# MASTER

M.SC. IN ECONOMICS

# MASTER´S FINAL WORK

DISSERTATION

BUSINESS CYCLE ACCOUNTING IN 21ST CENTURY ANGOLA

BENTO GREGÓRIO MARIA

OCTOBER - 2024

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**SUPERVISION:**
LUÍS F. COSTA

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## GLOSSARY

BCA – Business Cycle Accounting.

BNA – *Banco Nacional de Angola*

GDP – Gross Domestic Product.

GFCF – Gross Fixed Capital Formation.

IMF – International Monetary Fund.

INAGBE – *Instituto Nacional de Gestão de Bolsas de Estudo.*

INE – *Instituto Nacional de Estatística.*

JEL – Journal of Economic Literature.

MFW – Master's Final Work.

OLS – Ordinary Least Squares.

PWT – Penn World Table.

ABSTRACT

The aim of this dissertation is to analyse business-cycle fluctuations in 21st Century Angola, using quarterly data from 2002:I to 2022:IV. For that purpose, I use the Business Cycle Accounting (BCA) approach to estimate the time-varying wedges that separate actual data from artificial data produced by a frictionless model. I conclude that the investment wedge exhibits the best performance for output, followed by government and efficiency wedges. In addition, I also conclude that government wedge exhibits the best performance for investment and hours worked, followed by investment wedge (for investment) and efficiency wedge (for hours worked). Additionally, I divide the analysis into four sub-periods: expansion (2002:I – 2008:IV), stagnation (2009:I – 2014:II), crisis (2014:III – 2019:IV), and the pandemic (2020:I – 2022:IV). The results show that the investment wedge performs best during expansion, the efficiency wedge dominates during stagnation and the pandemic period, and the government wedge plays the most significant role during crises.

KEYWORDS: Business Cycle Accounting; Wedges; Angolan Economy.

JEL CODES: C10; C13; C51; C63; C87; E32.

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## STATEMENT

I declare that I have used ChatGPT resources as an additional tool in the preparation of my dissertation.

The use of this technology was focused on grammatical and stylistic corrections, as well as on assisting with technical details for resolving some coding issues during programming.

Regarding grammatical correction, generative artificial intelligence was used to review and suggest improvements in some textual passages, aiming at clarity for the reader as well as correcting grammatical errors, without altering the original content or the overall structure of the work.

Regarding the assistance with technical details used in programming, it was consulted at times to clarify specific questions about implementation and coding best practices, particularly in code automation, without altering the original context of the code.

I emphasize that at no time was direct copying of the content suggested by the tool used, and all suggestions were reviewed and adapted according to the specific context of the work. Artificial intelligence was used as an auxiliary resource, similar to other consultation and review tools, respecting ethical and copyright norms.

## Acknowledgments

I am grateful to the Government of Angola for the financial support provided through the annual programme that sends three hundred Angolan graduates and master's students with high academic performance and merit to the best universities in the world, 2021/2022 edition. I am also especially indebted to the staff at *INAGBE* and INE for all their support. Additionally, I would like to express my gratitude to my dissertation supervisor for the invaluable guidance provided throughout these years of my master's degree in Economics, particularly in the area of Macroeconomics.

BUSINESS CYCLE ACOUNTING IN 21ST CENTURY ANGOLA

By Bento Gregório Maria

In this Dissertation was analysed causes of fluctuactions using a BCA methodology, for Angolan Economy, during first quarter 2002 to last quarter 2022. Using BCA methodology, I concluded that Investment wedge shows the best performance for output, while government wedge shows the best performance for Investment and hours worked, respectively.

## 1. INTRODUCTION

Angola, as an African economy heavily dependent on natural resources, has faced challenges regarding stability and economic diversification. With a population of 35 million and a GDP per capita (in PPP) of 1,771,232.92 million (in national currency), it is considered the second largest oil producer in Africa. The oil sector accounts for 31.1% of GDP, followed by 22.5% for trade and 10.3% for agriculture (INE, 2024).

The aim of this dissertation is to analyse the potential groups of causes that can explain fluctuations in aggregate economic activity in Angola between 2002:I and 2022:IV. In order to do that, I use the BCA methodology developed by Chari et al. (2007), as it offers a framework that allows for the decomposition of business-cycle fluctuations into different components, or wedges. Applying this method to Angola can help identify groups of possible causes of macroeconomic fluctuations in the 2002:I – 2022:IV period. These wedges leading to fluctuations may emerge from both domestic and external factors (Brinca et al., 2016).

Frequent fluctuations in oil prices have led to significant expansion and contraction cycles that affect production, employment, and social welfare. However, little has been done to develop studies of this nature to understand their causes and attempt to answer questions such as: What are the main causes of macroeconomic fluctuations in Angola during the 21st century?

For this dissertation, I apply the BCA methodology to analyse economic fluctuations in the Angolan economy in the 21st century, as well as the groups of possible causes that may have generated them, especially during periods of economic recession.

The relevance of this study lies in its contribution to understanding the causes of economic fluctuations in Angola, as applying BCA is expected to provide a more detailed view of the factors driving economic expansions and recessions in the country.

Additionally, this dissertation contributes to the literature on business cycles in resource-dependent economies, an area that still lacks detailed research, especially in the African context. From my search into bibliographic databases, I concluded that applications of the BCA methodology to in African countries are scarce.

## 2. LITERATURE REVIEW

The seminal paper in BCA methodology was introduced in 2002, to explain fluctuations during great depression with topic “Accounting for the great depression”, that helped researchers to develop a quantitative model of economic fluctuations, and consolidated in 2007, where were introduced distortions (wedges), to explain causes of macroeconomic fluctuations, things that for instance others models as Real Business Cycle (RBC) cannot explain (Chari et al., 2004) and (Chari et al., 2007). Since then, numerous researchers have expanded the BCA methodology, particularly in refining the analysis of various wedges. These advancements generally follow two key steps: first, estimating the wedges, and second, explaining the observed macroeconomic movements in the data (Brinca et al., 2024). Together, these studies have significantly deepened the application of BCA to better understand the sources of business cycle fluctuations across different economies.

In the literature on the efficiency wedge, Chari et al. (2007) made a seminal contribution by identifying the role of distortions as a key driver of aggregate productivity, establishing a foundation for subsequent research in this area. Simonovska & Soderling (2014) contributed to the empirical computation of the efficiency wedge by formalizing its representation through the production function, emphasizing the time-varying nature of productivity shocks. Brinca et al. (2016) synthesized much of this research, providing a comprehensive review of the methodologies used to measure and interpret efficiency wedges across different economies and contexts. Abreu (2018), further contributed by providing insights into the role of TFP shocks in the context of the Portuguese economy, expanding the geographical application of BCA. Brinca et al. (2020) advanced this by the measurement of technology parameters used to represent these distortions, applying the BCA framework to modern datasets. Arouca (2023) applied BCA to Portugal during the Great Recession and Financial Crisis, concluding that the efficiency wedge played the most significant role in explaining movements in output, investment, and hours. Brinca & Costa-Filho (2024), offered a comparative analysis, applying the framework to Mexico, enhancing the understanding of how efficiency wedges vary across emerging markets.

