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## Impact of Covid-19 on the South African economy: A CGE, Holt-Winter and SARIMA model's analysis

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**Abstract.** The spread of the coronavirus disease (COVID-19) emanating from China touched South Africa like other countries across the world. This study analyses the impact of the COVID-19 pandemic on South African economy and total revenue. For this purpose, we have made use of a single country's Computable General Equilibrium (CGE) model, Holt-Winter (HW) and SARIMA models by formulating one scenario based on the likely duration of the pandemic. In the scenario, we assume that the pandemic will last six months. The results indicate significant impacts on the macroeconomic variables, employment and sectoral level and on households' well-being. First, at the macroeconomic level, the COVID-19 crisis resulted in a significant drop in the economic growth rate across all the macroeconomic variables. The Gross Domestic Product (GDP), exports and private consumption dropped by 7.10%, 13.19% and 7.10%, respectively. This represents a loss of real Gross Domestic Product of R338 billion. In contrast, the time series' models project the state revenue to be around R1 104.5 trillion for Holt Winter model and R1 210 for SARIMA model, on average R1 157 trillion for the two models is expected. Furthermore, the models anticipate the loss in revenue at a region of R213.0 billion to a maximum of R318.2 billion from SARIMA and HW models, respectively for the same period. Moreover, the unemployment was expected to grow because of a sharp drop in sectoral productions. In addition, our findings reveal a contraction of sectoral exports. Finally, the rise of consumer prices and unemployment did greatly dampen the purchasing power of households.

**Keywords.** Coronavirus, Covid-19, CGE model, Holt Winter model, South Africa.

**JEL.** C68, C53.

### 1. Introduction

The health crisis that started in December 2019 from the spreading of the coronavirus affected all the countries across the world. In fact, COVID-19 has spread from China to developed and developing countries. Even though African countries being among the last ones to be touched, they encountered a communal danger to human life, social cohesion, and an economic catastrophe. These countries are portrayed by a very unproductive health system and by insubstantial organisations.

Studies conducted by the World Bank (2020) and International Monetary Funds (2020) indicate that the spread of the coronavirus will utterly

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dampen African economies. Conferring to the Economic Commission for Africa (ECA), the continent's economic growth rate could shrink deeply (ECA, 2020). Both the International Monetary Funds (2020) and the World Bank (2020) foresee an economic downturn extending from -2.1% and -5.1% mainly due to the negative impact of the pandemic on the world trade and its impact on African economies. As at 09 October 2020, South Africa recorded 683 242 cases of covid-19 consisting of 49 282 active cases, 616 857 recoveries and 17 103 fatalities. In its bi-annual Africa report, the World Bank (2020) indicated that Sub-Saharan Africa will register its first recession in 25 years with growth forecasted to contract by 3.3% in 2020 due to the COVID-19 pandemic. This is against the backdrop of poor economic performance of two of the region's major economies. South Africa and Nigeria contracted by 17.1% and 6.1% respectively in the second quarter of 2020.

Key institutions such as World Bank, IMF and South African Reserve Bank (SARB) have downwardly revised economic activities amid the corona virus pandemic and noted that lack of economic traction will last for much of the short to medium term. The African Tax Administration Forum (ATAF) estimated that Africa will lose about USD 3.99 billion in Customs revenue due to the COVID-19 pandemic by December 2020 (ATAF, 2020).

South Africa's economy is indestructibly affected by the spread of the coronavirus disease (COVID-19). This has impelled the government to speedily implement a number of measures, including the shutting down of the air, rail and land borders, the shutting down of schools and universities, firms and, the interdict on crowds of more than 50 people in March 2020. These regulations endeavouring at controlling the spread of the virus did definitely have significant impacts on all sectors of the economy and principally on economic development, employment, and households' earnings.

