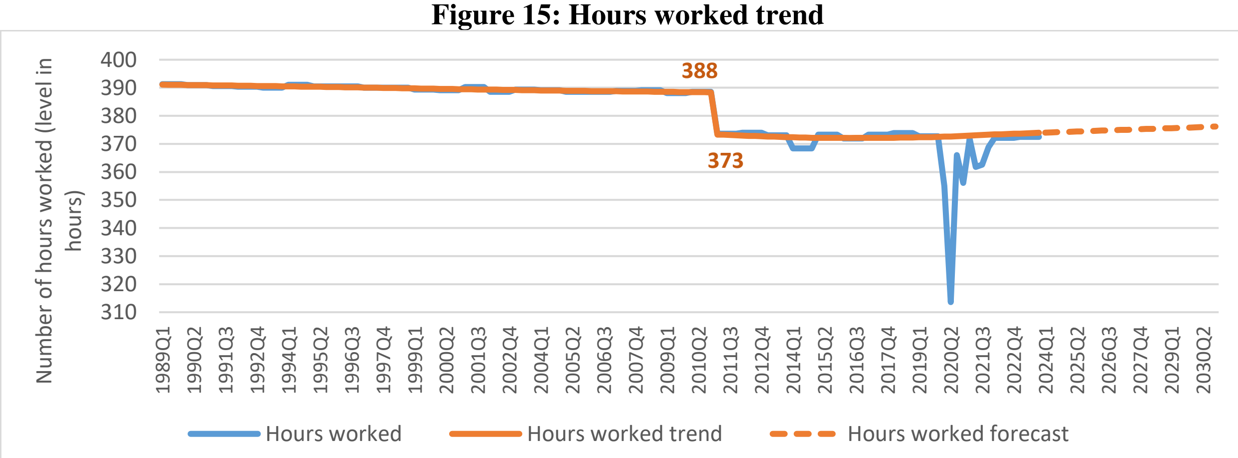
Table 5: Estimation results of number of hours worked models

Variables	Parameters	1989Q1–2010Q4	2011Q1–2019Q4
Model: State variable: h_t^*			
ε_t^h: level errors	$\sigma^2_{\varepsilon^h}$	0.13 (-105.2)	0.21 (-51.3)
$\varepsilon_t^{h^*}$: slope errors	q_{h^*}	1/7000	1/7000

* The figures in parentheses represent the Z-statistics of the estimated parameters.

Since the revolution, the number of hours decreased by 15 per quarter, approximately 4% of the potential before the shock. However, only slight improvements were observed, as shown in Figure 15.

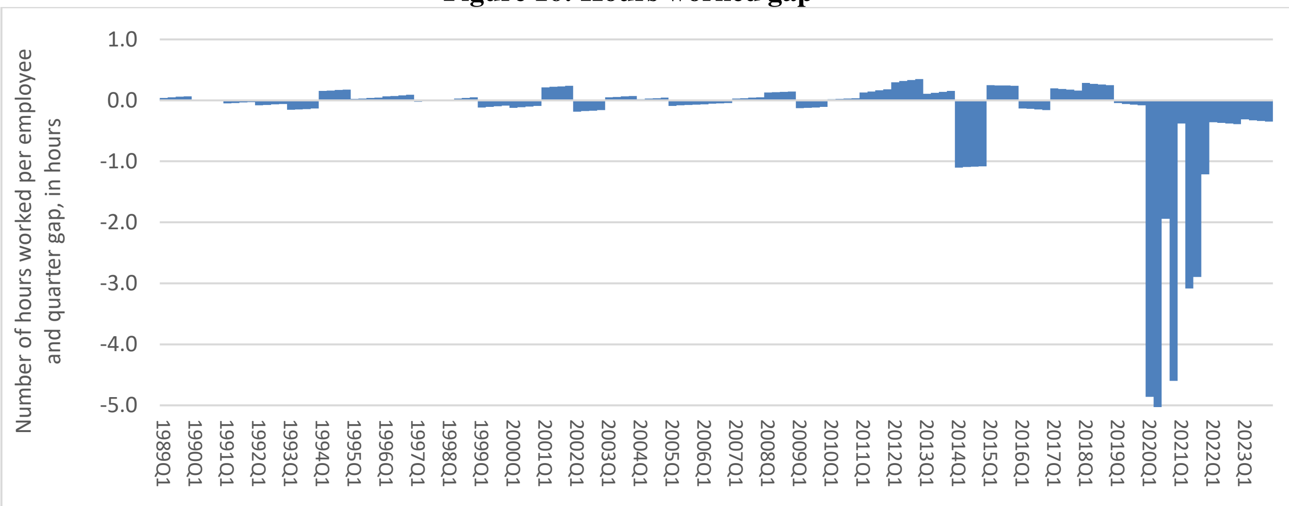
Figure 15: Hours worked trend



Source: INS's labor surveys, national and international data bases, and author calculations

The number of hours worked was typically approximate to their potential, except for the COVID-19 period, particularly 2020Q2, when they lost 16% of their potential because of the economic downturn during this period.

Figure 16: Hours worked gap



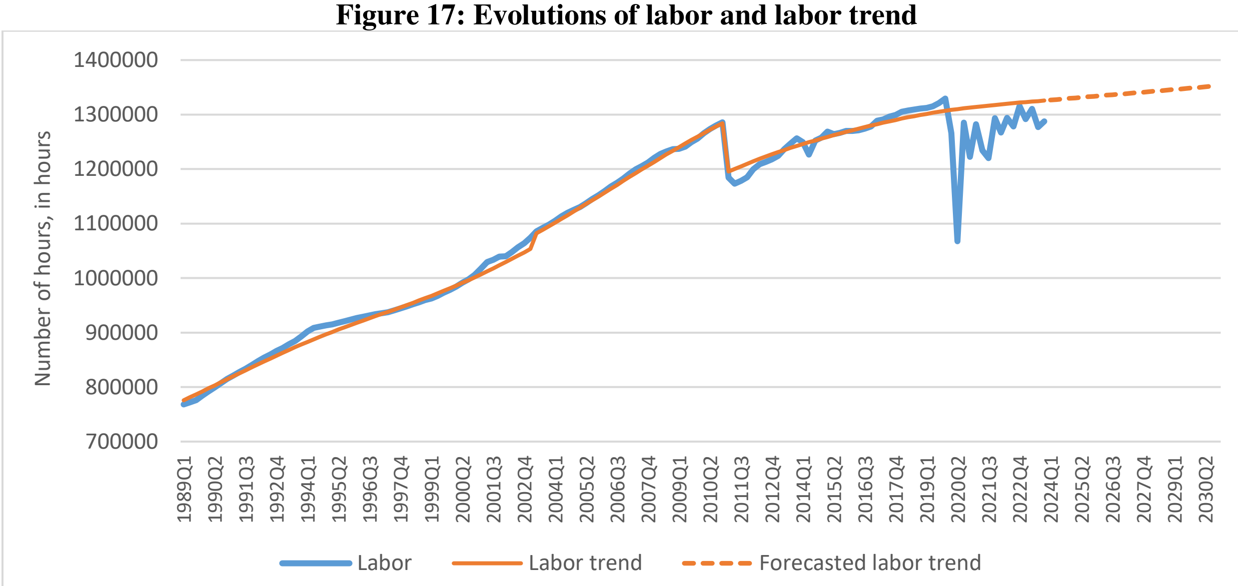
Source: INS's labor surveys, national and international data bases and author calculations

2.2.2.5 Labor estimation

The estimates of the various components helped deduce the trend using the following equation:

$$l_t = p_t^{tot} + a_t^{act} - u_t + h_t$$

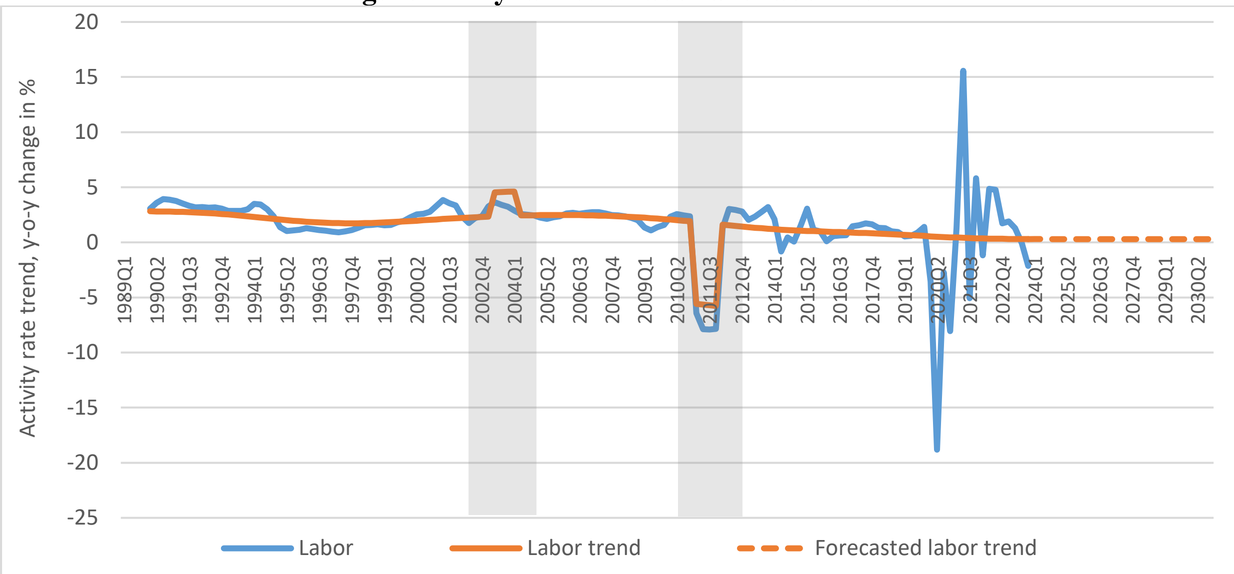
Figure 17: Evolutions of labor and labor trend



Source: INS and author calculations

Figure 17 shows the presence of two structural breaks in 2003Q2 and 2011Q1.

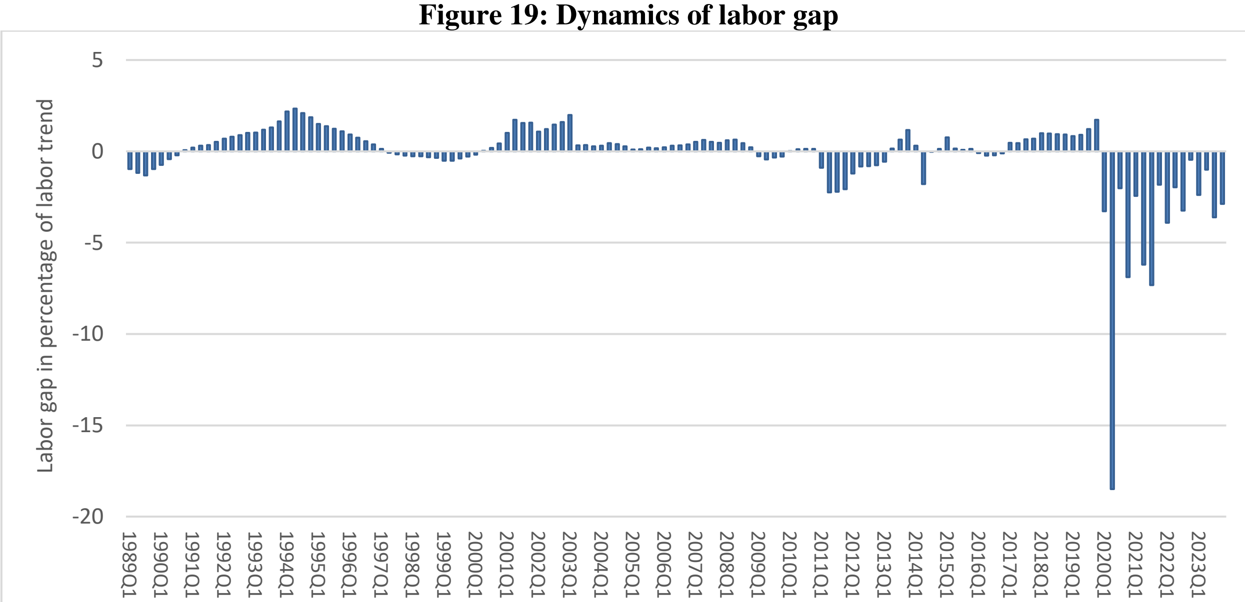
Figure 18: Dynamics of labor and labor trend



Source: INS and author calculations

After a downward trend since 1990, the dynamics of potential employment remained stable between 2000 and 2010 before slowing down in 2011, with the rate of change becoming virtually stable at approximately to 0%, as shown in Figure 18.

Figure 19: Dynamics of labor gap



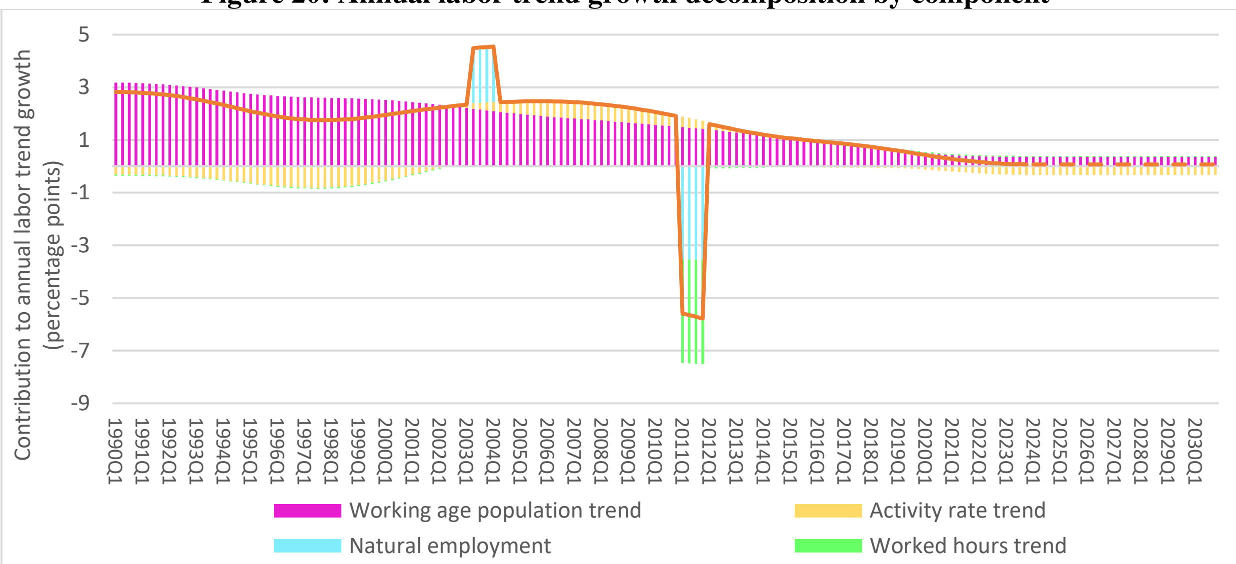
Source: INS and author calculations

The labor gap has typically been positive (Figure 19), reflecting an evolution of labor above its potential, aligning with the structural reforms implemented. gap h negative during the shocks of 2001, 2011, and particularly since the onset of COVID-19.

2.2.2.6 Labor trend growth decomposition

In the long term, employment evolution essentially depends on the working-age population, which has a persistent downward trend, as shown in Figure 20. However, during periods of shock, the determining variables are the natural unemployment rate and number of hours worked.

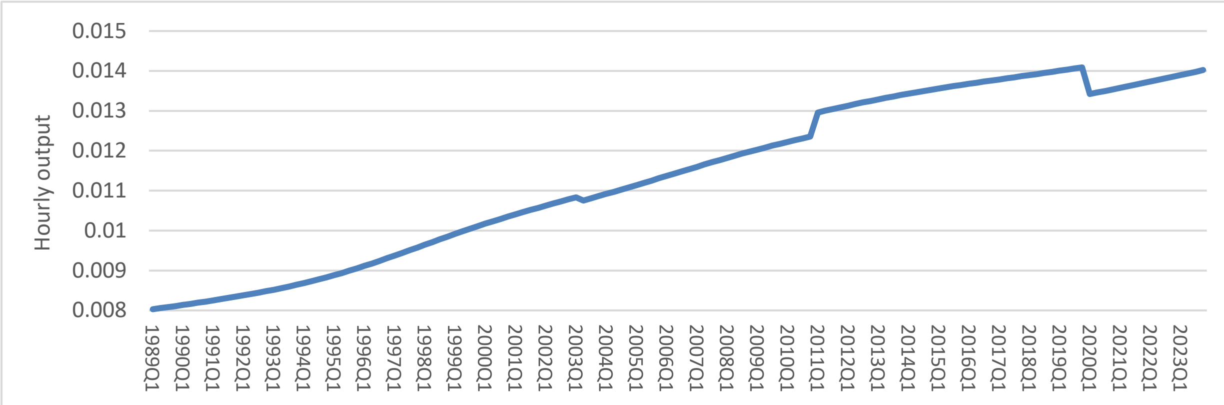
Figure 20: Annual labor trend growth decomposition by component



Source: INS and author calculations

Thus, the contributions of the various components confirm the predominance of the working-age population (approximately 90%) before declining from 2020 and stabilizing at approximately 50%. Since the onset of COVID-19, this activity rate has decreased by 48%. The contribution of hours worked became positive, accounting for approximately 7% of changes in employment. Labor productivity, measuring the hourly output of the economy trend, shows an upward trend (Figure 21), particularly from 2011, in relation to the working-age population long-term trend and the 2011 shock on worked hours and natural employment.