In the literature on the labour wedge, Costa-Filho (2018) expanded on this by emphasizing how the labour wedge creates deviations from the optimal conditions governing labour decisions, offering a more nuanced understanding of how these distortions impact both labour demand and supply. Additionally, Brinca & Costa-Filho (2024) underscored the importance of jointly measuring labour demand and supply, arguing that they cannot be separately identified within the BCA framework, providing a deeper insight into the complexity of labour market distortions.

In the literature on the investment wedge, Brinca & Costa-Filho (2024) contributed by linking it to the intertemporal substitution between current and future consumption, derived from the combination of the consumption Euler equation and firms' Euler equation. His work highlights how this wedge manifests as a time-varying tax on investment, influencing the decisions regarding investment and savings over time. This approach has deepened the understanding of how investment distortions affect economic dynamics through the lens of BCA, particularly in the context of intertemporal choices.

In the literature on the government consumption wedge, Brinca et al. (2016) provided a broader survey of the literature, emphasizing the importance of accounting for government spending in explaining macroeconomic fluctuations. Brinca & Costa-Filho (2024) contributed by analysing the fluctuations in net government spending and net exports, expanding the scope of BCA to include fiscal dynamics. Brinca et al. (2024) introduced a new assumption that advanced the understanding of government consumption, although they acknowledged that the original pioneers in BCA did not directly address this wedge, thus refining and expanding the framework to incorporate government fiscal policies.

Business Cycle Accounting (BCA) has been widely applied to numerous countries, providing valuable insights into the sources of economic fluctuations across diverse economic contexts. In Portugal, Cunha (2006) and Iskrev (2013) utilized BCA to analyse the drivers of economic cycles, revealing key distortions affecting the country's growth and recessions. Kabundi & Loots (2007) applied the framework to several countries in the Southern African Development Community (SADC), shedding light on how regional economic policies and external shocks influence the business cycles of these economies. Chile's business cycles were explored by Simonovska & Soderling (2014), who used

BCA to highlight the importance of time-varying productivity in the country's economic dynamics. The framework has also been extended to broader regions, with Brinca et al. (2016) conducting comprehensive analyses of Europe and several American countries, showcasing how BCA can provide a comparative understanding of economic fluctuations across different institutional and policy environments. Enisan & Tolulope (2019) and Aigheyisi (2018) expanded the discussion to other African contexts, further illuminating the potential of BCA in understanding the economic challenges faced by developing economies. In Africa, although the literature on BCA is still limited, there are notable contributions. Okhankhuele (2020) and Alege (2012) examined the Nigerian economy using BCA, identifying key wedges, such as inefficiencies in labour and investment, which constrain growth. In Mexico, Brinca & Costa-Filho (2024) applied the framework to investigate the country's macroeconomic fluctuations, emphasizing the role of investment and government consumption wedges in shaping Mexico's economic performance.

## 3. THE BCA MODEL

In this chapter, I closely follow Chari et al. (2007), who divide their analysis into two sections: the first consists of estimating wedges, and the second aims to explain observed movements in the data.

During the estimation of wedges, it is necessary to compute the efficiency wedge, labour wedge, investment wedge, and government wedge. These wedges are equivalent to distortions in the economy (Brinca et al., 2016), (Brinca et al., 2024).

### *3.1. Prototype Economy*

The prototype economy is a frictionless idealised artificial economy that can serve as a benchmark with each we can compare the actual data. In this prototype economy, the representative consumers maximise their expected discounted lifetime utility over per capita consumption and labour for each possible state of nature $s^t$ in period $t$:

$$\max_{c_t, l_t, , k_{t+1}} \sum_{t=0}^{\infty} \sum_{S^t} \pi_t\,(s^t)\beta^t U\big(c_t(s^t), l_t(s^t)\big)N_t, \tag{1}$$

where $c_t$ represents per capita consumption, $l_t$ stands for labour, $\pi_t(s^t)$ denotes the probability of a given state of nature $s^t$, $N_t$ represents population, $k_t$ stands for capital, $U(\bullet)$ is derivative of utility function, and $0 < \beta < 1$ denotes discount factor.

Subject to the following budget constraint for all $t \geq 0$ and $s^t$:

$$c_t(s^t) + \left(1 + \tau_{xt}(s^t)\right)x_t(s^t) = \left(1 - \tau_{lt}(s^t)\right)\omega_t(s^t)l_t(s^t) + r_t(s^t)k_t(s^t) + T_t, \quad (2)$$

where $x_t$ represents investment per capita, $\omega_t$ stands for wage rate, $r_t$ is rental rate of capital, $T_t$ denotes per capita lump-sum transfers from the government to households, $\tau_{xt}$ represents tax on investment, and $\tau_{lt}$ stands for tax on wages; and the capital accumulation equation assuming a convex adjustment cost:

$$(1+\gamma)k_{t+1}(s^t) = (1-\delta)k_t(s^{t-1}) + x_t(s^t) - \phi\left(\frac{x_t(s^t)}{k_t(s^{t-1})}\right), \quad (3)$$

where $\phi(\bullet)$ represents the per unit cost of adjusting the capital stock, $\gamma \geq 0$ stands for technological growth rate, and $0 < \delta < 1$ is the depreciation rate.

The representative firm sell its product, rent capital, and hire labour in perfectly competitive markets in order to maximise profits:

$$\max_{k_t, l_t} \Pi_t(s^t) = y_t(s^t) - r_t(s^t)k_t(s^{t-1}) - \omega_t(s^t)l_t(s^t), \quad (4)$$

where $y_t$ represents per capita output and we use it as the *numéraire* for our artificial economy; subject to the following technological constraint:

$$y_t(s^t) = A_t(s^t)F\left(k_t(s^{t-1}), (1+\gamma)^t l_t(s^t)\right), \quad (5)$$

Where $A_t$ denotes total factor productivity, $k_t$ *and* $l_t$ represent capital and labour respectively.

The government faces the balanced-budget constraint below:

$$G_t(s^t) + T_t(s^t) = \tau_{xt}(s^t)x_t(s^t)N_t + \tau_{lt}(s^t)\omega_t(s^t)l_t(s^t)N_t, \quad (6)$$

Where $G_t$ denotes government consumption.

Notice that $\tau_{lt}$ and $\tau_{xt}$ introduce a distortion in (intra- and inter-temporal) relative prices, which means that the decentralised equilibrium in this prototype economy is not Pareto optimal. The adjustment cost $\phi(\bullet)$ also introduces a friction that induces a deviation from a frictionless balanced-growth path, but we can see it as more of a technological constraint. Non-zero $G_t$ and $T_t$ reduce welfare, but they are non-distortionary. Finally, $A_t$ works as a productivity deviation from the balanced-growth path, which would increase welfare if could be made stable (alas, it cannot).

Put together equations 2 and 3 and 5, will become:

$$y_t(s^t) = c_t(s^t) + x_t(s^t) + g_t(s^t), \tag{7}$$

Where $c_t$, $x_t$ and $g_t$ denote per capita consumption, per capita investment and per capita government consumption respectively.