The purpose of this study is to assess the impacts of the COVID-19 on South Africa's economy. For this purpose, we will use three models: the Computable General Equilibrium (CGE) model, Holt Winter (HW) model and SARIMA model. The first model is a simulation model, a single country's CGE model which uses a database composed of a social accounting matrix representing the structure of South Africa's economy. The most central advantage of this model consists of its proficiency to effectively denote sectoral and institutional linkages, as well as trade relations between South Africa and the rest of the world. The structure of this model is fundamental insofar as the impacts of the pandemic may not only impinge on the domestic economy but the world economy as well. The second and the third model is the lighter time series model known to predict the continuation of time series data which have both trend and seasonality with high precision (Pindyck & Rubinfeld, 1998).

In this study, the main hypotheses is founded on both the time necessary to limit the pandemic followed by a recommencement of economic activities and the effect of the exports of the manufactured goods on the international trade. Taking into account uncertainty over the

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duration of the pandemic, one hypothesis has been put across with a pessimist scenario asserting that the pandemic prolongs over 6 months with a 50% decline in world demand for South Africa's exports. We will also use the time series method through Holt Winter (HW) and SARIMA models to assess the impact of COVID-19 on the South African total revenue. These models are the lighter time series models and they are known to predict the continuation of time series data having both trend and seasonality with high precision. These types of models assumes that all explanatory variables are embedded in the past occurrence of the same univariate time series of interest, giving more weight to the recent data. It is for this reason the univariate time series forecast are considered unbiased (Shumway & Stoffer, 2006).

The rest of the paper is presented as follows: Section 2 introduces the economic overview of the South Africa, Section 3 presents the literature review, Section 4 describes the methodology, Section 5 presents the findings and Section 5 provides the conclusion and recommendations.

### 2. Economic overview

The first quarter of 2020 saw South Africa enter a third straight quarter of economic decline. But 2020 began a qualitative shift in the national and global economy. In the second half of 2019, the downturn was driven largely by the continued stagnation in commodity prices. From January to March 2020, however, the economy was increasingly weighed down by the impact of the COVID-19 pandemic. As a result, the South African economy is expected to shrink by around 7% in the coming year, while the global economy will fall by 5%, and by 6% if China is excluded (National Treasury, 2020). Moreover, the first quarter of 2020 marked the second deepest decline in GDP since 1994. While the contraction over the past nine months has not been as deep as the 2008/9 global financial crisis, the lockdown in April 2020 means the coming quarter will probably be the deepest downturn since the transition to democracy. The South African Reserve Bank has forecast a decline of 7% in the GDP for the year (SARB, 2020).

In short, despite increasingly relaxed restrictions on economic activity, the economic recovery appears to have slowed down in the past three months. The main reason was the steep fall in domestic and global demand compared to pre-pandemic days. Most of all, South Africa's major trading partners all face a significant economic decline. Data from the Organisation for Economic Co-operation and Development (OECD) indicate the extent of the global downturn. Besides, most major economies began to contract in the first quarter of 2020, as the Chinese economy plummeted 10%. Consequently, in the second quarter, except for China, all of South Africa's main trading partners – the UK, Germany, the US and Japan – shrank by at least 8%. China, which brought the pandemic under control by March, saw its GDP rebound 12%. In the second quarter South Africa did better than

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India, the UK, Spain and Mexico, but slightly worse than Columbia, Hungary, Greece and Portugal (OECD, 2020).

As expected, the GDP of South Africa dropped sharply, by 16% in seasonally adjusted terms, in the quarter ending in June 2020 as a result of the COVID-19 pandemic. The fall dwarfed both the 2008/9 crisis and the recession of the three preceding quarters. Economic activity crashed in April, during the strict Level 5 of the lockdown. The gradual relaxation in restrictions since then have seen a bounce back to near pre-pandemic levels. In spite of the lockdown, COVID-19 continues to pose a threat, limiting recovery especially in tourism and recreational services even in the absence of regulations. Furthermore, long-standing structural challenges and declines in major trading partners will slow recovery (SARB, 2020).