Figure 21: Labor trend productivity

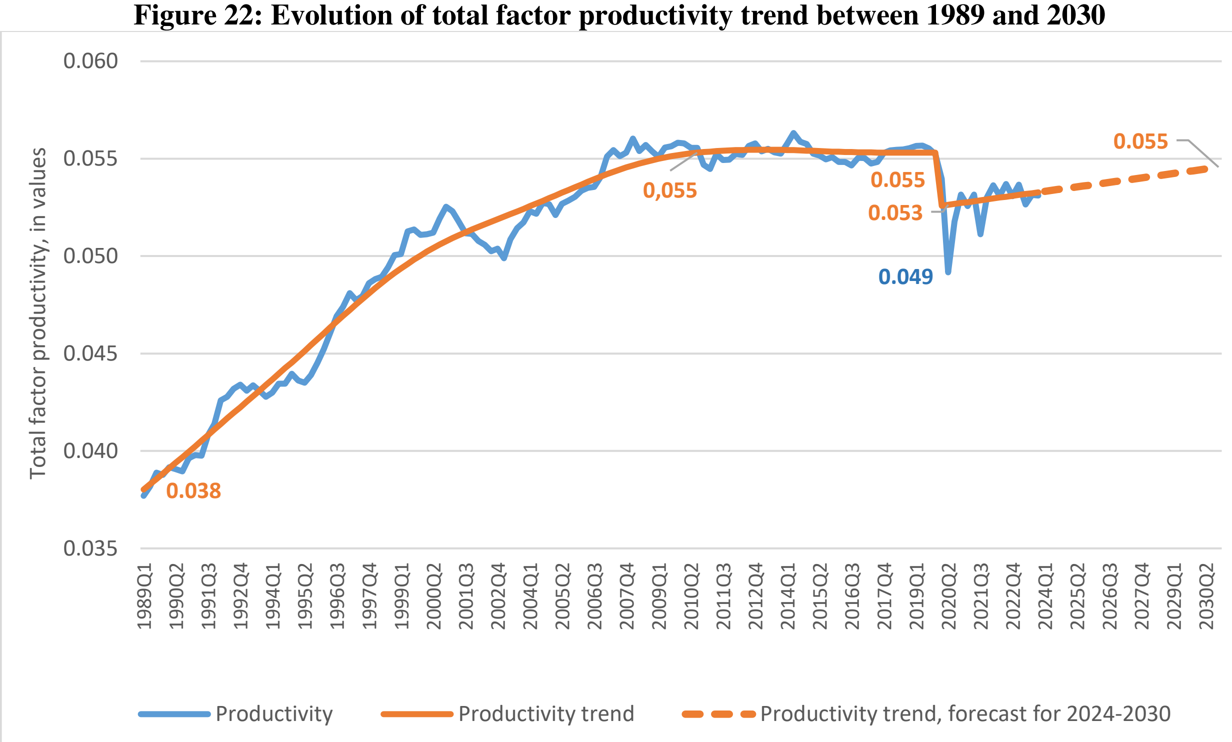


Source: INS and author calculations

2.2.3 TFP trend

The productivity series, calculated as a Solow residual, showed a distinct break in 2020, which coincided with the COVID-19 period (Figure 22). Thus, potential productivity is estimated separately for each period: pre-2020 and post-2020. The investigation to determine the dating of structural breaks requires the study and detection of significant changes in productivity growth rates. This results in dates that are practically close to the dates of structural breaks in other production factors. For each sub-period separated by two structural breaks, we estimated the potential productivity from 1989 to the end of the sub-period using unobservable component models.

Figure 22: Evolution of total factor productivity trend between 1989 and 2030

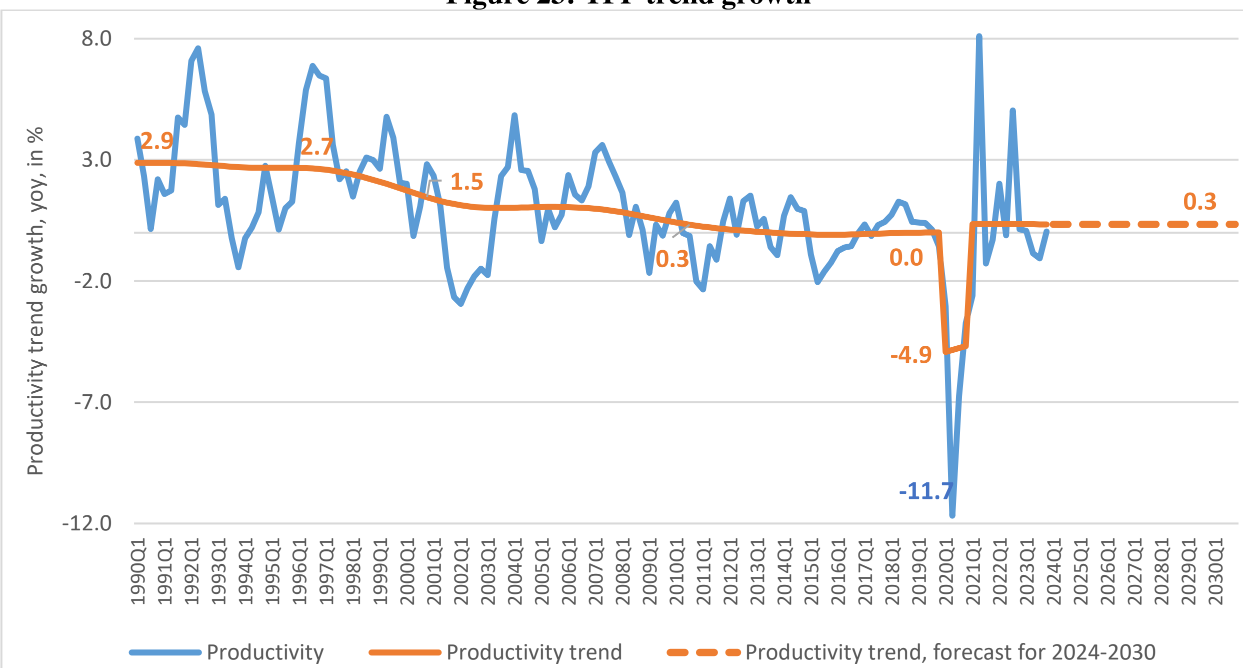


Source: INS and author calculations

The estimates of potential productivity show a relatively rapid evolution over the sub-period 1989Q1–2001Q4, which slowed down during the second sub-period (2002Q2–2008Q1). The level of potential productivity decreased by 0.006 points following the 2001–2002 shock, and the trend slowed. The slowdown in productivity continued over the 2008Q2–2019Q4 period; however, at a more accelerated pace. The COVID-19 shock weighed heavily on productivity, and the exit was accompanied by a slow recovery of productivity.

Figure 23 confirms the deceleration and loss of productivity growth that goes from a plateau to a trough from one period to the subsequent.

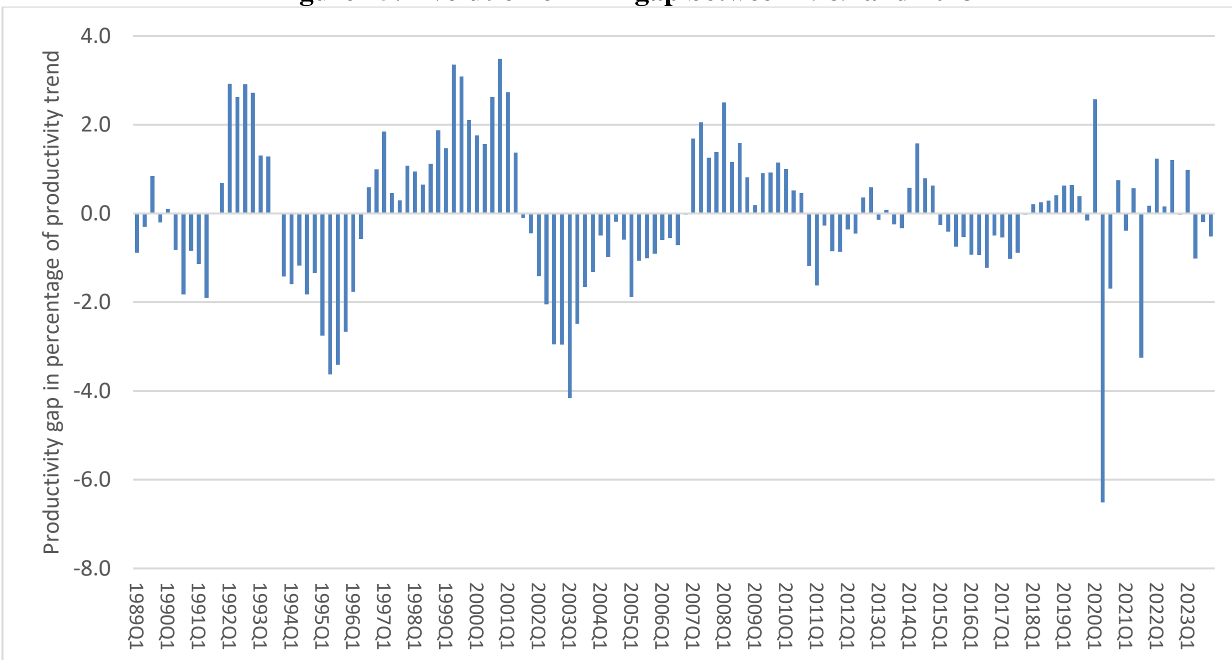
Figure 23: TFP trend growth



Source: INS and author calculations

Figure 25 shows the evolution of the gap productivity. During the first and second periods, this was relatively high, fluctuating between positive and negative, reflecting the volatility of productivity. From 2011 onwards, the productivity gap weakened, aligning with the downward trend in productivity and its volatility, except for the COVID-19 period, which was characterized by a high productivity gap.

Figure 25: Evolution of TFP gap between 1989 and 2023

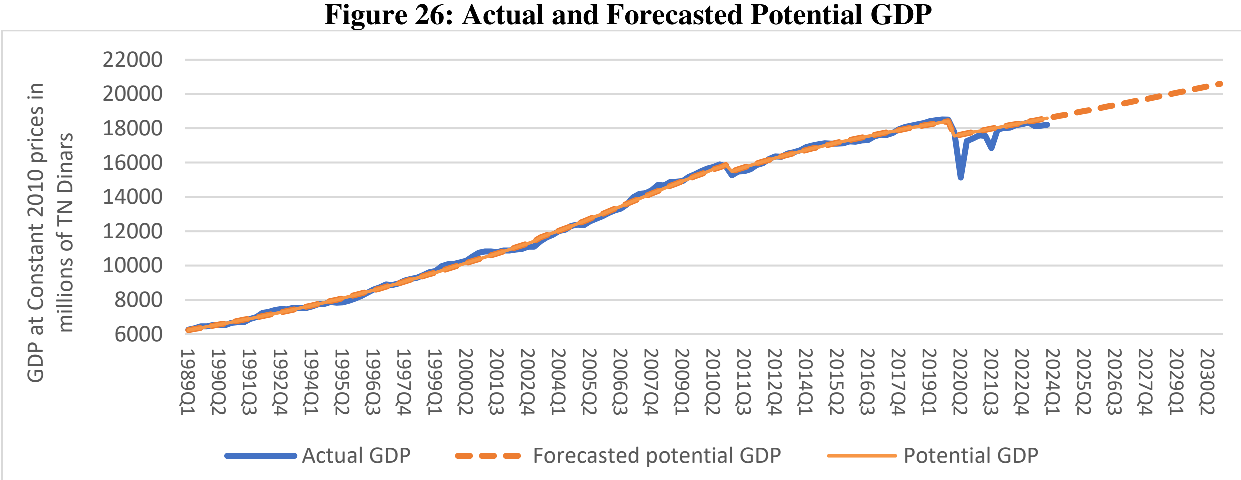


Source: INS and author calculations

2.2.4 Potential output

After estimating various production factors, the potential GDP was obtained by aggregation using the production function approach. The potential GDP in Tunisia is sensitive to national and international economic environments and exogenous shocks affecting various political, social, security, and economic aspects. Depending on the type of environment and shock, the evolution of potential GDP changes for level, trend, or both (Figure 26).

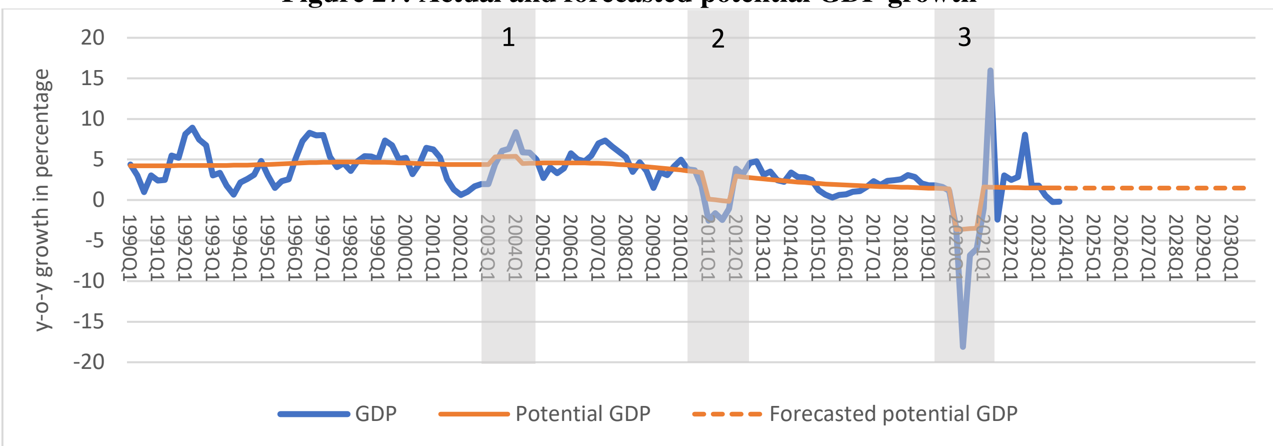
Figure 26: Actual and Forecasted Potential GDP



Source: INS and author calculations

The potential GDP evolution showed three structural breaks in 2003, 2011, and 2020, resulting in four phases (Figure 27). The first break in 2003 resulted in a slight upward change in the level and a change in the trend of potential GDP growth compared with the previous phase. The 2011 break caused a downward shift in the level, followed by a change in the evolution of growth, which became less tense. Finally, the shock in 2020 resulted in a more significant change in the level than the previous shocks without any effect on the trend in potential GDP.

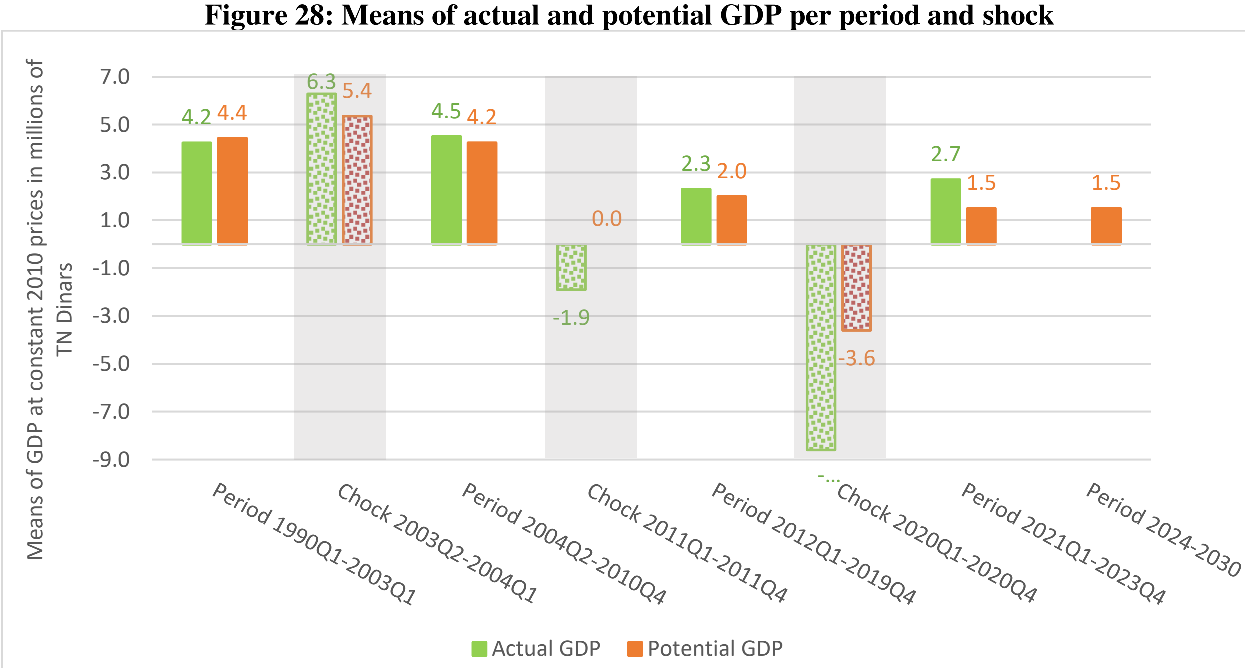
Figure 27: Actual and forecasted potential GDP growth



Source: INS and author calculations

After an upward trend in potential GDP growth during the first phase, growth started at a relatively acceptable level following a structural change in 2003 and continued at a fairly high pace, despite a slight deceleration. From the 2011 shock onwards, the trend in potential growth became bearish before stabilizing at approximately 1.5% after the COVID-19 period.