From the first-order conditions for both the representative household and firm, we obtain the following (optimal) equilibrium conditions:

$$-\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)} = \left(1 - \tau_{lt}(s^t)\right)A_t(s^t)(1+\gamma)F_{l,t}, \tag{8}$$

$$U_{c,t}(s^t)\left(1+\tau_{xt}(s^t)\right) = \beta \sum_{s^{t+1}} \pi_t(s^{t+1}|s^t)\left[U_{c,t+1}(s^{t+1})A_{t+1}(s^{t+1})F_{k,t} + (1-\delta)\left(1+\tau_{x,t+1}(s^{t+1})\right) + \phi_{k_{t+1}}\right], \tag{9}$$

where $U_{c,t}$ represents derivative of utility function with respect to consumption , $U_{l,t}$ stands for derivative of utility function with respect to labour, $F_{l,t}$ is derivative of production function with respect to labour $F_{k,t}$ denotes derivative of production function with respect to capital, and $\phi_{k,t}$ represents per unit cost of adjusting the capital stock.

### *3.2. Applying BCA*

The frictions in the prototype economy correspond to four wedges that can be obtained (directly or indirectly) from the observed data. First, the efficiency wedge is defined as:

$$A_t(s^t) = \frac{y_t(s^t)}{F\left(k_t(s^{t-1}),(1+\gamma)^t l_t(s^t)\right)}. \tag{10}$$

Second, the labour wedge is given by:

$$\left(1-\tau_{l,t}(s^t)\right) = -\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)}\left(A_t(s^t)(1+\gamma)F_{l,t}\right)^{-1}. \tag{11}$$

The investment wedge is obtained via the consumption Euler equation:

$$\frac{1}{(1+\tau_{xt}(s^t))} = U_{c,t}(s^t)\big(\beta \textstyle\sum_{s^{t+1}} \pi_t(s^{t+1}|s^t)\big[U_{c,t+1}(s^{t+1})A_{t+1}(s^{t+1})F_{k,t} + (1-\delta)\big(1 + \tau_{x,t+1}s^{t+1}\big) + \phi_{k_{t+1}}\big]\big)^{-1}. \quad (12)$$

Finally, the government wedge is obtained in the following way:

$$g_t(s^t) = y_t(s^t) - c_t(s^t) - x_t(s^t). \quad (13)$$

In order to estimate the wedges for the Angolan economy in the 2002:I-2022 period, I used the BCAppIt! V1.000 add-in for MATLAB produced by Brinca et al. (2020). I experimented with the numerical algorithm using 25, 50, 150, and 200 iterations, opting for the latter due to its precision, despite requiring more computational time. The four wedges (efficiency, investment, labour, and government) are computed either directly from the data and through the equations provided.

### *3.3. Parametrisation*

For the parametrization of the model, I employed a Cobb-Douglas production function *F*(•), as it is used in macroeconomic models due to its simplicity and empirical relevance, with $\alpha$ = 0.33. in addition, for the utility function *U*(•) I assumed a Constant Relative Risk Aversion form, which is common in dynamic macroeconomic models due to its flexibility in representing preferences for consumption and labour. This functional form allows for a realistic balance between consumption and labour decisions, reflecting agents' preferences for smooth consumption over time and their aversion labour.

The values for $\delta$, $\varphi$ and $\theta$ were calibrated based on the literature and empirical evidence by Brinca et al. (2024) to match observed macroeconomic dynamic for the Angolan economy.

## 4. DATA

The main data sources for macroeconomic data used were *Instituto Nacional de Estatística* (INE) and Penn World Table (PWT).

The data for total population in each quarter was obtained from INE, using cubic spline, because there is not quarterly data.

In BCA analysis, variables in volume are used in per capita terms, so the population measure is crucial for the procedure.

For output, I used quarterly GDP at 2002 prices from(INE) INE and PWT. However, there is no quarterly data available from INE's macroeconomic series prior to 2014. Therefore, I used cubic-spline interpolation for real GDP from 2002:I to 2013:IV, using oil production (instead of time) as this indicator is highly correlated with real GDP at an annual frequency. Moreover, output and oil production were cointegrated, as one might expect from an economy highly dependent on this specific export. De-trended output per capita was denoted by $y_t$ in the previous chapter (Mohammed, 2018).

After the data were interpolated, specifically the Real GDP, it was necessary to meet certain criteria. These included ensuring that the sum of all quarters of the Real GDP equalled the annual value provided by INE, and that the value of each quarter was consistent, with the second quarter equalling the annual value divided by four. Therefore, for Real GDP, I used the interpolated data from 2002 to 2013, while for the subsequent years up to 2022, the primary data provided by INE were used.

For investment, I used annual data on Gross Fixed Capital Formation (GFCF) at 2002 prices from INE and PWT, multiplying the shares from INE by the values from both *INE* and PWT. After that, I applied cubic spline interpolation using time, as there was no other variable highly correlated with investment, such as the consumption of durable goods, to perform the interpolation. As in the previous chapter, de-trended investment per capita is denoted by $x_t$ here.

For consumption, I used annual data on consumption at 2002 prices from (INE) and PWT, multiplying the shares from INE by the values from both INE and PWT. After that, I applied cubic spline interpolation using time, as there was no other variable highly correlated with consumption, such as the consumption of durable goods, to perform the interpolation. As in the previous chapter, de-trended consumption per capita is denoted by $c_t$ here. Therefore, I considered the annual values for private consumption, using the primary data from PWT, calculated based on the shares, to obtain the private consumption data by multiplying each value by Real GDP. Cubic interpolation was then performed to obtain private consumption in real terms for the years 2002 to 2022.

The remainder of domestic expenditure, i.e. government spending and net exports, at 2002 prices, was obtained from INE and PWT by multiplying the shares from INE by the values from both INE and PWT. After that, I applied cubic spline interpolation using time, as there was no other variable highly correlated with these components. As in the previous chapter, de-trended government spending and net exports are denoted by $g_t$ here. The shares from PWT were also considered, for the same reasons mentioned earlier, and multiplied by the value of Real GDP to obtain the variable in question. The data were interpolated to obtain quarterly values, ensuring that the sum of all quarters equalled the annual total.

After reviewing all the shares, an indicator designated as a residual by the PWT was identified, which results from net exports and discrepancies in statistical data. As an alternative, data from the *BNA* were also considered, as most of the information is sourced from INE. Therefore, the shares to be used were drawn from both INE and *BNA*, since at this stage, I had data from 2002 to 2022, with relevant information available from these entities.

Regarding the total population and employed population, I used data from INE for the period between 2014 and 2022, and data from PWT for the period between 2002 and 2014. Due to the lack of quarterly data, I once again applied cubic spline interpolation, ensuring that the average of the quarters equalled the annual value. Therefore, interpolated data were used for both the total population and employed population from the first quarter of 2002 to the last quarter of 2022.

Finally, for the labour input, i.e. average hours worked, I used data from the industrial production survey statistics on the index of hours worked (INE, 2023), as well as employment statistics. For hours worked per worker, the index of hours worked, weekly hours worked per worker, and employment in absolute terms were considered. This resulted in the multiplication of the quarterly index by the hours worked and the number of employees in the quarter. As in the previous chapter, de-trended hours worked per worker is denoted by $l_t$ here.

Due to the lack of data before 2002, it was not possible to perform cubic interpolation for those missing years, and it was preferred to use the primary data provided by *INE*. Therefore, this variable was calculated between the first quarter of 2002 and the last quarter of 2022.

Here too, the data were interpolated in a first phase using the values resulting from the Real GDP already calculated for all years, multiplied by the share of private consumption, knowing that the shares of private consumption result from the ratio between private consumption and Real GDP.