Stats SA has called the second-quarter GDP figure a “punch in the gut” and said it should be referred to as the “pandemic quarter”. It has attributed the sharp downfall to months of an unprecedented COVID-19 pandemic and subsequent lockdown. A steep decline of 51% was reported for the GDP. This contraction dwarfs the annualised slowdown of 6.1% recorded in the first quarter of 2009 during the global financial crisis. Historical data from 1960, sourced from the South African Reserve Bank, show that the second quarter of 2020 experienced the biggest fall in GDP since that year, far steeper than the annualised 8.2% decline in the fourth quarter of 1982. Nearly all industries experienced a massive drop in output in the second quarter of 2020. Construction was the biggest loser, already in bad shape before the pandemic. The industry experienced its eighth consecutive quarter of economic decline, slumping further by 76.6% (Stats SA, 2020).

Globally, the downturn caused by the COVID-19 pandemic is expected to exceed the 2008/9 crisis. Of South Africa’s main trading partners, only China is expected to report any economic growth. More often than not, lower- and middle-income economies perform better than high-income countries during the pandemic period. In this case, however, growth will also depend on the extent to which countries manage to control the contagion (World Bank, 2020).

The National Treasury (2020) expects the economy of South Africa to contract by 7.2% in 2020 primarily, due to restrictions on economic activity to contain the spread of the Covid-19 virus. Seeing that government’s fiscal position deteriorated, the ratio of investment to GDP fell to 17.9%, the lowest since 2005, while the unemployment rate reached 30.1% - highest since the survey began in 2008. Households and firms are grappling with the combined effects of economic restrictions and the continued spread of the virus. The halt in economic activity resulting from the lockdown, and its lasting consequences, are expected to result in tax revenue underperformance of R304.1 billion in 2020/21 compared with the 2020 Budget estimate. In 2020/21, the consolidated deficit is projected to increase to 15.7% of GDP. If this trend is not reversed, South Africa is likely to face a sovereign debt crisis. Gross national government debt is projected to increase from R3.26 trillion (63.5% of GDP) in 2019/20 to R3.97 trillion

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(81.8% of GDP) in 2020/21. By the end of 2022/23, gross loan debt is expected to amount to R4.83 trillion, or 86% of GDP. Debt-service costs will increase from R204.8 billion in 2019/20 to R236.4 billion in 2020/21, or from 4% of GDP to 4.9% of GDP. Debt-service costs are expected to reach R301.1 billion, or 5.4% of GDP in 2022/23. Critical risks to the economy include continued volatility in global financial markets, sudden interruptions in capital inflows, the reliability of electricity supply, additional commitments to fund financially distressed state-owned companies, low levels of confidence, policy uncertainty and concerns about government's commitment to the independence of the central bank (SARB, 2020).

After 2020/21, tax revenue as a proportion of GDP is expected to follow a similar trajectory to that experienced after the global financial crisis in 2008. Additional tax measures, alongside economic recovery, will increase the tax-to-GDP ratio (23.5%) (National Treasury, 2020).

### 3. Literature review

According to the World Trade Organisation (2020), world trade fell sharply in the first half of the year, as the COVID-19 pandemic upended the global economy. Nonetheless, rapid government responses helped temper the contraction, and WTO economists now believe that while trade volumes will register a steep decline in 2020, they are unlikely to reach the worst-case scenario projected in April 2020.

Latest statistics indicate that the volume of products trade contracted by 3% year-on-year in the first quarter according to WTO statistics. Preliminary estimates for the second quarter, when the virus and associated lockdown measures affected a large share of the global population, indicate a year-on-year drop of around 18.5%. Although this drop seems high, it could have been much severer. The WTO's 20 April annual trade forecast, in light of the large degree of uncertainty around the pandemic's severity and economic impact, set out two plausible paths: a relatively optimistic scenario in which the volume of world merchandise trade in 2020 would shrink by 13%, and a pessimistic scenario in which trade would fall by 32%. The current economic environment reflects that trade would only need to grow by 2.5% per quarter for the remainder of the year to meet the optimistic prediction. Nonetheless, looking ahead to 2021, adverse developments, including a second wave of COVID-19 outbreaks, weaker than expected economic growth, or widespread recourse to trade restrictions, could see trade expansion fall short of earlier predictions (WTO, 2020).