Figure 28: Means of actual and potential GDP per period and shock



Source: INS and author calculations

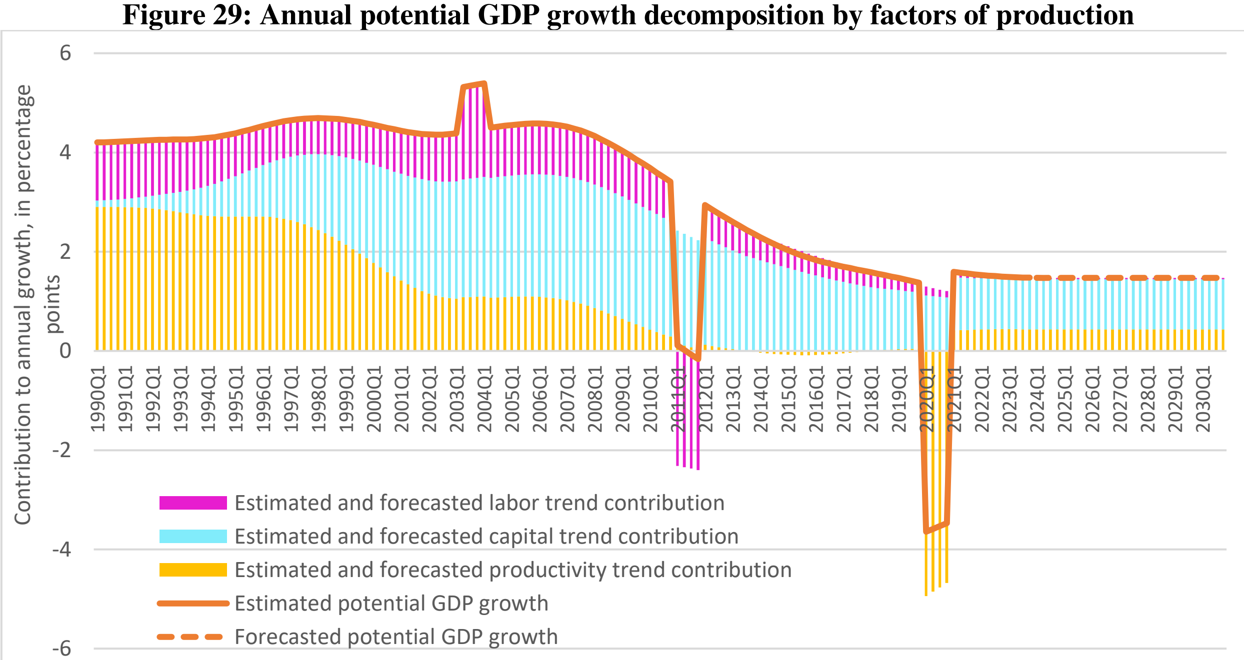
Figure 28 shows that the potential growth exhibits a downward trend. The 2003 shock (five quarters) raised potential growth by 1% point, whereas the 2011 shock (four quarters) lowered it by 4.2% points. The 2020 shock had a significant impact on potential growth, decreasing it by 5.6% points. Periods of exceptional rises and falls in potential growth levels determine the duration of shocks. Thus, the shock of 2003 lasted five quarters, and that of 2011–2020 lasted four quarters each.

2.2.5 Decomposition of potential growth by production factors

An analysis of the contributions to potential growth can help understand the causes of potential GDP growth in some periods and its slowdown in others (Figure 29).

- During the first period (1989–2003), the contribution of the productivity trend was predominant, accounting for over 50% of the potential growth until 1998, before declining to a mere 20% by the end of the period. The contribution of capital accelerated, explaining 54% of potential growth in 2003 and offsetting the decline in the contribution of the productivity trend. The contribution of labor was stable overall, at approximately 21% on average.
- The first structural break (2003Q2–2004Q1) was characterized by a remarkable rise in labor growth contribution, which led to potential growth.
- The second period was characterized by the maintenance of a high level of potential GDP growth, driven by capital accumulation, which, on average, accounted for approximately 60% of potential growth. However, productivity experienced a slowdown that accelerated from 2008 onwards, explaining the slowdown in potential growth. Labor's contribution has been stable at approximately 22%.

Figure 29: Annual potential GDP growth decomposition by factors of production

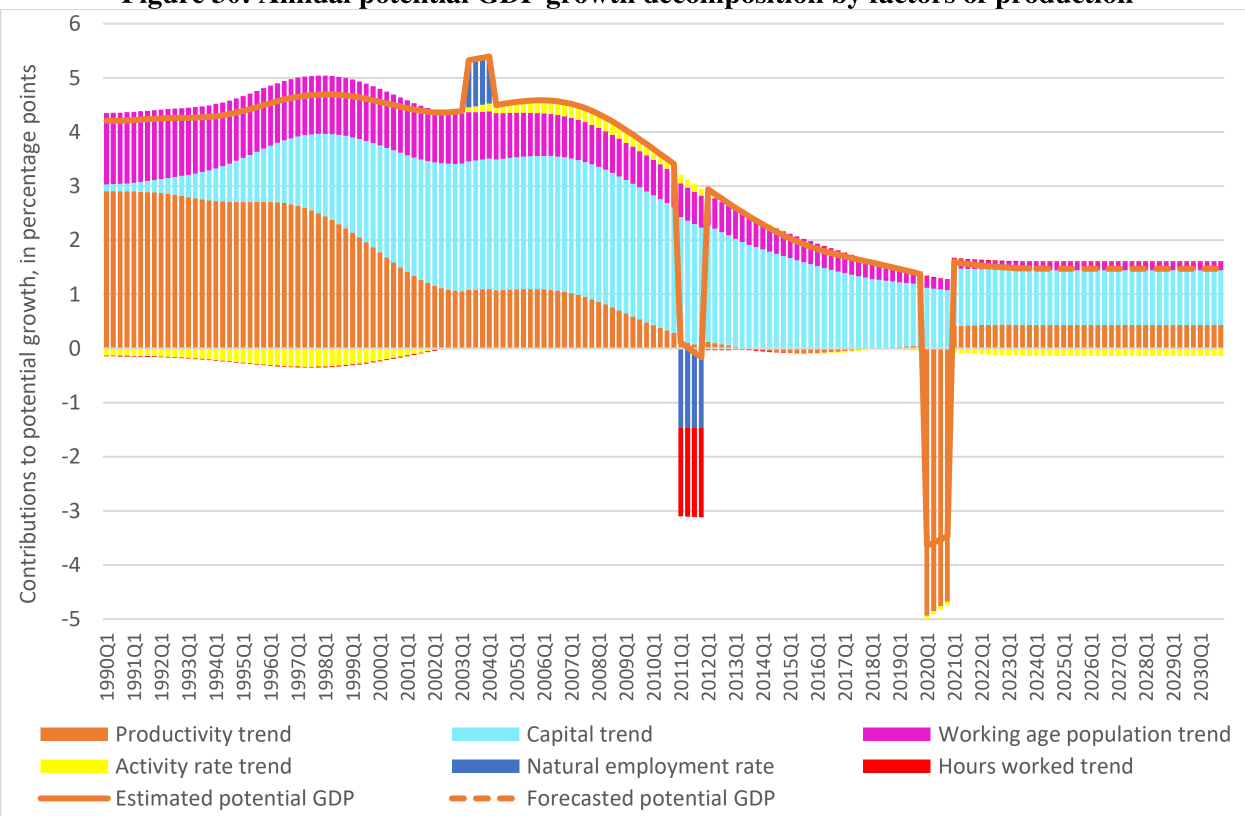


Source: INS and author calculations

- The 2011 shock resulted in a sharp decline in labor contribution, which explains the decline in potential growth. However, this shock had no immediate impact on capital trends and the contribution of productivity, which was already meagre (almost zero).
- The period following the revolution (2012–2019) was characterized by a decline in potential growth, explained by a downward trend in the contribution of capital and labor. The productivity trend remains approximate to zero.
- The shock in 2020 resulted in an unprecedented drop in productivity, explaining the decline in potential growth.
- The final period (from 2021) is characterized by a slight improvement in potential growth, which is close to the pre-COVID-19 level. This improvement is driven, in particular, by the continued contribution of capital at a relatively high level, close to that of 2019 (78%), despite its weakness, as well as the recovery in productivity, accounting for 30% of the potential growth. The contribution of labor stabilizes at approximately 2%.

These results show that Tunisian's potential economic growth has been primarily driven by TFP, capital, and, to a lesser extent, labor. As illustrated in Figure 30, the average TFP gains rose steadily before declining in the early 2000s, with a significant drop since 2009. The contribution of capital grew notable before slowing after 2010, while labor's contribution has been declining since the 2000s. Figure 30 shows the detailed contributions of the production factors to the potential growth.

Figure 30: Annual potential GDP growth decomposition by factors of production



Source: INS and author calculations

As explained in the section on decomposing the evolution of the labor component, the demographic factor is the driving force behind its long-term evolution, while periods of shock highlight the contribution of the natural unemployment rate, and the number of hours worked.

The slowdown in labor's contribution to potential growth reflects the downward trend in the working-age population. This decline was amplified by a negative contribution from the activity rate trend up to 2002, which became positive between 2003 and 2010. This contribution has approached zero after the revolution, before becoming negative again since the onset of COVID-19. The rise in both labor and potential growth during the first structural break (2003) is explained by the natural employment rate.

The fall in potential growth in 2011, essentially explained by the fall in labor, concerned both the contribution of the trends in the natural employment rate and the number of hours worked. However, the COVID-19 shock is not directly linked to a fall in labor.

2.2.6 Breakdown of output gap by production factor

The output gap, a simple synthetic indicator of the economy's position in the cycle, became volatile and differed from one sub-period to the subsequent, which aligned with the dynamics of actual and potential GDP.

The first period (1989–2003) was characterized by steady fluctuations. By the end of this period, the amplitude of these fluctuations increased, and a positive output gap emerged, indicating an above-average utilization of the economy's production capacities.

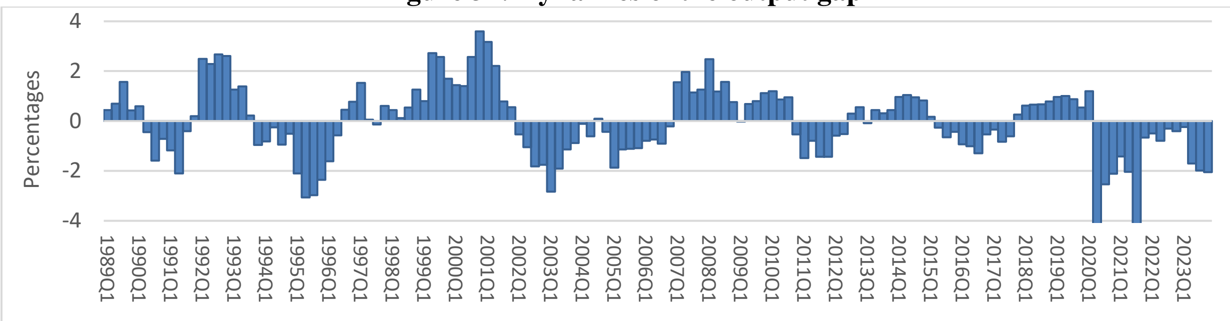
The second period (2003–2010) was characterized by a weakening of the output gap amplitude, with the first sub-period of a negative output gap followed by a second positive sub-period.

The third period shows output gaps with amplitudes ranging from -1.5% to 1%; however, frequently fluctuates near the steady state, with an average period of four years.

Since the onset of COVID-19, the output gap has become negative, indicating an underutilization of production factors linked to the deficit of demand in relation to supply, with a decrease in amplitudes post-COVID-19.

Thus, the output gap evolution evidently shows that underemployment of production capacity reached its highest levels during years when effective growth rates were fairly low, specifically in 1994, 2002, and 2020, with gradual resorption after the last two years of the crisis. Additionally, the output gap evolution has shown that the average duration of the economic cycle in Tunisia over the study period 1989–2023 was five years, with a reduced average duration after the revolution before entering an extended low phase since the onset of COVID-19.

Figure 31: Dynamics of the output gap

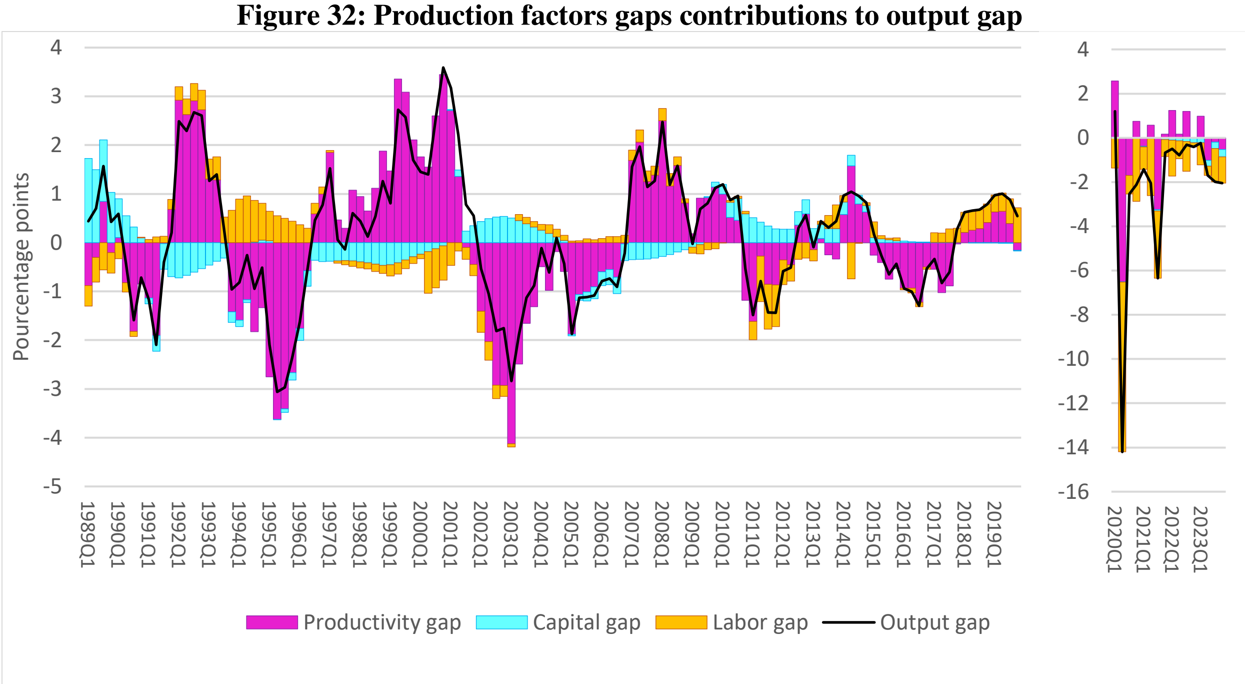


Source: INS and author calculations

Figure 32 shows the output gap decomposition into contributions from TFP, capital, and labor. As expected, the main driver of the output gap is the TFP gap, which generates a relatively large and persistently positive output gap in prosperous times and drives a marked slowdown during crisis years. The contributions of capital gap and, to a lesser degree, labor gap were generally in the opposite direction to output gap, attenuating the contribution of productivity gap. The high correlation between productivity and the cycle reflects adjustment lags in capital and labor.

The contribution of the capital gap to the output gap became very small from 2014 onwards, whereas that of the labor gap became larger and had the same sign as the output gap.