I also simplified the data processing process compared to the procedures, as they use nominal variables and deflators (Brinca et al., 2020). In this dissertation, since all the data are already real, there was no need to obtain deflators. Thus, all the variables in the national accounts are real.

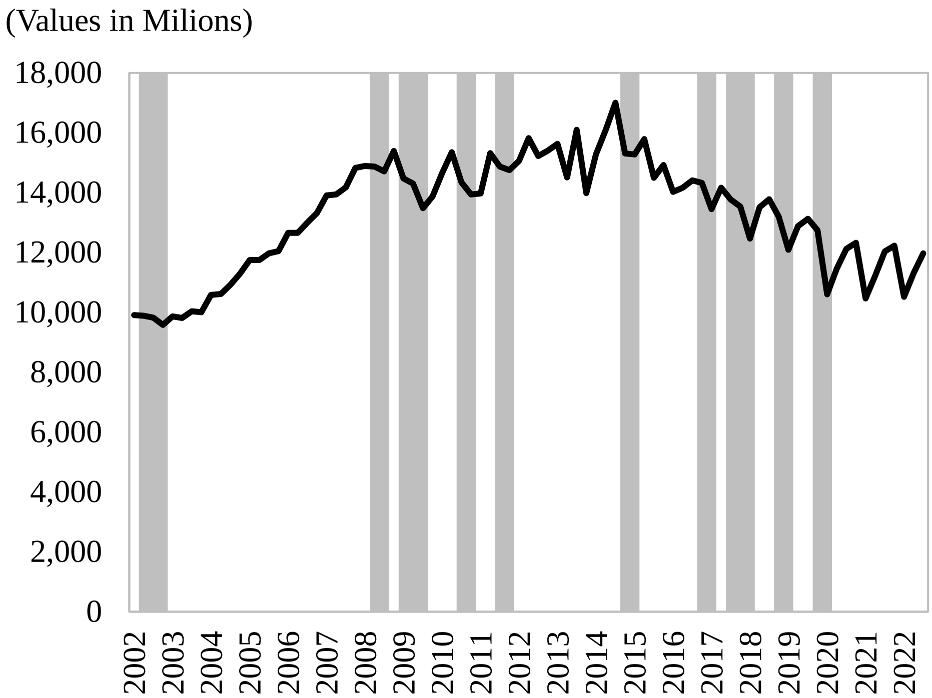
The dataset and the codes used in this dissertation are available online.[1]

## 5. BENCHMARKS FOR THE ANGOLAN ECONOMY

Before estimating the wedges, I would like to present mean statistics for the Angolan economy, between the years 2002 and 2022. According to data from INE, *Banco Nacional de Angola* (BNA), and the World Bank, Angola had around 16.5 million inhabitants in 2002 and 33.5 million in 2002. The share of agriculture in GDP by 2002 was 4% and it was 9% in 2022. The oil industry represented almost 45% of GDP in 2002 and it decreased to less than 30% in 2022. Public administration and social security represented 9% of GDP in 2002 and 2% in 2022. The share of exports in GDP decreased from 57% in 2002 to 41% in 2022, while the share of imports decreased from 48% to 17% in the same period. As for the exchange rate of the kwanza against the euro, it can be said that one euro was worth twenty-nine kwanzas in 2002 and 539 kwanzas in 2022. In addition, the inflation rate in 2002 was 109% while it decreased to 21% in 2022. Finally, the Human Development Index, according to United Nations Development Programme, increased from 0.406 in 2002 to 0.591 in 2022.

[1] Please refer to https://github.com/bmaria7/bca.

Figure 1: Real GDP per capita.

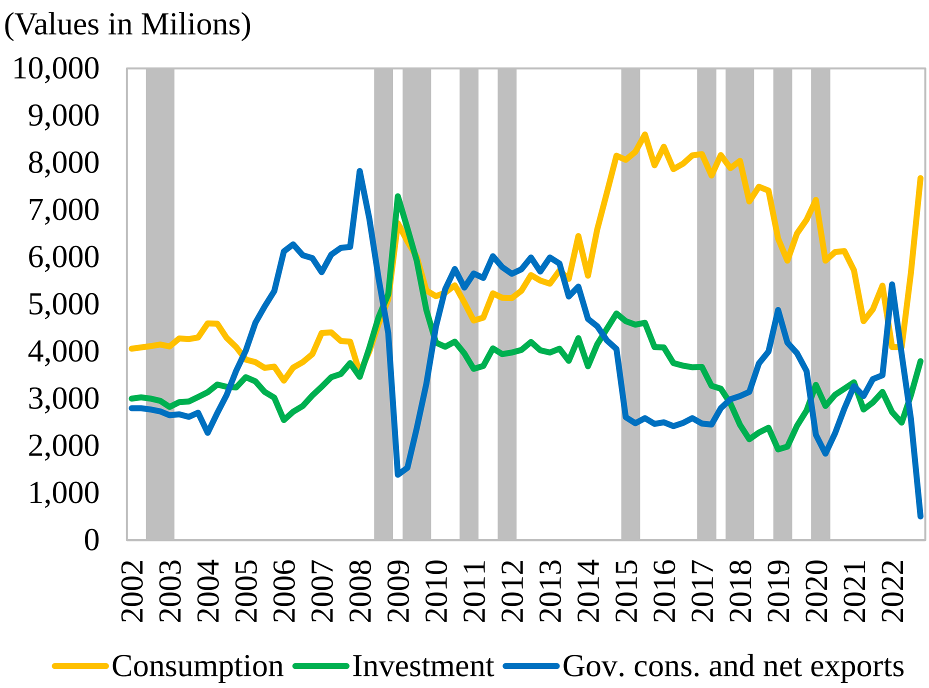



SOURCE: own calculations.

Angola experienced 10 periods of economic recession in the 21st century, as defined by two consecutive quarters of decline in real GDP per capita. The recession episodes identified are: 2002:II-2003:I, 2008:III-2008:IV, 2009:II-2009:IV, 2010:IV-2011:II, 2011:IV-2012:II, 2015:I-2015:II, 2017:I-2017:II, 2017:IV-2018:II, 2019:I-2019:II and 2020:I-2020:II.

These recessions are represented as grey columns in Figure 1, which also depicts the evolution of real GDP per capita (*y*) in this period. We can see that the average annual growth rate for this indicator was 0.4%.

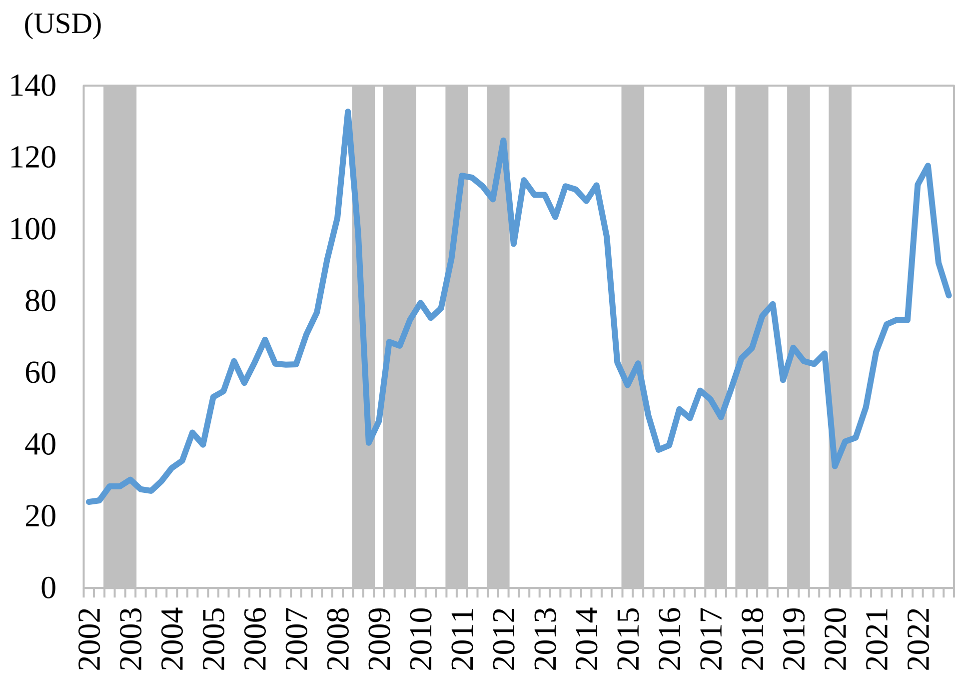
Figure 2: Consumption, Investment, Gov. cons. and net exports.




SOURCE: own calculations.

Figure 2 represents the evolution of real private consumption (*c*), investment (*x*), and the sum of government consumption with net exports (*g*), all per person. Again, we can see that no clear long-run trend is apparent for investment and for government consumption together with net exports, while there is a slight increasing trend in private consumption.

Figure 3: Oil price.




SOURCE: own calculations.

Figure 3 shows that some recession periods are indeed related to significant sudden drops in oil prices, e.g. 2008:III-2008:IV, 2017:I-2017:II and 2020:I-2020:II. However, some of these episodes are surprisingly related to increases in oil prices, e.g., 2009:II-2009:IV, 2010:IV-2011:II and 2017:IV-2018:II. This is why we need to dig deeper into the possible explanations for business-cycle fluctuations in Angola.

## 6. RELEVANT WEDGES IN THE ECONOMY

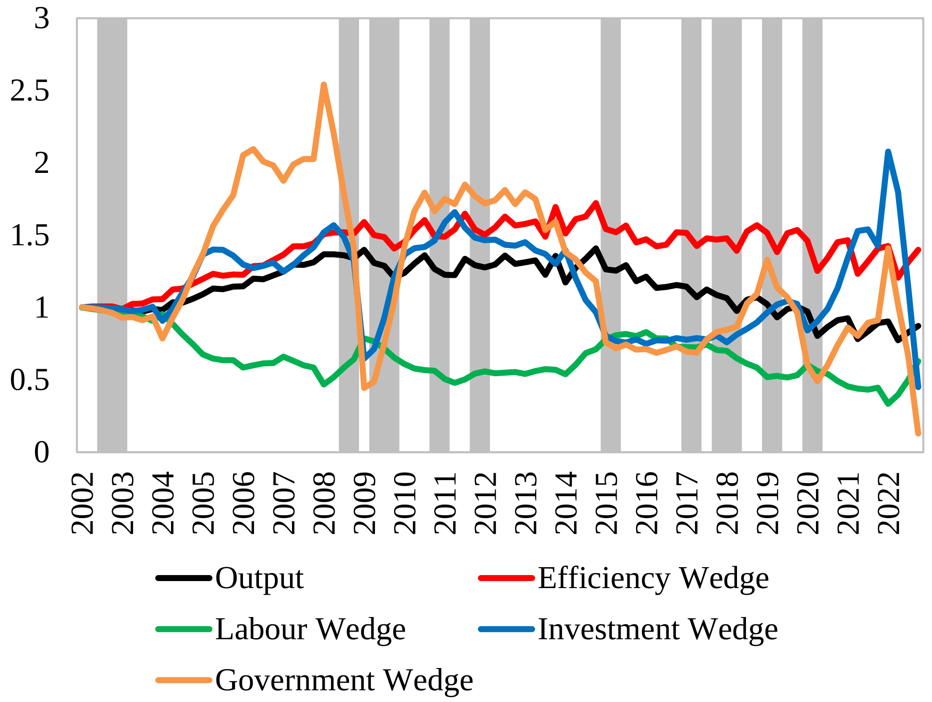
In this chapter, I present the results of the BCA model, when applied to the Angolan economy in the 2002:I-2022:IV period.

Variables $y$, $x$, and $g$ are de-trended using Hodrick-Prescott (HP). However, as we have seen in Figure 1, there is a nearly flat trend for output per capita, which is not usually observed in most BCA applications.

### *6.1. Wedge Accounting*

The output of the BCA methodology are the time-series for the four wedges mentioned in chapter 3: the efficiency wedge ($A$), the labour wedge ($1-\tau_{l,t}$), the investment wedge ($1/(1+\tau_{x,t})$), and the "government" ($g$). Notice that the label for the latter is particularly misleading in an open economy like Angola that strongly depends on state of the international oil market for its exports, which play the role of the main engine of economic activity.

Figure 4 – Output and estimates for the wedges.




SOURCE: own calculations.

Figure 4 depicts the estimated wedges. Simple visual inspection suggests that the labour share is not a good candidate to explain output fluctuations in Angola.

Table I - Volatility and cyclicality of wedges

| | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| Relative volatility | 1.215 | 1.38 | 4.305 | 6.530 |
| Cyclicality | 0.872 | 0.057 | -0.106 | 0.179 |

SOURCE: own calculations.

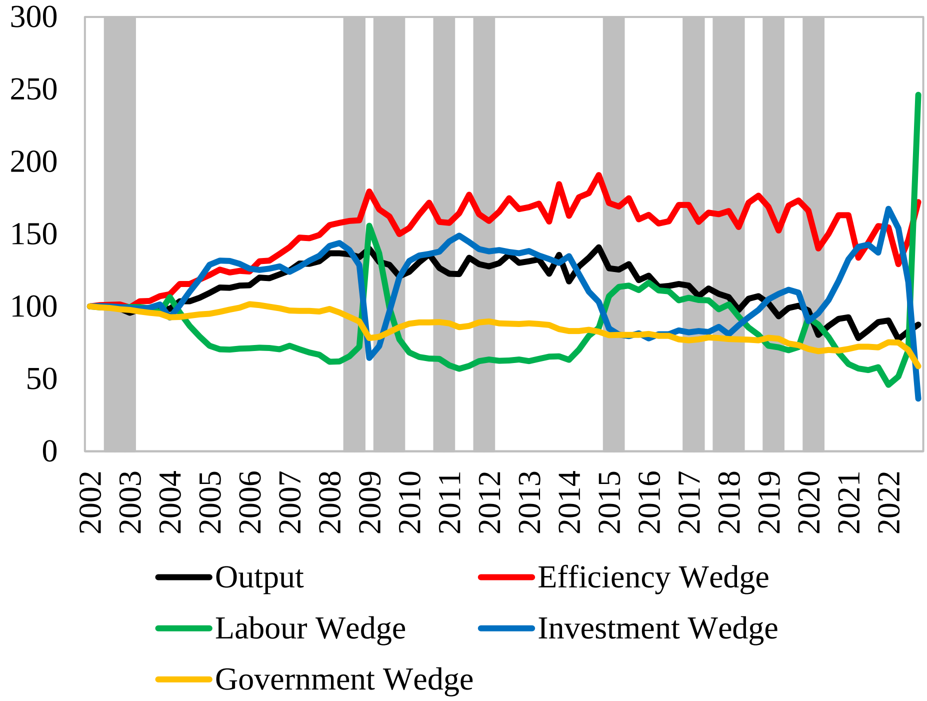
Table I shows two second-order moments for the wedges' distributions: (i) the relative volatility, i.e., the ratio between the standard deviation for each wedge and that of output, and (ii) the cyclicality, i.e., the contemporaneous correlation of which wedge with output. First, we can see that the government wedge is more than six times as volatile as output and the investment wedge is four times as volatile, while the remaining two wedges are slightly more volatile than GDP. Second, the efficiency wedge is strongly pro-cyclical, but the other three wedges are basically acyclical.