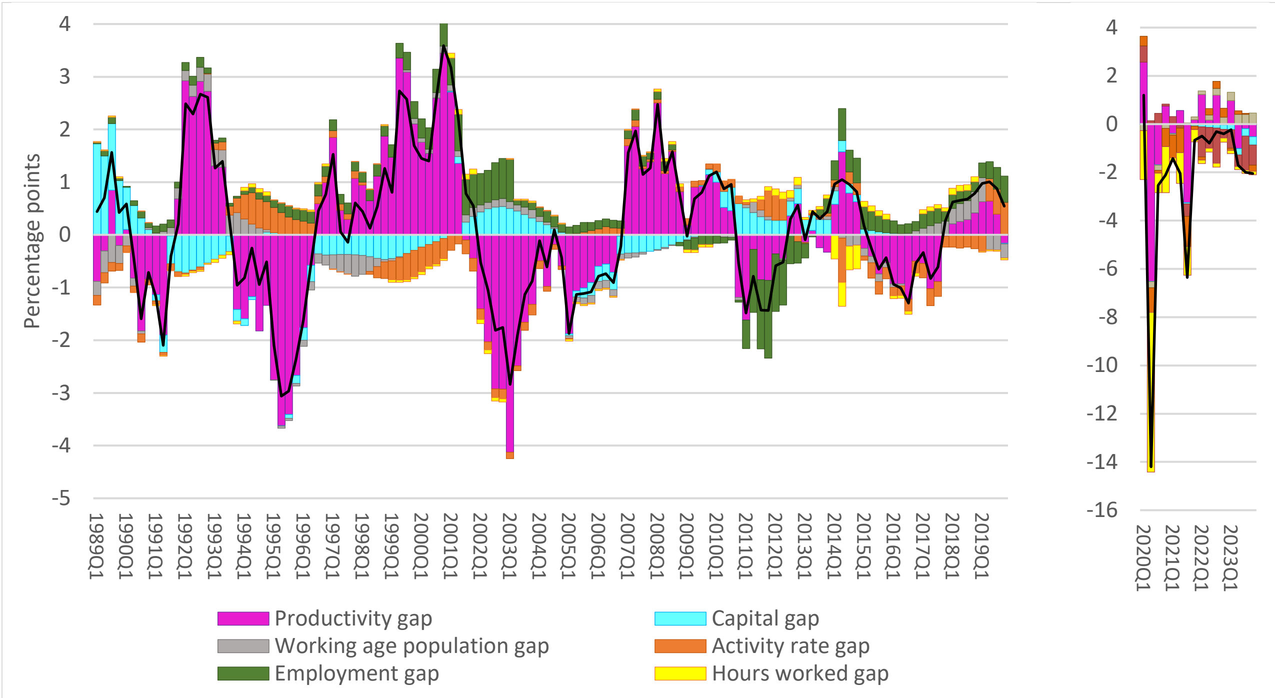
Figure 32: Production factors gaps contributions to output gap



Source: INS and author calculations

Figure 33 depicts the decomposition results in detail using production factors. The contribution of the labor gap is explained by the gap activity rate. The contribution of the employment gap to structural breaks is significant. The contribution of the worked-hours gap was dominant in the COVID-19 shock, and weak in other shocks.

Figure 33: Detailed production factors contributions to output gap



Source: INS and author calculations

Section 3: Discussion

This section discusses the potential growth and its factor trends during 1989-2023, by comparing the subperiods before and after the major crises and the potential and actual growth. Subsequently, we explain the sources of the crises and analyze their impacts. Later, we examine how different crises affect the contributions of potential growth factors.

3.1 First period: 1989–2003

During this period, the Tunisian government adopted a structural adjustment program (SAP) from 1989 to 1994 to boost the Tunisian market by minimizing the state's economic sphere, thereby increasing growth and preserving monetary stability. The program achieved good macroeconomic performance; however, it created an imbalance between the labor market and weakened social welfare.

Furthermore, Tunisia has progressively adopted economic openness and free trade measures, prioritizing the development of the private sector and promoting export industries. Accession to the World Trade Organization (WTO) in 1995 and the Association Agreement with the European union (EU) triggered the gradual adoption of free trade measures for industrial products with the EU between 1996 and 2008, helping boost the competitiveness and modernization of companies and increase their export capacity.

Structurally, Tunisia has shifted from being a producer and exporter of agricultural products, phosphate, and oil to that of manufactured goods. The growth of high-tech companies has been facilitated by the emergence of a modest but growing trend in investment in research, development, and innovation. Consequently, the share of technical content in exported products increased, while the share of products that rely solely on comparative advantages, such as low labor costs and lax taxes, has decreased. Conversely, the privatization policy increased foreign direct investment and modernized business management practices and manufacturing processes. These measures have contributed to Tunisia's gradual transition from an inward-looking semi-closed economy to an outward-looking market economy. Nonetheless, Tunisia's growth model is insufficiently inclusive, particularly considering social and regional inequality, and insufficiently shielded from the external shocks associated with economic openness.

This study did not examine the 1980s shocks and their influence on the 1990s because the time frame before 1989 was not included. Future studies can further examine the variables that affect potential production and the output gap while considering the reforms made to the Tunisian economy, particularly openness.

3.1.1 Capital trend

Increased competitive pressures associated with economic openness have forced Tunisia to strengthen its industrial partnerships, boost its competitiveness, reinforce the socioeconomic environment, and accelerate the modernization of its enterprises.

The moderate increase in investments throughout the 1990s was followed by a slowdown of approximately 4.8% and 3.9% in 1990 and 2000, respectively. Consequently, the investment rate remained high. This significant investment effort enabled Tunisia to achieve a 30% ratio of total investment to GDP and a 20% ratio of private investment to GDP in the 1990s. Moreover, this dynamic reflects an increase in the foreign direct investment (FDI) flows, which averaged 3.3% of GDP between 1992 and 1994, compared with 0.7% of GDP in the second half of the 1990s. FDI contributes to the development of local businesses, specifically by introducing new technologies. Furthermore, FDI in the offshore sector contributes significantly to GDP growth and capital accumulation. The significant increase in net capital stock during the early 1990s may be from the major economic reforms undertaken.

However, public investment was limited to specific regions and accounted for only 8% of the total investment in the 1990s. Furthermore, they could not encourage private investment. Conversely, the private sector remained modest in size and was mainly composed of family-led and small-and medium-sized businesses (SMEs), which accounted for over half of all investment volume, despite complex conditions for access to financing.

3.1.2 Labor trend

The overall upgrading of the Tunisian economy and the reforms undertaken did not significantly improve the labor market, which has several shortcomings that limit job creation. Institutional uncertainty has weakened the credibility of reforms and led to unfavorable circumstances for private sector development and innovation.

The lack of preparation in many sectors for economic liberalization has resulted in persistently high levels of unemployment. The disparity between the annual creation of new jobs and the continuous growth in the working population has increased. This mismatch between job supply and demand may be owing to the inability of job seekers to fit the required profiles and the high standards set by companies.

The expansion of education, schooling, and university studies has outpaced economic growth. The rapid increase in student enrollment has exacerbated the challenges of job creation and unemployment. Tensions in the labor market have become more pronounced, particularly among young adults, who are increasingly represented in the unemployment statistics. In 1997, 49% of the unemployed had been without a job for an extended period, and 63% were under the age of 29. This may be from the relative rigidity of the labor market and the mismatch between the labor supply profile and the demand for skills expressed by employers. These dynamics underscore the growing need to hire workers with a high degree of professionalism and diverse skill sets.

The privatization policy was poorly targeted and did not significantly increase job creation. To address unemployment, enterprises are being urged to improve their technical skills. The lack of a strategic focus in privatization hindered the advancement of technology and innovation.

Despite these challenges in the labor market, the unemployment rate declined over this period, aligning with the overall expansion of economic activity.

3.1.3 Productivity trend

Despite numerous efforts by the Tunisian government to enhance productivity, the quality of labor has witnessed limited improvement, affected by regional discrimination, wage gaps between men and women for the same type of work in several jobs, and a mismatch between supply and demand for labor.

The State has prioritized job creation at the expense of employment quality. FDI efforts primarily target low-tech industries such as textiles and clothing, which have benefitted from FDI incentives, while industries with higher technological potential but less immediate value have been neglected. Additionally, Tunisia has overlooked the acquisition of licenses, which is an effective way to acquire technology, despite FDI being a potential avenue for technology and innovation.

Nevertheless, there has been a structural improvement in the proportion of technological continuity in manufacturing and exports. This is primarily owing to increased technical skill levels within companies, though these remain relatively low. The privatization policy has contributed to the modernization of production techniques and management procedures, and specific initiatives have been implemented to support young adults in transitioning into the workforce.

Moreover, the share of exports from traditional manufacturing export sectors, including textiles, agri-food, phosphate derivatives, electrical products, and building materials, gradually declined, falling to 88% by 1995. Conversely, exports from technology-driven sectors (electronics, textiles and engineering plastics, automobiles and aeronautics, and Information Technology (IT) / Business Process Outsourcing grew (BPO) increased steadily, reaching 12% by 1995.

The onset of the subsequent period was characterized by security and climatic shocks, significantly impacting the Tunisian economy. The following section examines and analyzes these effects on production factor trends and the output gap.

3.2 Second period: 2003–2010

In the early 2000s, Tunisia faced multiple domestic and foreign crises which had both direct and indirect adverse effects. The September 11 terrorist attacks in New York began to reveal their impact on the Tunisian economy, particularly on tourism. This was followed by the national terrorist attack on April 11, 2002, at the Ghriba synagogue in Djerba, which significantly affected Tunisia’s tourism industry.

These attacks created an atmosphere of mistrust and uncertainty, undermining confidence in the State’s capacity to contain terrorist threats and exacerbating their direct economic consequences.

Additionally, several years of drought following these events further strained Tunisia’s agricultural sector, which performed poorly and faced significant challenges owing to climatic shocks, particularly in 2002. This sector remains vulnerable to external shocks, such as weather-related hazards, with agricultural growth sharply declining by 7.37% and 6.9% in 2005 and 2007, respectively, compared to the previous year.

By analyzing the economic, social, and political contexts and the changes that occurred between the pre-crisis and post-crisis periods, this study examined how the various shocks listed above affected the potential production factors and the output gap.

3.2.1 Capital trend

In 2002, Tunisia experienced a notable slowdown in economic activity owing to a dramatic decline in agricultural production, along with declining investment in the agricultural sector and worsening international trade.

FDI was deterred by terrorist attacks, which impacted Tunisia's export operations. Furthermore, a challenging business environment, exacerbated by an atmosphere of mistrust, increased insecurity, and uncertainty, led to substantial but slower-changing FDI flows. Owing to this unfavorable business environment, FDI predominantly targeted the energy sector.

Despite these challenges, the net capital stock continued to grow rapidly. However, the investment levels remained relatively stable during the 2000s, averaging approximately 24% of GDP, with private domestic investment consistently below 15%. Additionally, private domestic investment remained concentrated in the real estate sector, with minimal investments in high value-added activities within other manufacturing sectors.

The economic impact of these shocks was also evident in the tourism sector, where tourism revenues dropped by 15.6% in 2002 and 4% in 2013, according to statistics from the Central Bank of Tunisia. Restrictions on international travel and increased security costs for tourism businesses further hindered investment and operations in the sector.

To analyze the impact of these shocks on capital trends throughout the 2000s, we compared and evaluated the changes in the capital trend level and path relative to the pre-shock period. Our empirical results show no change in the level between the two periods. Thus, shocks have no immediate effects but affected this trend, which has shifted significantly since 2003.

Consequently, the acceleration in capital trends during this period cannot be attributed to these shocks, which had a negative influence. Furthermore, as previously noted, the negative impact of security and climatic shocks were confined to only the two years following 2002.

Considering these findings, the improvement in the capital trend may be from the increase in investments over this period. Specifically, there was an average investment gain of 48.33% from the previous period, as illustrated in Figures 3, A.3, and A.4. However, this level remains relatively steady because the new investments were introduced progressively rather than a sudden influx at the beginning of the period.

Additionally, the capital trend has shown a significant upward shift since 2003, indicating that capital accumulation accelerated at a faster rate compared to the previous timeframe. Practically, the average capital trend was 4.2%, compared to 3.1% if conditions had remained unchanged. This analysis suggests that while shocks had no discernible effect on the capital trend, reforms have enhanced it, resulting in an increase in capital accumulation valued at more than 67% of the GDP in Tunisian Dinar (TND) compared to the static capital trend.

3.2.2 Labor trend

Various terrorist acts have fostered an unfavorable business climate, impeding efforts to attract investment and promote employment by reducing unemployment and increasing work productivity. Furthermore, certain labor market deficiencies hinder the growth of job opportunities.

On the one hand, job growth and unemployment have been impacted by the lack of confidence among firms and investors amid escalating uncertainty. Additionally, regions most impacted by instability associated with violent extremism have experienced a worsening skilled labor shortage as workers have migrated to safer regions.

On the other hand, young adults are increasingly drawn to creative and technologically advanced work fields. However, this demographic faces higher unemployment rates compared to other age groups. The shift in the corporate world towards new, highly value-added, inventive, and specialized professions has rendered academic and vocational training insufficient. Existing training programs are either outdated, inadequate or only partially aligned with current business models.

Consequently, companies cannot meet their demands, and the unemployed, particularly young university graduates, cannot find suitable jobs. This situation has created a significant mismatch between labor supply and demand. Human capital has become underemployed. This mismatch, which particularly affects young adults, may widen further given the significant contribution made by this age group to demographic growth. Young adults, particularly women, are no longer encouraged to engage in formal employment. Instead, they are inclined towards the informal sector to engage in their own activities as self-employed workers.

Empirical investigations showed the following results.

Activity Rate trend

The labor market has witnessed improvements owing to economic opening and reforms implemented in the 1990s. The promotion of workforce participation has encouraged several previously discouraged individuals to join the labor market. Although the increase in employment and unemployed individuals has been insignificant, it reflects the positive impact of these reforms. Job demands during this period followed an upward trend, as shown in figure A.8. Furthermore, as Figure A.9 illustrates, the percentage of discouraged workers decreased from 3% before the reform to 2.4%. Hence, the changes improved the active population, which increased by 0.6% over the previous period. However, the instability of the natural unemployment rate led to the trend of activity rate unchanged, assuming that other variables influencing the activity rate also increased at a similar pace.

Working Hours

The 2000s security crisis and the implemented changes did not impact the working hours. The trend of number of working hours remained in the same direction, without any changes in level or orientation.

Natural unemployment

These improvements reduced the natural unemployment rate from 14.6% to 12.8%, which was positively affected by the changes and decreased by 1.8%.

Labor trend

The labor trend benefitted from the reforms' favorable effects on the trends of the activity rate, natural unemployment, and hours worked. Considering these advantageous outcomes, the labor trend has grown dramatically during this period. The labor trend rose according to the reforms by 82,772 hours, or 7% of the total number of hours in 2010Q4 trends in the number of hours worked.

3.2.3 Productivity trend

Apart from these growth-related obstacles, numerous deficiencies have negatively influenced Tunisia's competitive environment, including those in innovation, sophistication, creativity, significant delays in financial market development, uncertainty and instability in the political environment, ineffective government bureaucracy, and challenges in obtaining financing sources. Furthermore, the uncertainty imposed by these barriers detrimentally affects the business climate.

The State has not fully leveraged the financial advantages available to enhance logistical and technological infrastructure, strengthen public skills, and promote business development, particularly in interior regions. However, efforts to integrate the Tunisian economy at regional and global levels have been notable. Tunisia has signed several free trade agreements and participated in projects focused on trade facilitation, Maghreb regional integration, and financial sector reform. Furthermore, the authorities liberalized medium- and long-term external borrowing for listed companies, increased the capital amount that export companies can freely transfer for overseas investments, increased business travel allocations, reduced restrictions on foreign currency accounts, and synchronized onshore and offshore regulatory regimes.

Empirical investigations led to the following results.

The TFP trend exhibited a structural shift during 2001 and 2002, as determined by the trend estimate and the timing of its rupture starting in 1989. As mentioned previously, this period was marked by terrorist attacks and droughts. Figure A.5 illustrates that, starting in 2003, the TFP trend experienced a change in direction rather than a shift in level during this crisis. Specifically, the TFP trajectory became more subdued compared to the 1990s. Consequently, the TFP trend decreased by 0.002 points, from 0.057 in the scenario without structural changes to 0.055 reported in 2010Q4, as confirmed in Figure A.6.

The TFP growth trend may have been less affected had the crisis not occurred. Without the crisis, the growth rate would have been reduced from 1.5% in 2000Q4 to 1.2%, rather than the actual reduction of a mere 0.3% reported in 2010Q4. Thus, the crisis may have affected the TFP trends. While the TFP growth trend did not change in level, it did decline in trajectory, losing 0.9% of its previous increase.

Regarding the contribution of productivity trend growth to potential growth, we noted a 4% decline during the crisis period. It decreased from 24.4% in 2000 to 20.4% in 2001 and 2002. Furthermore, its contribution declined significantly throughout the post-crisis sub-period and became progressively smaller before it was eliminated at the beginning of the next term. Compared to the pre-crisis sub-period, when the productivity trend's contribution share was the most significant, it became the factor with the lowest contribution share during the post-crisis sub-period.