*6.2. Single-Wedge on Models*

Considering the time-series for each wedge, let us use each one at a time in the BCA model, assuming the remaining three stay constant at its average level. Thus, we can see how much can be explained of the fluctuations in the main macroeconomic variables by resorting to a single wedge.

Figure 5 suggests that the investment wedge may be the more successful one to explain output fluctuations, followed by the government and the efficiency wedges.

Figure 5 – Explaining output with one wedge at the time.




SOURCE: own calculations.

Nonetheless, visual inspection may be misleading. Therefore, we need to use a formal performance statistic to measure how closely one variable (e.g. output) generated by the BCA model tracks the actual variable. For that purpose, I will use the $\phi$-statistics of (Brinca et al., 2016). The results are shown in Table II below.

Table I – $\phi$-Statistics for Single-Wedge on Models

| Variables/Wedges | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| Output | 0.163 | 0.144 | 0.406 | 0.288 |
| Investment | 0.040 | 0.016 | 0.046 | 0.897 |
| Hours | 0.040 | 0.033 | 0.018 | 0.909 |

SOURCE: own calculations.

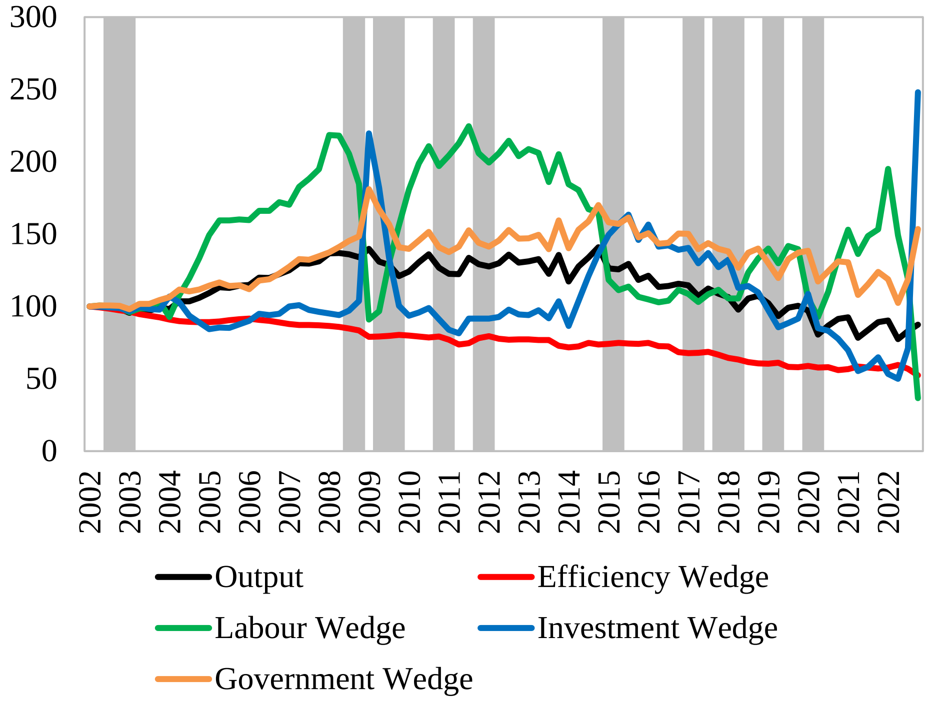
As we can see on Table II, the investment wedge alone is able to explain 40% of output fluctuations, while the government wedge alone explains 29%, although government wedge alone, explains 90% and 91% of investment and hours respectively.

Figure 5 shows the predicted output with different wedges (efficiency, labor, investment, and government) normalized to 100. From 2002 to 2009, output grew by 21% but dropped 4.8% in 2010, fluctuating slightly until 2015, when it fell by 26%. With just the efficiency wedge, output rose 81% until 2014 but then decreased by 15.9%. The labor wedge showed a nearly 31% drop from 2002 to 2008, followed by a 10.5% increase in 2009 and a 10.8% rise until 2014, but then it fell by almost 39% until 2022. The investment wedge showed a different trend, initially dropping 25% and then declining by 28% until 2018, with a further 25% drop by 2022. Finally, without the government wedge, output decreased steadily by 20% from 2002 to 2022, with small fluctuations.

### *6.3. Single-Wedge Off Models*

Figure 6 below depicts the output time-series produced by a model when a wedge is removed.

Figure 6: Output and without Single Wedges




SOURCE: own calculations.

Table II - $\phi$-Statistics for Single-Wedge Off Models

| Variables/Wedge | No Efficiency | No Labour | No Investment | No Government |
|---|---|---|---|---|
| Output | 0.164 | 0.114 | 0.259 | 0.464 |
| Investment | 0.749 | 0.096 | 0.000 | 0.154 |
| Hours | 0.873 | 0.016 | 0.035 | 0.075 |

SOURCE: own calculations.

As we can see at Table III, the government wedge explains less output than investment wedge, while efficiency wedge for investment and hours than government wedge.

Figure 6 shows that without the efficiency wedge, output falls steadily by 38% by 2022. Without the labor wedge, output rises sharply until 2007, then fluctuates with a major drop by 38% until 2018, followed by some ups and downs. Removing the investment wedge keeps output stable at first, but after a big jump in 2009, it falls 55% by 2014 and declines again after a brief rise. Without the government wedge, output behaves similarly but at slightly higher levels, with steady growth until 2009, followed by a gradual decline of 43% by 2022.

## 7. DISCUSSION

In the previous chapter we concluded that the investment wedge seems to be the most important to explain output fluctuations in 21st century Angola, as it explains around 41% of these fluctuations. The second most important is the government wedge, which explains around 29%. Finally, the efficiency and the labour wedges, explaining respectively 16% and 14% of output fluctuations, exhibit the worst performance. Regarding other macroeconomic variables, the government wedge shows the best performance, followed by the efficiency wedge, which presents an interesting complement, both requiring further analysis.

However, are these conclusions robust to splitting the period into sub-periods that make sense from the point of view of recent economic history in Angola? That is why I split the 2002:I-2022:IV period into four sub-periods.

The first one, which I will name the Expansion period, starts in 2002:I and ends in 2008:IV, due to the similar characteristics as average growth rate in Real GDP and oil prices.

The Stagnation period (2009:I – 2014:II), Crisis (2014:III – 2019:IV) and Pandemic (2020:I – 2022:IV), I have chosen for the same reasons in the first period.

Table IV below presents the $\phi$-statistics for each wedge in each sub-period.

Table III - $\phi$-statistics for each wedge in each sub-period

| Wedge | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| | | Output | | |
| Expansion | 0.249 | 0.021 | 0.638 | 0.089 |
| Stagnation | 0.960 | 0.003 | 0.001 | 0.036 |
| Crisis | 0.382 | 0.034 | 0.195 | 0.389 |
| Pandemic | 0.899 | 0.004 | 0.003 | 0.094 |
| Whole period | 0.163 | 0.144 | 0.406 | 0.288 |
| | | Investment | | |
| Expansion | 0.114 | 0.375 | 0.030 | 0.481 |
| Stagnation | 0.576 | 0.031 | 0.000 | 0.393 |
| Crisis | 0.499 | 0.009 | 0.175 | 0.318 |
| Pandemic | 0.641 | 0.000 | 0.000 | 0.359 |
| Whole period | 0.040 | 0.017 | 0.046 | 0.897 |
| | | Hours | | |
| Expansion | 0.174 | 0.073 | 0.015 | 0.738 |
| Stagnation | 0.954 | 0.006 | 0.001 | 0.040 |
| Crisis | 0.137 | 0.016 | 0.065 | 0.782 |
| Pandemic | 0.584 | 0.002 | 0.003 | 0.412 |
| Whole period | 0.040 | 0.033 | 0.018 | 0.909 |

SOURCE: own calculations.

### *7.1. Expansion (2002:I – 2008:IV)*

In this initial sub-period, the investment wedge shows the best performance, as it explains around 64% of output fluctuations. It is followed by the efficiency wedge, which explains 25% growth is observed not only in Real GDP but also in the rise of oil prices. Real GDP grew during this period at an average of 7.6%, and oil prices reached their peak in the second quarter of 2008 at 132 USD per barrel. Neither the government nor the labour wedges contribute much to explain what happened to output.

Notice that the investment wedge plays a much larger role to explain output fluctuations than in the whole period. In contrast, the government wedge plays a very small role[2].

[2] Table for $\phi$-Statistics during expansion is available in the appendix: Table V

It is also noteworthy that during this phase, because of high levels of oil exports, the state began to pay more attention to the oil industry than to other sectors, investing in more drilling and oil extraction blocks.

*7.2. Stagnation (2009:I – 2014:II)*

Contrary to what the $\phi$-Statistics generally show that the investment wedge is the one with the best performance (63.8%), during this period, the efficiency wedge can explain 96%, which may aid in the analysis that, despite recessions during this phase, the price of oil shows an upward trend in its price level[3].

What can be understood is that the efficiency wedge occurs due to distortions in Total Factor Productivity, showing up as an aggregate productivity shock (Chari, et al., 2007).

Instead of witnessing another general decline in oil prices, there is an increase in private consumption and investment in 2009, followed by stagnation in the subsequent periods. During this phase, the emphasis is on new foreign investment programs as well as opportunities for economic diversification.

*7.3. Crisis (2014:III – 2019:IV)*

In comparison to what the Fi-Statistics show, that the investment wedge best explains output fluctuations with 63.8%, here it can be seen that during the third quarter of 2014 to the last quarter of 2019, the efficiency wedge, government wedge, and investment wedge show better performances, with 42.2%, 38.6%, and 17.2%, respectively[4].

During this phase, a downward trend in oil prices, as well as net exports, is observed. It is also noted that public consumption shows a negative slope, with a marked decrease in per capita public spending.

This phase is marked by a drop in purchasing power parity, given the devaluation of the national currency, as well as the withdrawal of fuel price subsidies, an increase in the public debt ratio, as well as a drop in net international reserves.

[3] Table for $\phi$-Statistics during stagnation is available in the appendix: Table VI
[4] Table for $\phi$-Statistics during crisis is available in the appendix: Table VII

### *7.4. Pandemic (2020:I – 2022:IV)*

In this phase, contrary to what the Fi-Statistics generally present, the efficiency wedge explains the output best at 89.9%, followed by the government wedge with 9.4%. What can be observed here is that there is a recovery in oil price growth, but this is accompanied by crisis episodes[5].

Thus, I can point not only to oil prices, which are no longer as high as before, but also to the pandemic period, which significantly reduced the industrial sector, thereby lowering productivity.

Since the government wedge shows the second-best performance, it raises the question of whether net exports can also be explained here, as well as the application of certain restrictive fiscal policies.

## 8. POSSIBLE SOURCES FOR THE WEDGES

In this section, I present the possible sources for the four wedges analysed during the previous sections. For each type of wedge, possible sources are shown, based on the facts that occurred in the Angolan economy during the 21st century.

Note that one event can cause one or more wedges, for example covid-19 in Brinca & Costa-Filho (2024), and a wedge may also arise from one or more events, for example government wedge in Cunha (2006).

### *8.1. Investment Wedge*

One of the possible sources for the investment wedge is dependency on oil. The country struggles to attract investments to other sectors. These difficulties create a distortion in investment by focusing excessively on oil exploration, according Christiano et al. (2002), thus causing an investment wedge.

Another possible source is misuse of resources and failed investments. The economic report on Angola, prepared by the Catholic University, mentions significant investments in projects that ended up being abandoned or underutilized, such as the "Ganjelas in Huíla," an irrigation project that received considerable investment but was left abandoned.

[5] Table for $\phi$-Statistics during pandemic is available in the appendix: Table VIII

Another example is the new Luanda airport, inaugurated on 10/11/2023 and valued at 2.8 billion dollars, with an area of 75 km².

This misallocation of resources creates distrust among investors and contributes to a lack of new investments, thus characterizing an investment wedge, according Kydland & Prescott (1982).

As said also in previous session, because of high levels of oil exports, the state began to pay more attention to the oil industry than to other sectors, investing in more drilling and oil extraction blocks.

Devaluation of the National Currency and High Inflation  is also one of the sources for investment wedge. The significant devaluation of the national currency and uncontrolled inflation directly impact the cost of inputs and labour, creating an environment of economic unpredictability.

On the other hand, the exchange rate policy, which resulted in the significant devaluation of the Kwanza, also negatively impacts exports.

According to Christiano et al. (2002),the currency devaluation discourages productive investment because investors cannot accurately predict their returns due to economic fluctuations, thereby leading to an investment wedge.

And finally, Covid-19 is also one possible source for investment wedge. During the pandemic, due to uncertainties, frictions began to emerge in the credit market. These frictions, as Cunha (2006) states, lead to an investment wedge.

### *8.2. Government Wedge*

One of the possible sources for the government wedge is dependency on oil. Angolan economy is overly reliant on oil exports, which is highlighted in the report of *Centro de Estudos e Investigação Científica* (2021). and INE (2024b) as one of the main factors of economic vulnerability.

The lack of diversification and the impact of global oil prices create instability in exports, hindering the development of other areas of foreign trade and creating a government wedge.

Another possible source is devaluation of the national currency and high inflation. Although devaluation can make exports more competitive, due to the inelasticity of supply in many sectors, Angola's exports have not been able to fully benefit from this, exacerbating the distortion between export potential and reality, causing a government wedge.