3.3 Third period: 2011–2019

Between 2011 and 2019, Tunisia faced significant political and social instability, impacting various aspects of everyday life and the medium- and long-term development of the economy. In late December 2010, a protest movement emerged, addressing issues such as nepotism, dignity, unemployment, social injustice, and corruption. Concurrently, a political movement to establish a new democratic political environment and reforming the institutional framework also gained momentum.

However, the revolution deviated from its objective owing to the lack of alignment and complementarity between these two movements. This divergence and failure had broad implications. Although the transition to a more democratic regime achieved some success, political leaders struggled to act effectively because of internal conflicts and power struggles. Hence, instead of prioritizing economic and social growth, the situation was further exacerbated.

On April 11, 2013, two years after the 2011 event, Tunisia became victim to a suicide attack in Djerba, which directly and negatively impacted tourism, FDI, and investor confidence.

Two years later, Tunisia experienced two devastating terrorist attacks: on March 18, 2015, the Bardo Museum in Tunis was attacked, and on June 26, 2015, Sousse was attacked. These incidents imposed significant challenges on economic operators, including supply difficulties and increased costs linked to insecurity.

The subsequent section analyzes the effects of social, political, and security shocks, particularly focusing on the initial shock.

3.3.1 Capital trend

The challenging social conditions, limited access to financing, absence of a clear future vision, disruptions caused by bottlenecks in port areas, extended lead times for goods at ports, rising production costs, and road closures during protests significantly impacted investments following the 2011 shock. Economic competitiveness diminished, and security stability was compromised.

Consequently, numerous Tunisian and foreign investors and operators redirected their investments to other countries, notably Morocco. This shift led to a gradual decline in the contribution of capital, with investment rates falling by 5% points compared to the average of the previous period. This decrease reflects the cautious stance adopted by the private sector, which persisted from 2011 onwards, as well as the reduction in public investment. Government spending has mainly focused on wages and social compensation to address the social situation, which has a spillover effect on the private sector.

Figure A.1 illustrates the change in capital trends following the revolution, showing a notable decline in momentum. If the revolution had not occurred, the capital trend would have developed more rapidly, potentially increasing to 4.4% annually rather than 1.8% observed in 2019Q4, following a 3.9% increase in 2011Q1 (see Figure A.2). Consequently, the revolution negatively affected capital accumulation, which decreased by 2.05% of GDP in 2019Q4.

Following the revolution shock, Figure A.3 shows that investment horizontally trended within a narrow range, with minimal fluctuations and no notable highs or lows, averaging below 3,500 MD. This suggests weak, stagnant growth in investment. However, investment was more dynamic, comparatively high, and increased even before the revolution. These trends indicate that investments entered a consolidation phase, reflecting investors indecision and an uncertain business environment.

The capital utilization rate remains positive but has decreased to zero since the second quarter of 2016, indicating that enterprises require additional funding to finance their business activities.

3.3.2 Labor trend

The labor contribution diminished over the decade, along with the declining trend of the working-age population and shifting demographics in Tunisia. When demographic variables are excluded, increased unemployment, specifically among women and recent college graduates, has further contributed to this decline. Owing to high unemployment rates among recent graduates and skilled workers, and the substitution of skilled labor with unskilled labor, labor productivity has not reached its full potential. Regional disparities in employment exacerbate this issue.

The constraints affecting Tunisia's job creation development, which are currently failing to absorb or reduce the unemployed population, contribute to persistently high unemployment rates.

The informal sector has benefited from this environment and has expanded to accommodate more than half the workforce, albeit under poor working conditions, low wages, and without social protection. The benefits associated with employment vary significantly across the public, private, formal, and informal sectors, with the public sector offering better working conditions. These disparities hinder young adults from pursuing more skilled, productive, and innovative occupations.

Several young adults have sought illegal emigration to escape inadequate and challenging living conditions. Highly qualified professionals, particularly in the Information and Communication Technology (ICT) and health sectors, such as professors, Doctor of Philosophy (PhDs), physicians, engineers, IT professionals, and paramedical employees, have migrated to pursue new opportunities.

Empirical investigations led to the following results:

Activity rate trend

The activity rate decreased by 1.4% owing to the revolution crisis. There was no change in the direction of activity rate, which gradually declined.

Working hours trend

The revolution significantly impacted working hours. Since the revolution began, the average number of hours worked decreased by 15 hours per quarter in employees. However, the tendency for working hours increased. This discrepancy may be from the progressive removal of barriers impeding labor market expansion and the slow but steady improvement of the overall economic environment.

Natural unemployment

The natural unemployment rate increased dramatically from 12.8% to 15.9% compared to the pre-revolutionary period. The revolutionary crisis negatively impacted the natural unemployment rate, which increased by 3.1%.

Labor trend

The revolution negatively impacted all labor trend components, adversely affecting the resulting labor trend. This downturn led to a reduction in the total number of labor hours, with a loss of 48,053 hours, or 3.6%, by the end of this sub-period.

3.3.3 Productivity trend

The revolution had a markedly negative impact on the social and business environments, creating conditions unfavorable for the development of production factors, particularly productivity. The economic situation deteriorated, public and current account deficits widened, investments declined, and growth slowed. In sum, the crisis lowered productivity at all levels.

This decrease in productivity is from the persistence of several detrimental conditions, detailed below.

- Wage increase without corresponding productivity gains: Real wage rose, primarily to maintain social peace, but these increases outpaced labor productivity. The resulting high inflation eroded real wages, which remained above the productivity levels. This misalignment threatens the overall economic system, particularly the competitiveness of companies.

- Lack of resilience and inclusiveness: The growth strategy adopted by the Tunisian state did not support resilience and inclusiveness but instead prioritized income redistribution. This approach marginalized vulnerable traders, such as craftsmen and small shopkeepers, in favor of large retail chains, partially because of the restricted budgetary space allotted to employment promotion programs.

- Unfavorable business environment: Businesses are currently facing significant challenges owing to the administrative burden of compliance, the complexity of regulations, and socio-fiscal pressures. To navigate these difficulties, they switch to the informal sector, which severely penalizes formal employment and working conditions for employees.

- Failing innovation system: Post-Revolution, Tunisia's innovation system became increasingly fragile, lacking the necessary incentives to create a high-performing national innovation framework that permeates the economy, encourages businesses to engage in advanced industries and supports their growth, particularly in terms of funding, FDI, and patenting. The 2011 revolution crisis, coupled with the 2007–2008 financial crisis, made the innovation system increasingly vulnerable. In 2011, FDI dropped by 26%, significantly limiting opportunities for partnerships and the transfer of knowledge and technology between foreign and Tunisian businesses. Consequently, Tunisia has struggled to position itself in higher value-added markets, resulting in a lack of competition and the creation of highly skilled jobs owing to the underdeveloped and uncompetitive innovation system.

- Slow and asymmetrical international integration: Tunisia continued its efforts to achieve international integration through negotiations for mobility cooperation with the EU and the Deep and Comprehensive Free Trade Areas (DCFTA). However, these efforts have not been pursued with consistent diligence. There has been limited progress in liberalizing trade in services, and non-tariff barriers have not been eliminated. Moreover, the interests of these agreements were unequal. Tunisia reduced tariffs on industrial goods, particularly those imported from Europe, to facilitate easier, faster, and more cost-effective entry of goods from the EU and other international leaders. Efforts have been made to eliminate non-tariff barriers. However, the EU has implemented several non-tariff barriers that hinder or limit market access.

Empirical investigations showed the following results.

From one crisis to the next, shocks have increasingly detrimental effects, as shown in Figures A.5 and A.6. Therefore, the revolution had a more detrimental effect on the TFP trend trajectory than the 2001–2002 crisis. Since the revolution, the TFP trend and its annual growth have shifted in orientation rather than level. Specifically, the TFP trajectory shifted to a more subdued path compared to the 2000s. Accordingly, TFP trend growth declined by 0.4%, dropping from 0.4% in a scenario without structural changes to 0.0% by the fourth quarter of 2010.

This observation is confirmed in Figure A.7, which shows that TFP growth has contributed minimally to potential growth. The growth has not been significantly driven by the TFP trend growth, and this component is eliminated during production.

3.4 Fourth period: 2020–2030

Similar to other nations globally, Tunisia experienced the COVID-19 pandemic in 2020 and 2021 before overcoming the challenges posed by the post-revolution period. Its economy was severely impacted by COVID-19, resulting in a GDP decline, an increase in unemployment, and challenges for both employers and employees. This crisis led to a 4.5% growth contraction in the economy, an increase in the unemployment rate to 17.4% in the fourth quarter of 2020, and insufficient growth owing to investments being blocked by restrictive monetary policies.

Similarly, lockdown measures have reduced both supply and production. They have also diminished demand and household income, contributing to an increase in poverty. Demand and supply shocks exacerbated the vulnerability of SMEs and decreased public and private investments. The supply shock has had a direct and detrimental effect on the activities of various sectors. Numerous individuals lost their jobs because of the pandemic, which has threatened the travel sector into a deeper crisis.

The recovery from COVID-19 has been notably slow. The Russian-Ukrainian war further compounded the situation by reducing international demand for Tunisian manufactured goods, particularly from the Eurozone. The resulting increase in global commodity prices has negatively impacted macroeconomic stability, particularly public finances.

The following two years witnessed some continuation of macroeconomic challenges in the absence of significant structural reforms, characterized by macroeconomic challenges remaining unresolved because of restricted structural reforms, high inflation rates, a significant trade deficit, and the conversion of some industrialization and production activities into intermediation or import trading activities, among other things. In the short term, limited capital accumulation, restrictive cash management, and a general reduction in profit margins were remedies for a poor economic situation.

The following section measures and evaluates the impact of the COVID-19 pandemic on production trend factors and the output gap. We analyzed the level and trend changes of each factor relative to the pre-shock period and examine how the relative contribution of each factor trend to potential production has evolved.

3.4.1 Capital trend

After an extended period of cyclical difficulties and several enterprises declaring bankruptcy, the capital factors that emerged from the crisis weakened. Companies may reduce their investments because of lower growth expectations and funding challenges. The accumulation of productive capital has recently decreased because of the acceleration of equipment obsolescence driven by a decline in investment.

Empirical investigations led to the following results:

Since the revolution, capital trends have declined, dropping from 3.9% in 2011Q4 to 1.8% in 2019Q4, owing to the factors previously discussed. The direction of potential growth, particularly capital trends, is unpredictable given uncertain political, social, and economic environments. How a state with a significant budget deficit will implement reforms to alter this trajectory lacks clarity. Despite these challenges, there has been a modest increase in output, particularly in the manufacturing, tourism, and agricultural sectors, which may favor capital trend accumulation, investment, and potential growth.

To better understand the evolution of capital trends up to 2030, we utilize forecasts generated by UCM estimates of capital trends, applying the Kalman filter. These predictions, although linked with the most recent data, indicate that the situation post-COVID-19 may essentially remain consistent with pre-pandemic conditions. In a stable environment conducive to capital trends accumulation, annual growth in capital may continue to rise at a rate of 1.7%, with its trajectory shifting from a decline to a more stable, horizontal orientation.

3.4.2 Labor trend

The continued prevalence of high unemployment rates following the pandemic indicates unemployment hysteresis. These results can arise from several factors, including the erosion of skills among the long-term unemployed, a mismatch between workers' skills and available job opportunities, and a decrease in job-seeking efforts. In Tunisia, these factors collectively account for this phenomenon.

Empirical investigations showed the following results.

Activity Rate Trend

The effects of COVID-19 on activity rates remain highly uncertain. Owing to the unpredictability of the post-COVID-19 economic environment, which may be influenced by forthcoming reforms, this study maintained the natural unemployment rate and activity levels at their pre-COVID-19 levels. Hence, a pandemic may not affect the activity rate in the extended period.

Working Hours Trend

The number of hours worked continued its pre-COVID-19 trajectory, accelerating despite the declines and significant fluctuations observed during the COVID-19 pandemic. This acceleration aligns with the gradual resolution of pandemic-related disruptions, such as lockdowns, reduced part-time employments, and increased sick leave. As a significant decline in hours is unsustainable, hours worked may rise as the political, social, and economic environment stabilizes and barriers to growth are removed. Thus, the effects of COVID-19 on working hours may be cyclical rather than structural.

Natural Unemployment Trend

The negative impacts of COVID-19 on the natural unemployment rate may be temporary. With appropriate policy adjustments, this rate may revert to its pre-pandemic level and trajectory. The trajectory of natural unemployment during the post-COVID-19 period was prolonged.

Labor trend

This study assumed that the labor trend will remain dynamic as it was before the pandemic, assuming that the negative impacts of COVID-19 are cyclical rather than structural.

3.4.3 Productivity trend

Productivity continued to decline at an accelerated rate. This persistent decrease is from various reasons, including the persistence of challenges affecting supply, such as phosphate and energy production, and the more pronounced effects of climate change resulting from persistent drought. Productivity was negatively impacted owing to the bankruptcy of numerous businesses and the weakening of the industrial sector following multiple shocks. Additionally, a prolonged period of low investment has led to a slowdown in equipment renewal, causing production tools to age, thereby reducing their efficiency and productivity.

The primary long-term causes include insufficient investments in research and development (R&D). The education and training system remains inadequate, with limited focus on technology, innovation, and R&D. Practical skills remain underdeveloped compared to theoretical knowledge, and job-creating sectors lack new specialties to meet their needs. Moreover, the private sector has not sufficiently benefited from government initiatives to boost job creation, while the informal sector suffers from reduced worker vulnerability and limited improvements in worker quality.

The Tunisian labor market is characterized by stringent dismissal procedures, which restrict its ability to the new economic conditions caused by trade liberalization. Additionally, salaries are determined by a centralized collective system that, independent of labor productivity, generates comparable compensation regardless of differences in firm size, location, sector, or company within the same sector. Consequently, wage increases have not kept pace with productivity growth, negatively impacting the competitiveness of both the workforce and industries. This decline in worker productivity has made businesses less competitive and discouraged investors from investing in new projects and capturing FDI.

Empirical investigations showed that, following the crisis, the productivity growth trend significantly improved, increasing at an annual rate of 0.3% as opposed to -0.1% if the crisis and its repercussions did not occur. By 2030, the trend productivity might reach a pre-crisis level of 0.055 if the current trends continue (Figure A.5). The contribution of productivity trend growth post-COVID-19 would account for approximately 30%, including a negligible share before the crisis (Figure A.6).

4. Conclusion

This study assessed the productive potential and cyclical position of the Tunisian economy and investigated their responses to major shocks beyond a Cobb-Douglas production function with constant returns to scale using UCM and quarterly data spanning the years 1989 to 2023. Based on various indicators, we constructed the number of hours worked by employees by quarter series, considering sectors, regions, gender, agglomeration, and study background. Additionally, we created the number of hours worked per employee by quarter series based on various indicators, including sector, geography, gender, agglomeration, and educational background. Furthermore, to compute natural unemployment, we employed a nonparametric method based on the Beveridge curve, which yielded more accurate results compared to the multivariate parametric approach based on the Philips curve.

We determined and analyzed the potential growth, its factors' trends and contributions, and the output gap. We derive forecasts from smoothed trends for the 2030 timeframe. We also examined shifts in potential growth and its factors from pre-crisis to subsequent subperiods, exploring the causes and impacts of various crises on the contributions of potential growth components.

Since the 1990s, there has been a declining trend in potential GDP growth. All indicators of potential growth exhibit a consistent and substantial decrease following significant shocks, as the factors driving growth gradually weaken. Adverse events, particularly the COVID-19 epidemic and the global financial crisis, were pivotal in this decline. National recessions, such as droughts, terrorism, and revolutions, also reduced potential growth. Conversely, persistent recessions have led to slower trends in employment, investment, and productivity growth.

The GDP growth path shows four phases separated by three structural breaks: the first was caused by the drought and terrorist attacks between 2001 and 2002, the second caused by the 2011 revolution, and the third was related to the COVID-19.

These results suggest that Tunesia has failed to sustain high potential output growth rates over the last 40 years. The country could not halt the significant deceleration of potential output that began in the 2010s or avoid the negative potential growth differentials by 2020–23.

Following the first shock, TFP decreased by 0.3%. Despite the compensating effects of other factors, this led to a slight increase in the potential GDP growth pattern and level. The second shock resulted in a 1.3% average decline in the level and a subsequent modification in growth progression, slowing it. Compared to the preceding shocks, the third shock caused a more noticeable shift in the level, averaging a 1.2% decrease, although it did not affect the potential GDP trend.

The primary driver of the output gap is the TFP gap which generates a noticeable slowdown during crisis years and a relatively significant and sustained positive output gap during prosperous years. The output gap was largely offset by the contributions of capital and, to a lesser extent, labor gaps, which mitigated the productivity shortfall.