High Public Debt and Inefficient Spending is also possible source for government wedge. The increase in public debt and inefficient allocation of resources, as noted in the report, also contribute to this wedge.

A major example is the IMF debt package, approved on December 7, 2018.

The Extended Fund Facility (EFF) program, which followed the agreement negotiated by the Angolan government and the IMF in 2018, primarily aims at fiscal adjustment consolidation (IMF announces 3.3 billion euros aid package to Angola – DW – 08/12/2018).

The program's value was 3.8 billion euros, focusing on fiscal sustainability, inflation reduction, promotion of a more flexible exchange regime, financial sector stability, promotion of human development in the public sector, diversification, and inclusive growth.

Since 2021, Angola has paid around 176 million dollars to the IMF up to June 29.

The disbursement occurred in two parts: 2018 and 2021.

When the government invests in sectors with low economic returns while lacking support for initiatives that could generate more inclusive and sustainable growth, it causes a government wedge.

Even this package was accepted late due to certain conditions, and these restrictions, as Brinca et al. (2020) mention, can increase the government wedge.

And finally, restrictive fiscal policy is also one possible source for government wedge. Here, I highlight the fiscal consolidation policies focused on expenditure control and tax increases, which have contributed to a reduced capacity for economic stimulus.

A major example is VAT. According to Law 7/19 of the *Diário da República (Angola, 2019)*, the VAT was: 14%, as a general rate, for imports, supplies of goods, and provision of services; 7% for the simplified regime; 7% for hotel and restaurant services; 5% for imports and supplies of widely consumed foodstuffs and agricultural inputs listed in Annex I and Annex II of this Code; 1% for imports and supplies of goods subject to the special tax regime applicable to the Province of Cabinda, except for the goods listed in Annex III of this Code, which are subject to the general rate.

From November 2023 to today, according to Law 14/23 *(Angola, 2023)*: 5% for essential goods.

Another example is IRT, which was amended on 10/22/2014 by Law 18/14, then by Laws 9/19, 28/19, and later by Law 28/20.

According to the Angolan Ministry of Finance, from value added tax alone, 132.3 billion were collected in 2019, 751 billion in 2020, and 1.04 billion kwanzas in 2021, thus having a weight on GDP of 2.2% in 2020 and 2.3% in 2021 compared to the Consumption Tax, which was replaced by this one, it did not reach 1%.

When the government prioritizes fiscal stabilization and public debt control, which limits productive investments and negatively impacts economic growth, increasing the gap between growth potential and reality, it thus causes a government wedge.

### *8.3. Efficiency Wedge*

One of the possible sources for the efficiency wedge is dependency on oil. Angola has faced economic difficulties due to its excessive dependence on the oil sector, which limits economic diversification. The continued dependence on the oil sector means that other sectors of the economy, such as agriculture and manufacturing, remain underdeveloped. According to Kehoe & Prescott (2007) this lack of diversification leads to a poor allocation of resources, reducing the overall efficiency of the economy, thus causing an efficiency wedge.

Another possible source is for efficiency wedge is misuse of resources and failed investments. The *Dr. António Agostinho Neto* airport (as one of the major examples), With a capacity of fifteen million passengers, including ten million on international routes and five million on domestic services, while Angola's current traffic is not even two million passengers, this may represent over-dimensioning and misallocation of resources, potentially leading to an efficiency wedge.

And finally, covid-19 is one possible source for efficiency wedge. The health of the workforce is also crucial. Epidemics such as malaria, polio, and measles, as well as pandemics or public health crises like Covid-19, which began in 2020, can reduce efficiency and consequently lead to an efficiency wedge.

### *8.4. Labour Wedge*

One of the possible sources for the labour wedge is restrictive fiscal policy. Although not directly affected in the intertemporal choice between work and leisure (Arouca, 2023), the implementation of VAT and its adjustments have impacted the final price of products. Therefore, families began consuming more and had less disposable income.

Given that this type of situation affects the relationship between the marginal rate of substitution between consumption and leisure and the marginal productivity of labour, this may lead to a possible labour wedge.

This wedge manifests primarily as a variable tax on labour income (Arouca, 2023). By introducing new laws on the *IRT*, on the one hand, it increases the tax exemption band, especially for families with very low income, but it also significantly decreases the disposable income of families with greater purchasing power, thus giving rise to a possible labour wedge.

## 9. Conclusion

In this dissertation, I applied the BCA methodology to study the possible causes for economic fluctuations in Angolan economy in the 21st century.

One interesting by-product of this dissertation is that I produced consistent time-series for quarterly macroeconomic data for Angola in the 21st century, which will be available for other researchers to use or to improve upon.

I concluded that government wedge is the most important friction to generate business-cycle fluctuations in output, consumption, investment, and hours worked in Angola for the whole period. Considering that Angola is a small open economy that strongly depends on the evolution of the international oil market, the variability observed in this wedge can be closely associated with exogenous changes in the demand for Angolan exports of oil.

Nonetheless, the investment wedge also plays a large role, especially for replicating output fluctuations, for which it is the single most important wedge. This wedge is especially important in expansion, such that, explain 63.8% of increasing output around 49%.This wedge, of course, is not easily related to internal shocks, but it reflects a group of causes usually associated with domestic capital market inefficiencies.

The efficiency wedge was also shown to be an important source of fluctuations, especially during stagnation and pandemic, explaining for output, 96% and 90%, respectively. In addition, this wedge in these periods, also explain fluctuations in investment 58% and 64% for fluctuations in investment, 95% and 58% for fluctuations in hours. Again, this wedge is usually connected with domestic allocation frictions across all markets, but it may also be explained by the worldwide productivity shock of the Covid-19 pandemic, at least in 2020.

Finally, the labour wedge seems to play a significant role in business-cycle fluctuations in the Angolan economy during expansion, especially 38% of fluctuations for investment, although is the second best.

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# APPENDIX

Table IV - $\phi$ -Statistics for expansion

| | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| Output | 0.249 | 0.021 | 0.638 | 0.089 |
| Investment | 0.114 | 0.375 | 0.030 | 0.481 |
| Hours | 0.174 | 0.073 | 0.015 | 0.738 |

SOURCE: own calculations.

Table V - $\phi$ -Statistics for stagnation

| | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| Output | 0.960 | 0.003 | 0.001 | 0.036 |
| Investment | 0.576 | 0.031 | 0.000 | 0.393 |
| Hours | 0.954 | 0.006 | 0.001 | 0.040 |

SOURCE: own calculations.

Table VI - $\phi$ -Statistics for Crisis

| | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| Output | 0.382 | 0.034 | 0.195 | 0.389 |
| Investment | 0.499 | 0.009 | 0.175 | 0.318 |
| Hours | 0.137 | 0.016 | 0.065 | 0.782 |

SOURCE: own calculations.

Table VII - $\phi$ -Statistics for Pandemic

| | Efficiency | Labour | Investment | Government |
|---|---|---|---|---|
| Output | 0.899 | 0.004 | 0.003 | 0.094 |
| Investment | 0.641 | 0.000 | 0.000 | 0.359 |
| Hours | 0.584 | 0.002 | 0.003 | 0.412 |

SOURCE: own calculations.