Essentially, the activity rate, gap, explains the contribution of the labor gap. The employment gap contribution is significant during structural breaks. The contribution of the gap in hours worked was dominant in the COVID-19 shock and weak in the other shocks.

The analysis presented here involves a significant degree of uncertainty. Determining the direction of the output gap necessitates comprehensive economic analysis rather than reliance on a single model. Changes in the output gap, and consequently in the potential output, are more robust than the Non-Accelerating Wage Rate of Unemployment (NAWRU) and potential output levels.

Future studies must include more observables to the model (such as R&D, educational attainment, innovation, and technology diffusion indicators) to improve our understanding of endogenous TFP growth, explain the evolution of potential TFP, and strengthen the robustness of the findings.

More complex techniques such as dynamic factor analysis or Markov switching models can be adapted to further investigate the empirical distributions of the variables and enhance the comprehension of the results. Future studies can also develop real or financial indicators to forecast cyclical turning points, particularly during recession and slowdown phases.

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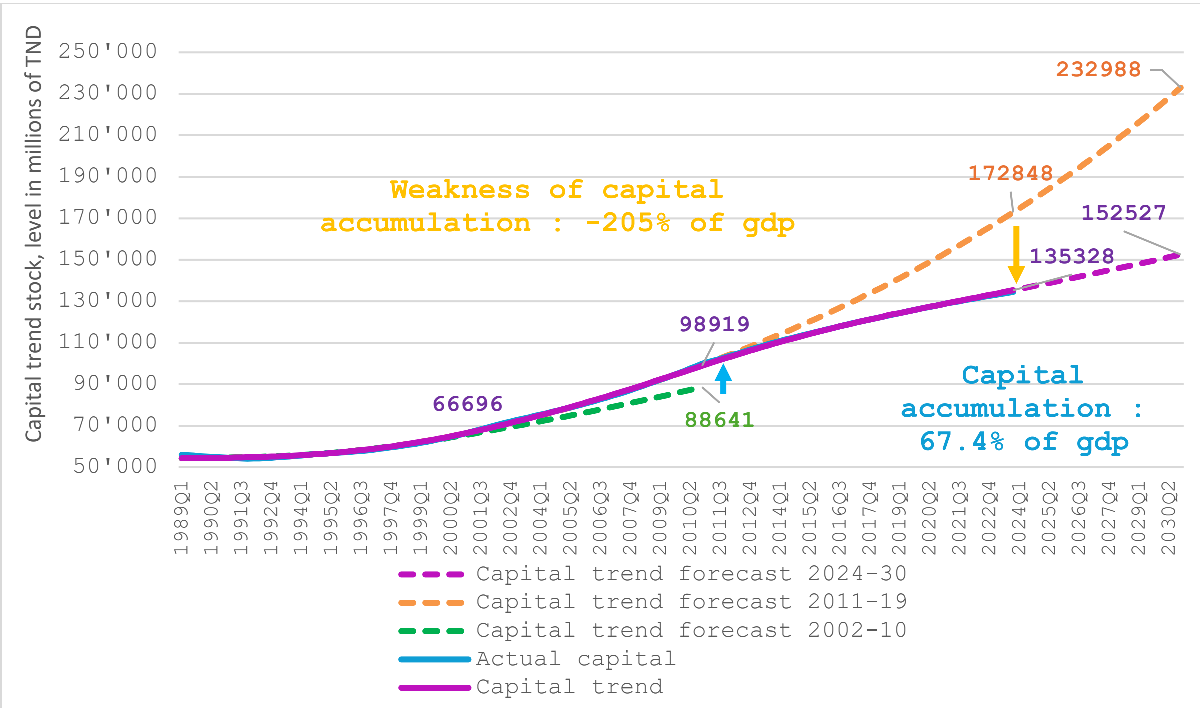
Appendices

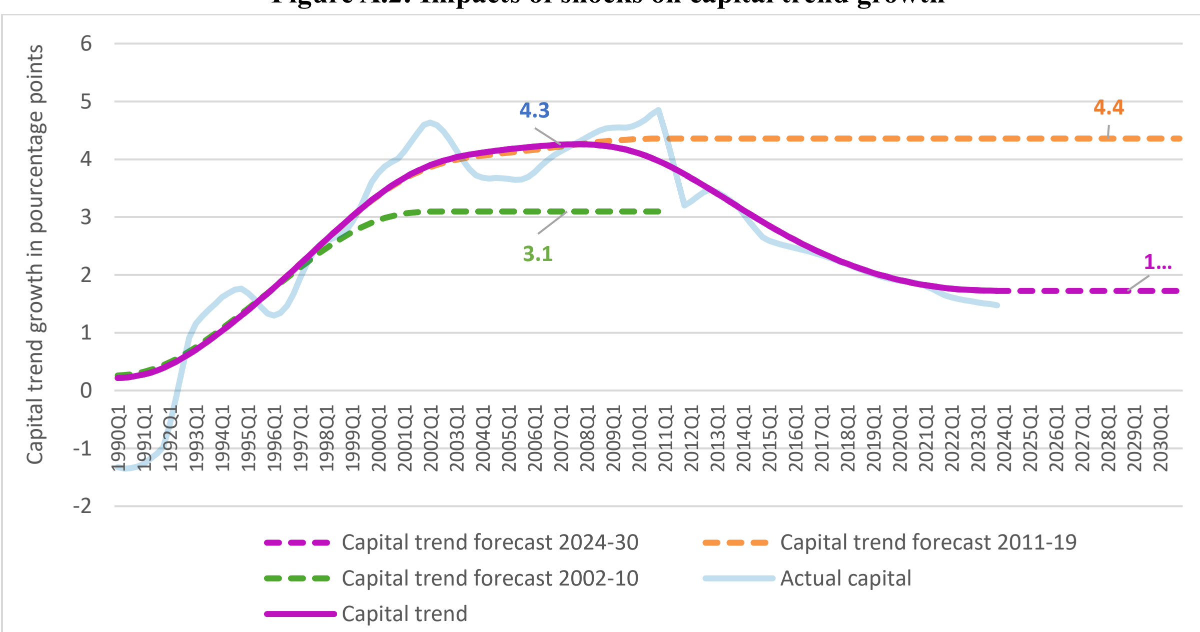
Additional Figures

Figure A.1: Impacts of shocks on capital trend level



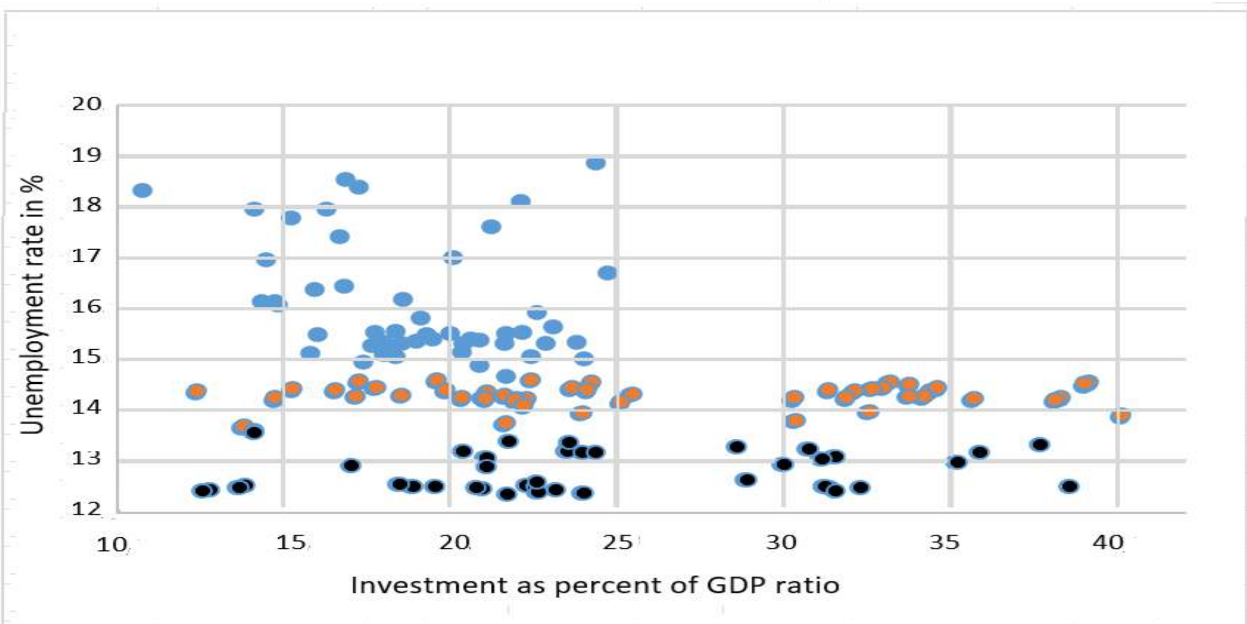
Source: INS and author calculations

Figure A.2: Impacts of shocks on capital trend growth



Source: INS and author calculations

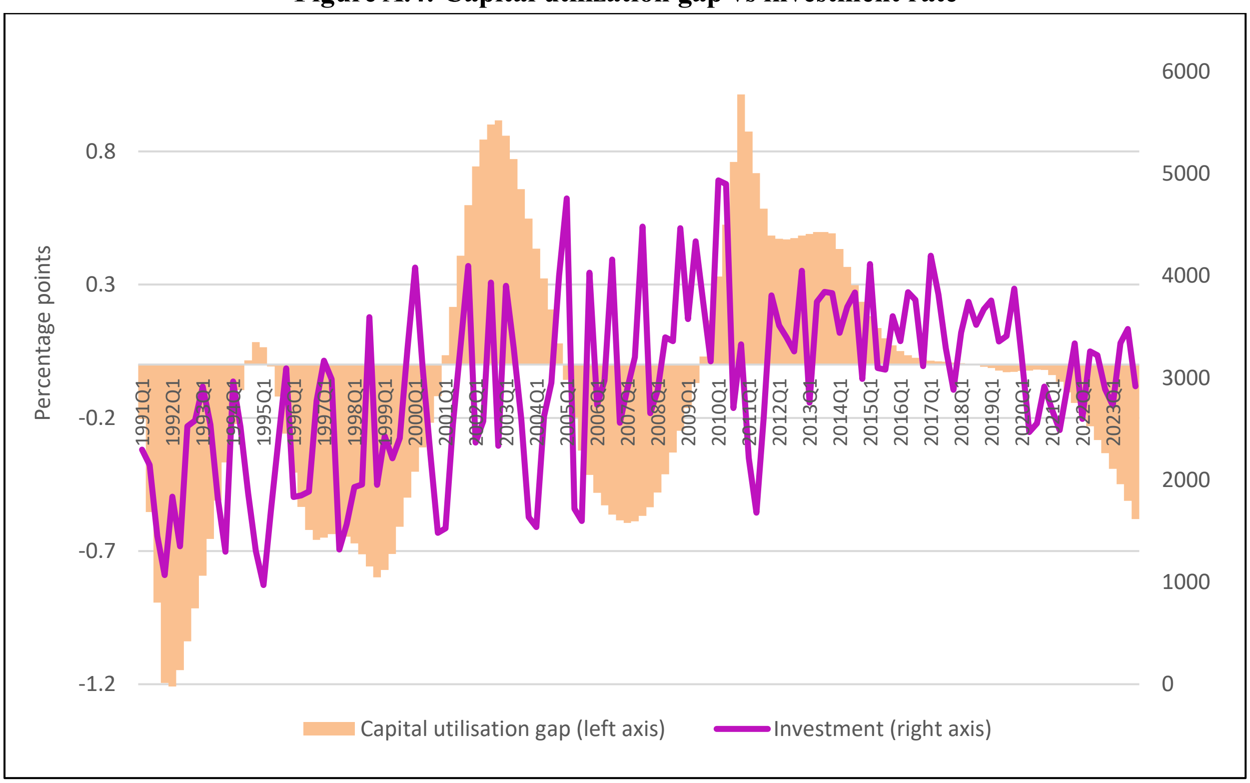
Figure A.3: Unemployment rate to investment rate as the percentage of GDP ratio



Source: INS and author calculations

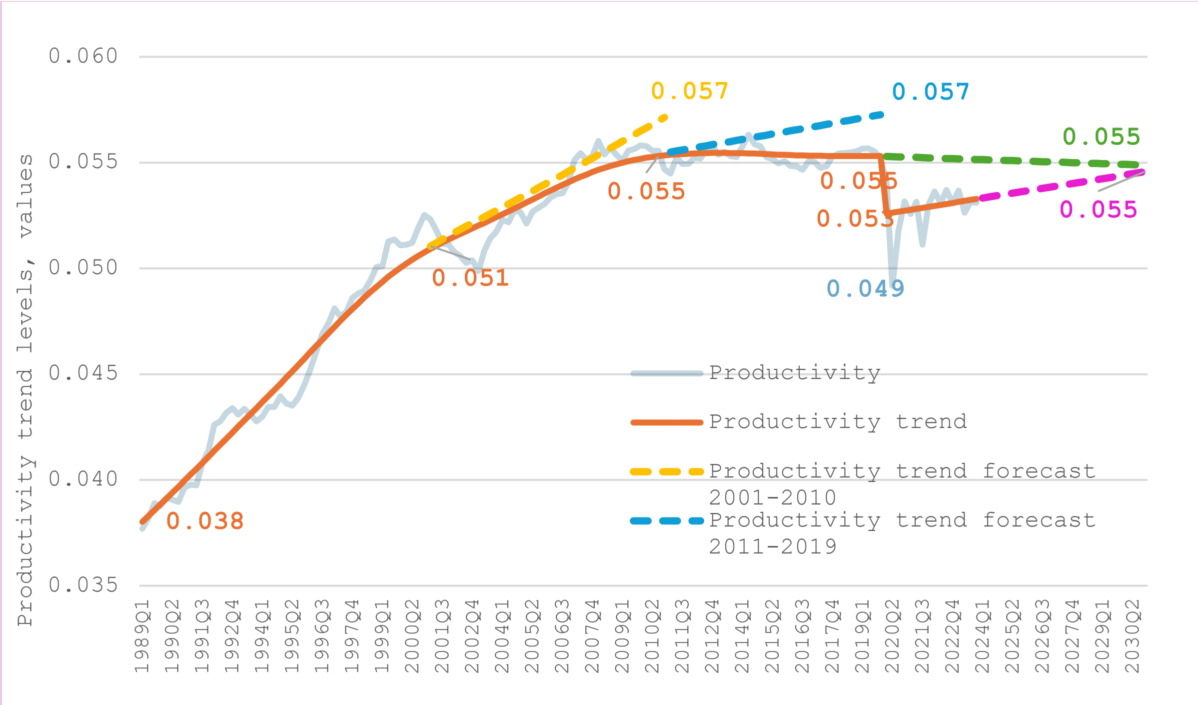
Notes: blue color: 2011Q1–2023Q4, orange color: 2003Q1–2010Q4 and black color: 1989Q1–2003Q1

Figure A.4: Capital utilization gap vs investment rate



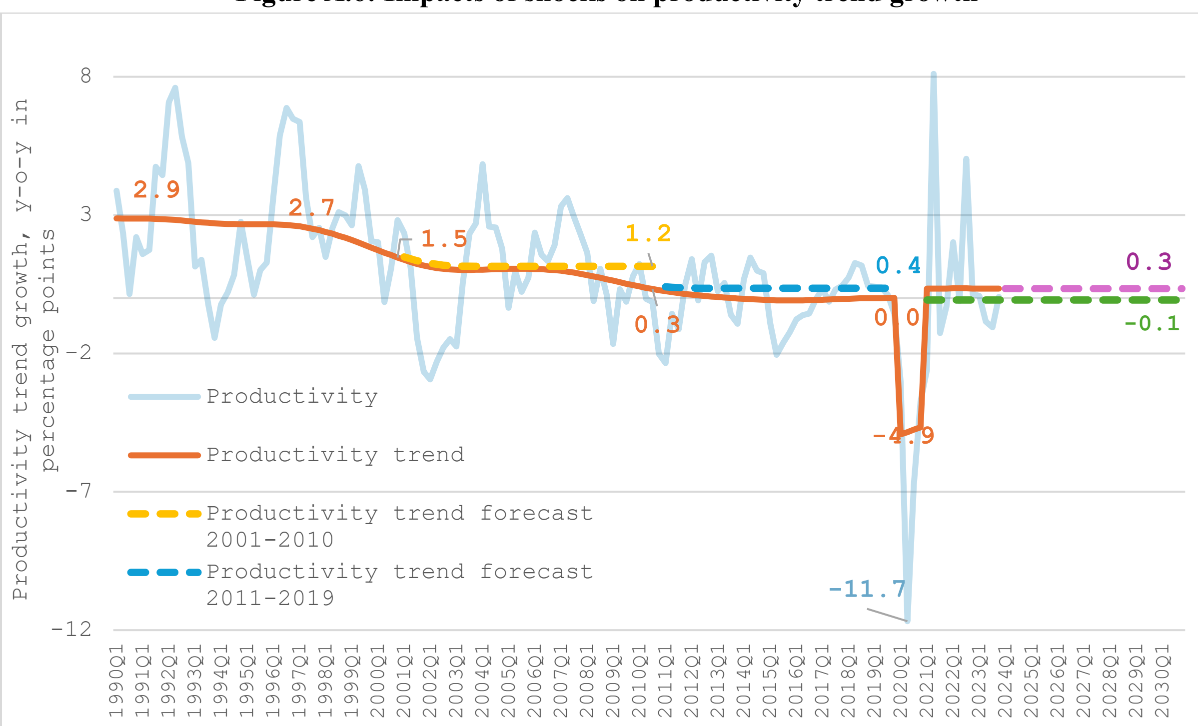
Source: INS and author calculations

Figure A.5: Impacts of shocks on productivity trend level



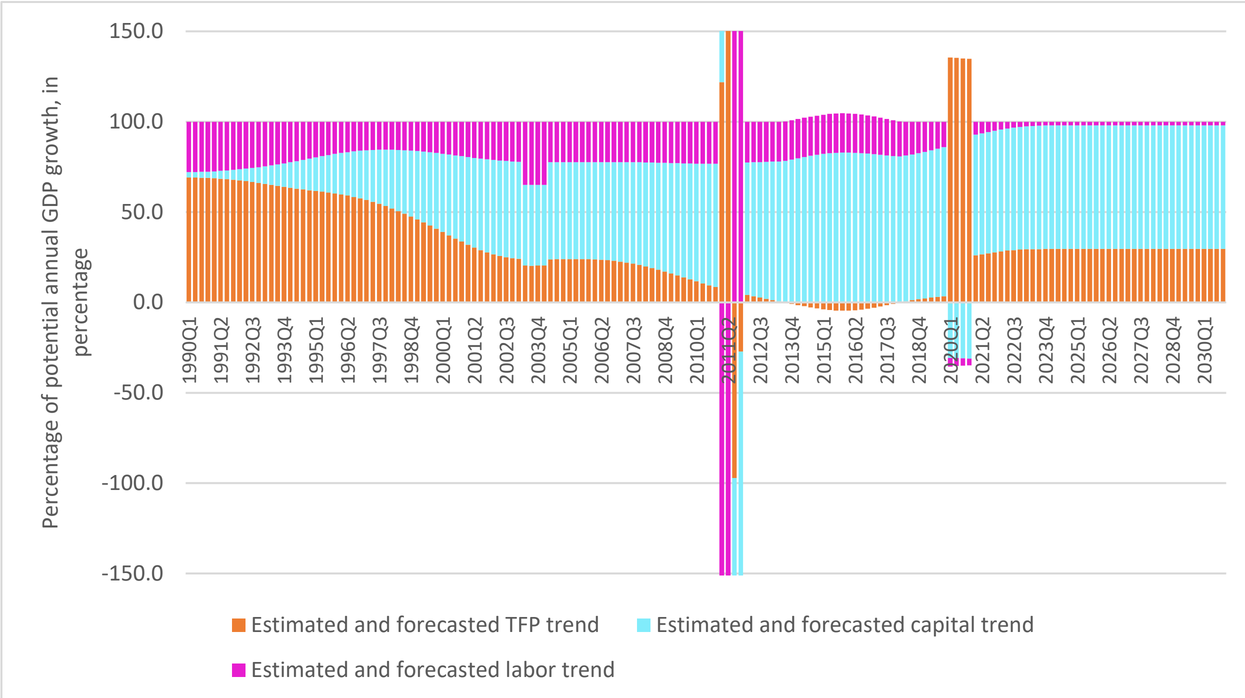
Source: INS and author calculations

Figure A.6: Impacts of shocks on productivity trend growth



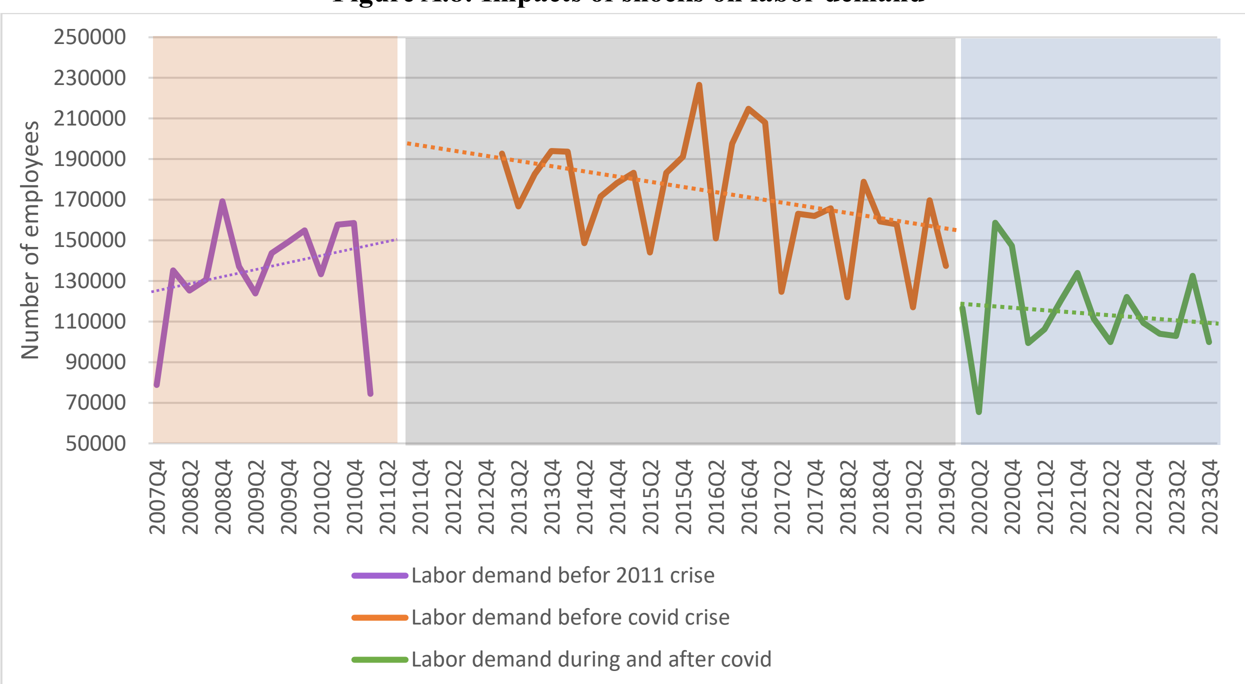
Source: INS and author calculations

Figure A.7: Contributions of production factors to potential GDP growth



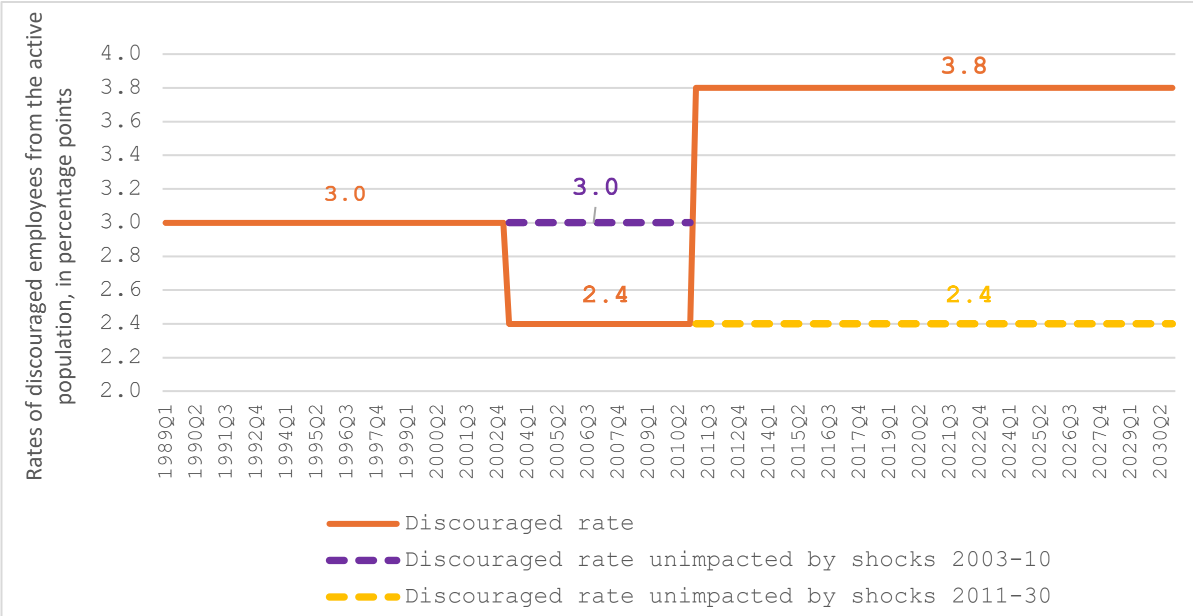
Source: INS and author calculations

Figure A.8: Impacts of shocks on labor demand



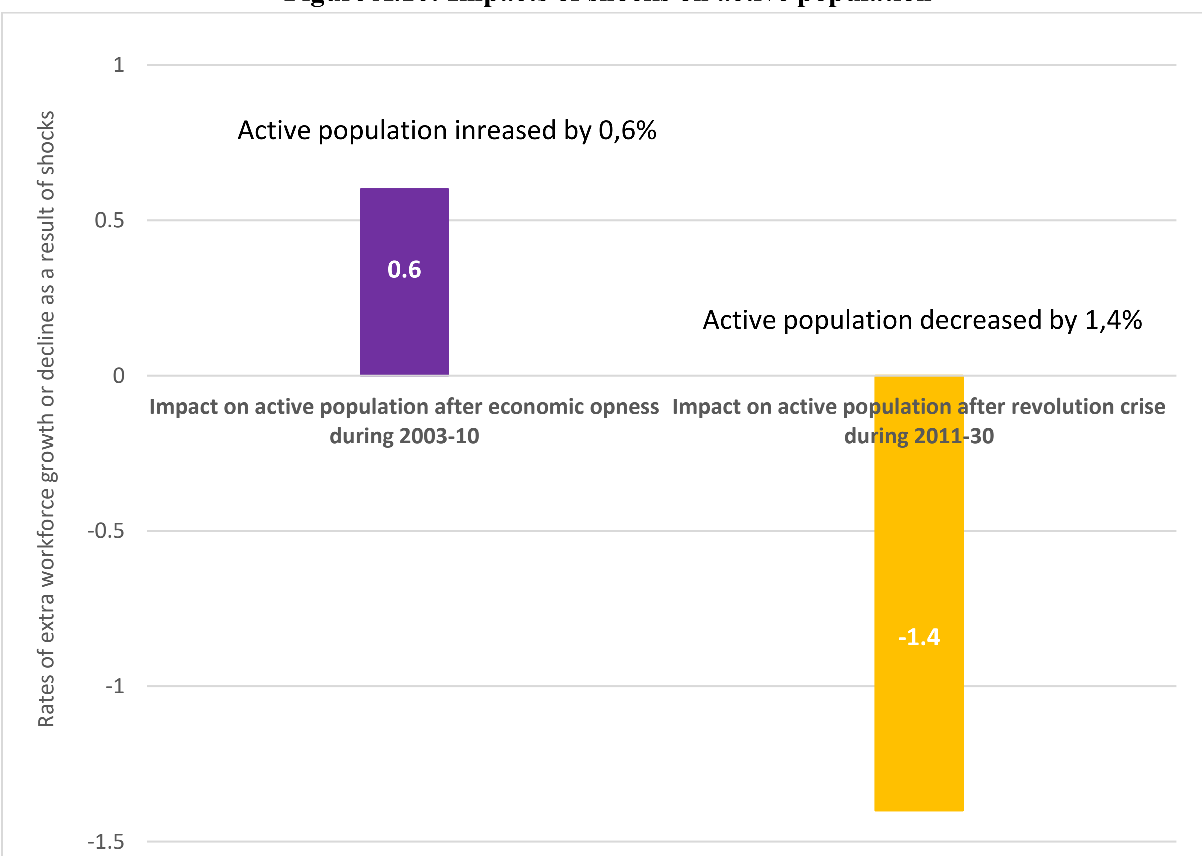
Source: INS and author calculations
Notes: Dashed lines are linear trends

Figure A.9: Impacts of shocks on discouraged employees' rates



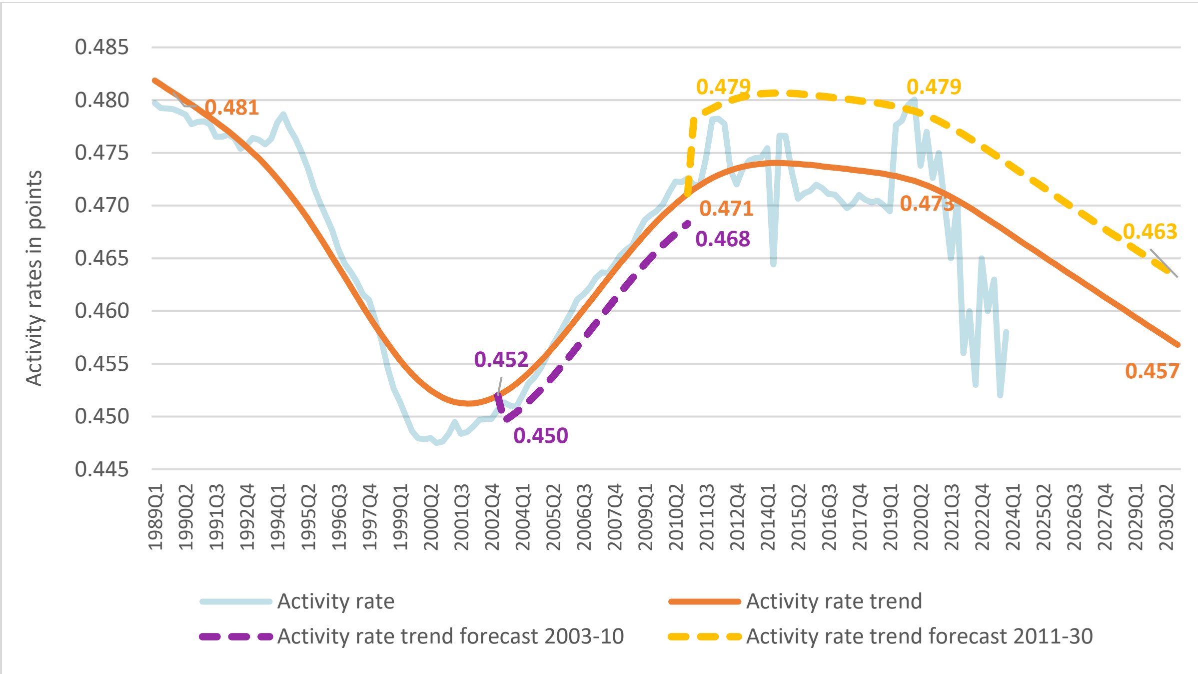
Source: INS and author calculations

Figure A.10: Impacts of shocks on active population



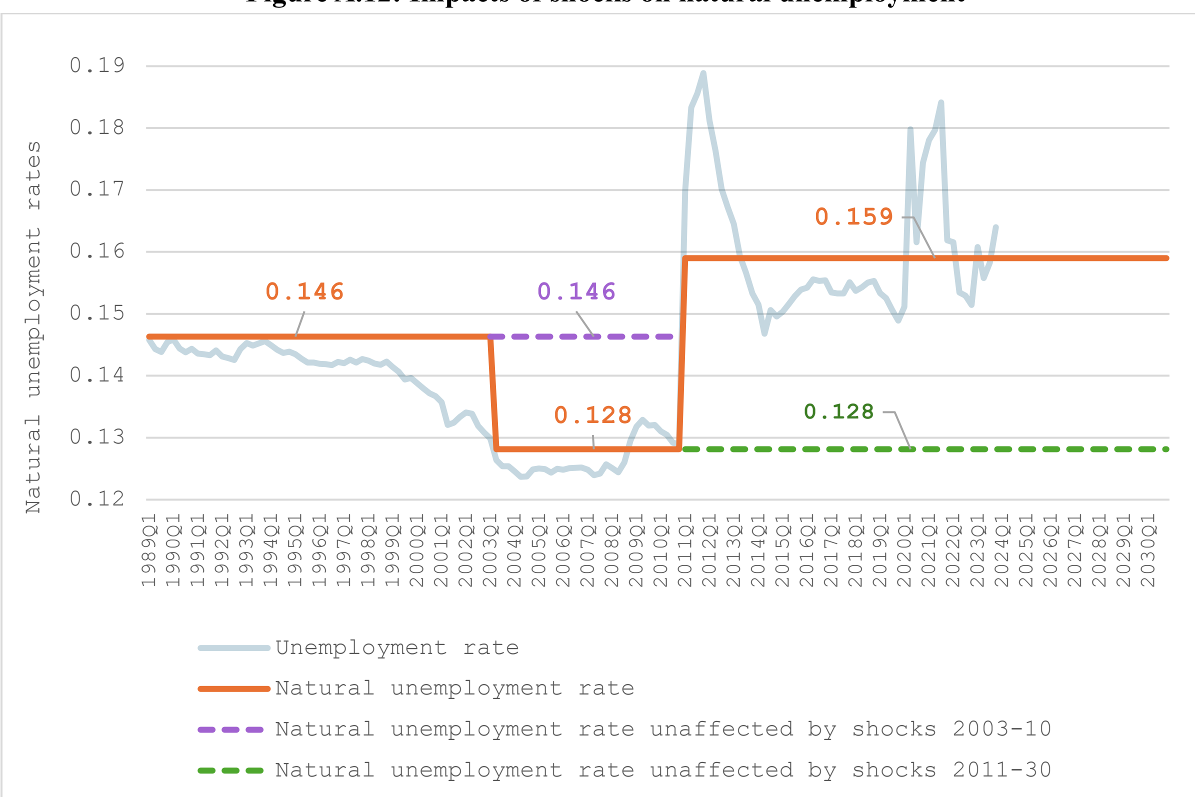
Source: INS and author calculations

Figure A.11: Impacts of shocks on activity rates trend



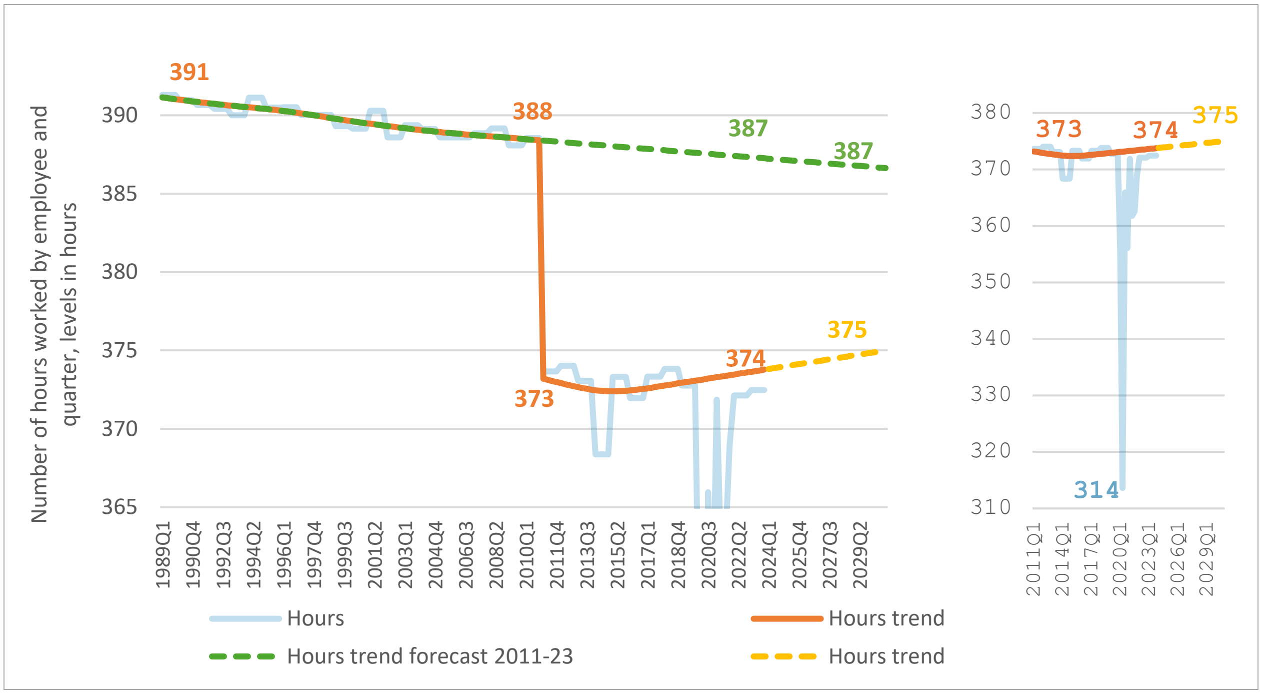
Source: INS and author calculations

Figure A.12: Impacts of shocks on natural unemployment



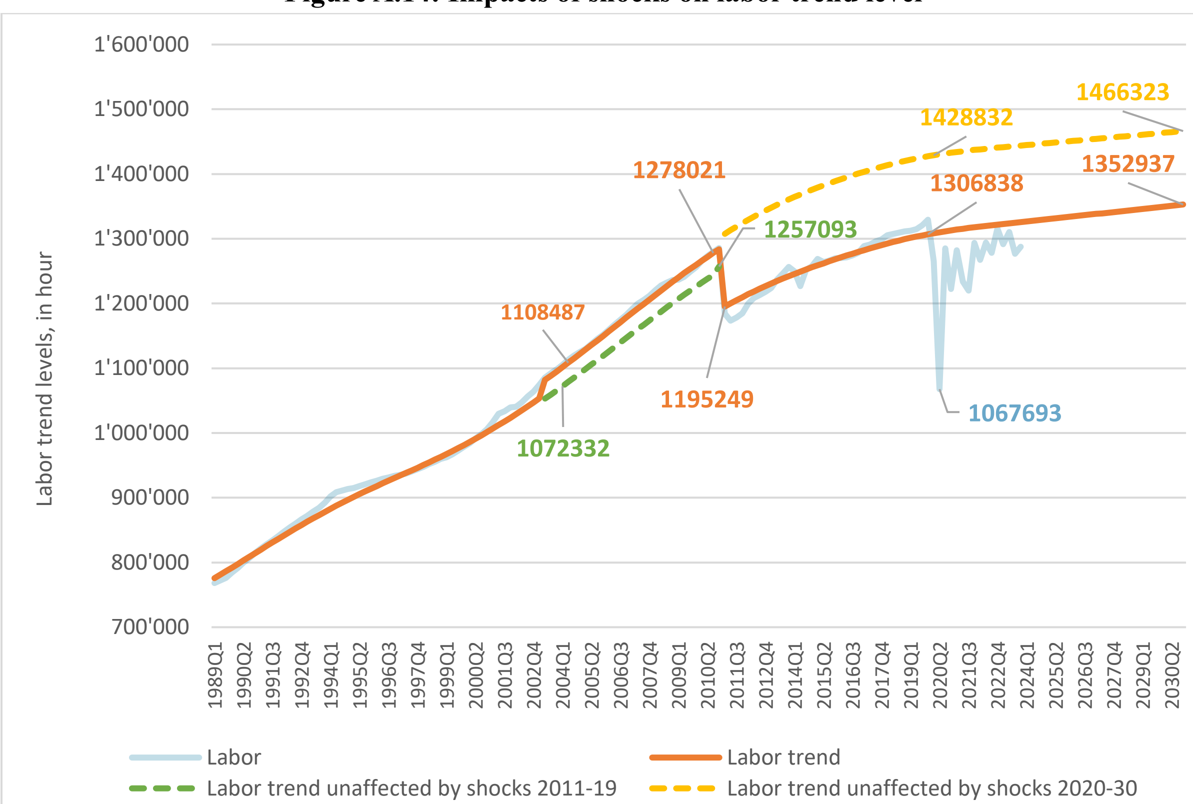
Source: INS and author calculations

Figure A.13: Impacts of shocks on number of hours trends worked by employee and quarter



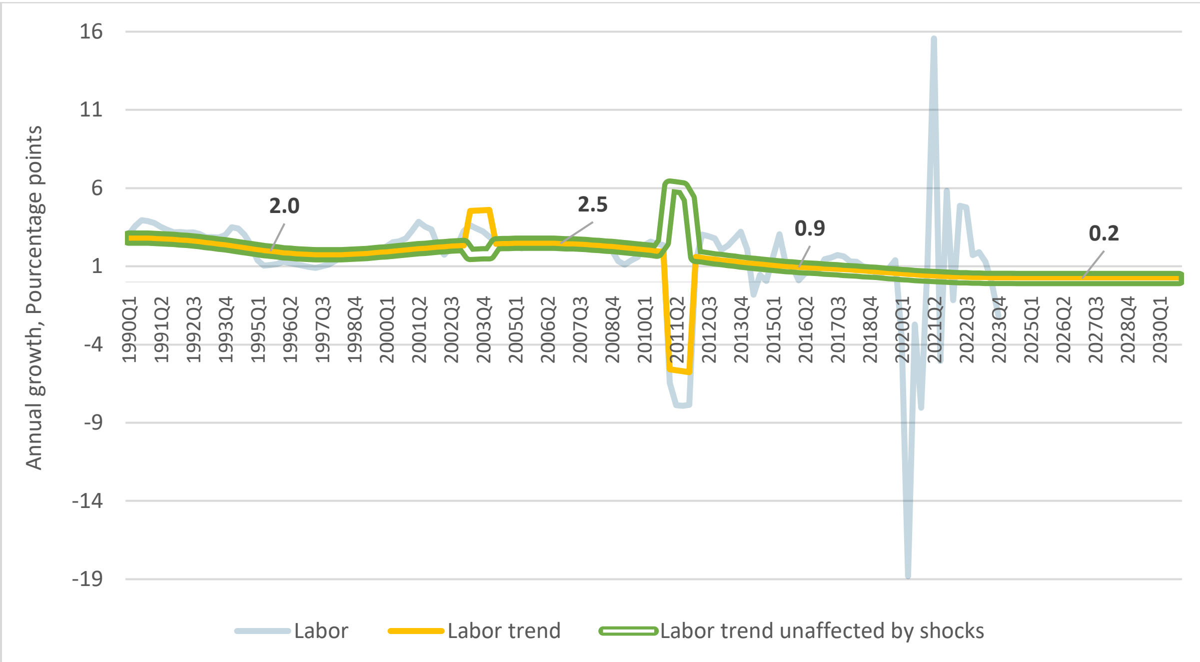
Source: INS and author calculations

Figure A.14: Impacts of shocks on labor trend level



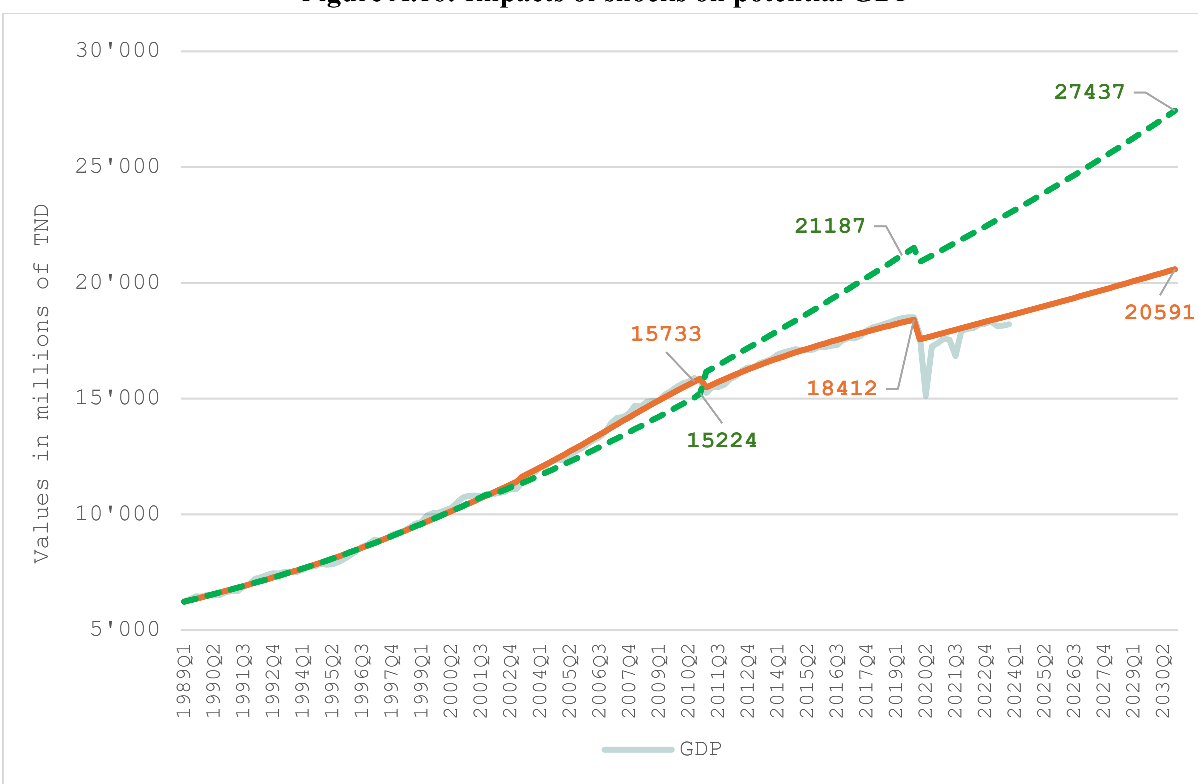
Source: INS and author calculations

Figure A.15: Impacts of shocks on labor trend growth



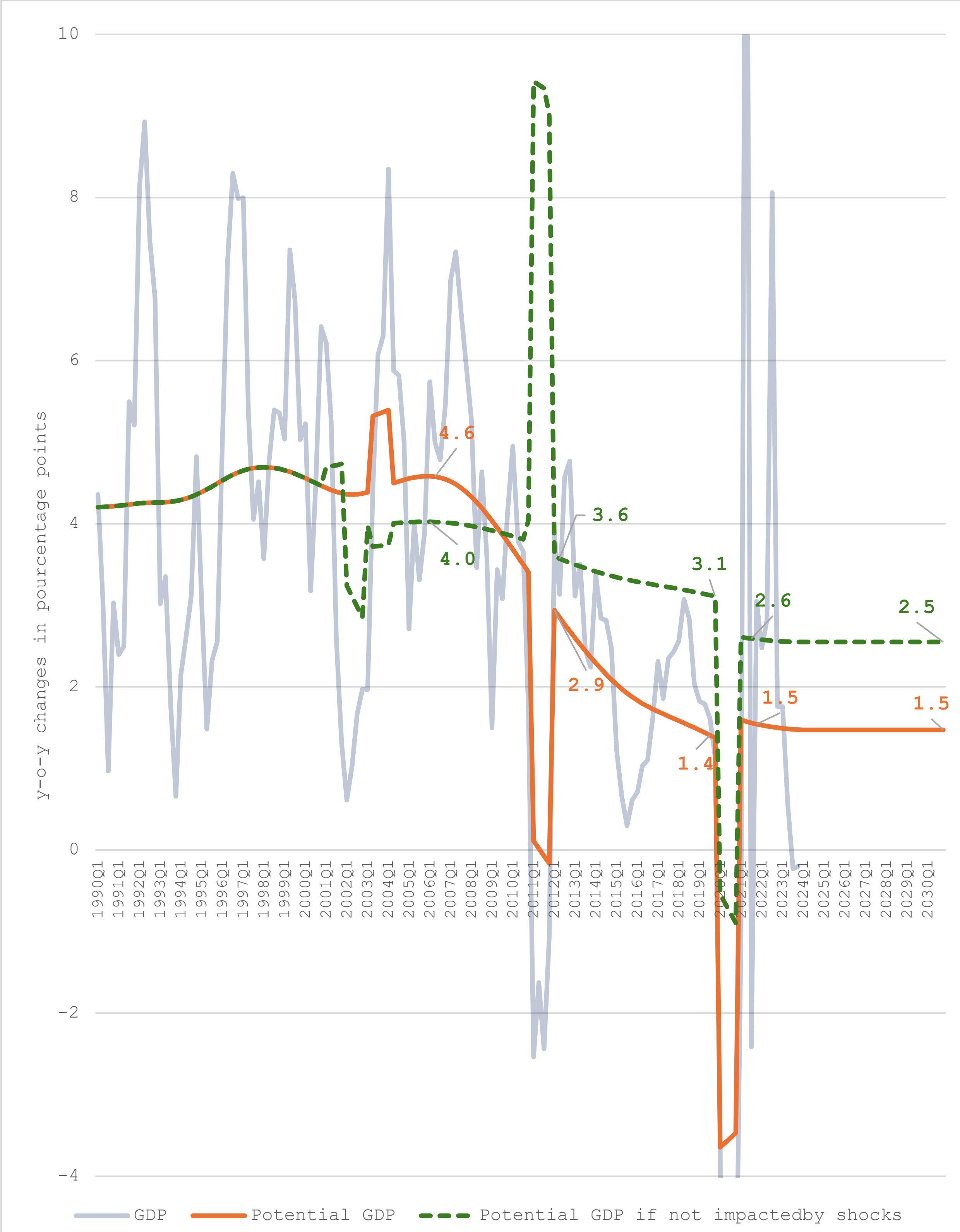
Source: INS and author calculations

Figure A.16: Impacts of shocks on potential GDP



Source: INS and author calculations

Figure A.17: Impacts of shocks on potential GDP growth



Source: INS and author calculations