The decline in trade we are now experiencing is historically large – in fact, it would be the sharpest on past performance. Nonetheless, there is an important silver lining here: it could have been much worse. This is genuinely positive news but we cannot afford to be smug. Policy decisions have been critical in softening the ongoing blow to output and trade, and they will continue to play an important role in determining the pace of economic improvement. In fact, for output and trade to return to normal in

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2021, fiscal, monetary, and trade policies will all need to converge in the same course (Inoue & Todo, 2020).

According to United Nations Department of Economic and Social Affairs (UN DESA) in the worst-case scenario, the world economy could contract by 0.9% in 2020. The UN Economic Commission for Africa (ECA) warned the unfolding coronavirus crisis could affect Africa's economic growth falling from 3.2% to about 2% in 2020, with oil exporting nations losing up to US\$ 65 billion in revenues. ECA's pointed out that Africa needs an immediate emergency economic stimulus of US\$ 100 billion (UN DESA, 2020).

Somlanare (2020) put forward that in Burkina Fasso, at the macroeconomic level, the COVID-19 crisis could result in a significant drop in the economic growth rate with an economic recession of -1.75%. This represents a loss of real Gross Domestic Product (GDP) of 295 billion US dollars.

Prediction research done by United Nations Economic Commission for Africa (UNECA) suggests that, in the worst-case scenario, Ethiopia's economy will contract by 4.5%, a range for real GDP growth in 2020 using evidence from past shocks and adjusting for the anticipated scale of impact of COVID-19. Moreover, the expectation is that in 2021, the economy will recover and the growth will be around 6%. For background info, the sectoral composition of Ethiopia's GDP is as follows: Agriculture: 33.3%; Industry: 28.1%; and Services: 39.8% (UNECA, 2020).

Morgan (2020) pointed out that the global economy is likely to experience a historic decline in output in the second quarter of 2020 generating a global downturn. World Bank expects a double-digit contraction in global growth in the first half of the year, with GDP contractions through the second quarter or until the outbreak disappear gradually. The study released by the Caribbean Development Bank indicates that the global growth will be at least 2 percentage points lower than previous estimates, while for the Caribbean region as a whole, the impact could be even more deep. There is expectation that in accordance with these projections, there will be a drop in GDP of at least 1.8% and as high as 4% or more for the Caribbean region. The latest estimations by the IMF predicted a more striking scenario for Jamaica, and estimate a 5.6% drop in GDP (IMF, 2020).

In Argentina, before the pandemic, real GDP was expected to decline by 1.2% in 2020 and inflation was expected to hike to 40%, according to Central Bank's Market Expectations Survey. Indeed, the contraction will be deeper due to the global and domestic effects of the COVID-19 occurrence. The general lockdown will weaken aggregate supply, while demand will be affected by higher unemployment, lower incomes and growing uncertainty, which will drive a reduction in private consumption. Investment will also be hit hard by financial volatility and an uncertain economic outlook, so the economy will be stuck in a vicious circle of decreasing consumption and lower employment and earnings. According

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to IMF estimates, real GDP will decrease by 5.7% in 2020, while for the World Bank it will narrow by 5.2% (IMF, 2020).

In Turkey, COVID-19 outbreak was described to have higher impact particularly on women workers due to increased domestic responsibilities such as child care, care of ailing family member, hygiene and food security. In fact, 34% of enterprises reported that circumstances brought on by COVID-19 outbreak affected women more adversely than it did men. Such perception was more prominent in enterprises with women supervisors (World Bank, 2020).

In Nigeria, the drop in oil prices by 55% between the end of 2019 to March 2020, is one of the most serious economic shocks that Nigeria has faced in its memory, especially as the oil sector contributes 65% and 90% to government and total export revenues, respectively. Since March 2020, the price of crude oil dipped to US\$29.62/barrel. Given that the Federal budget estimates for 2020 have pegged oil prices at US\$57/ barrel and production at 2.18 million barrels per day, if prices continue to remain at this level, it would translate to a decline in 48% of expected revenue from oil sales per month. This alone could reduce fiscal revenue by close to \$10 billion and export earnings by \$19 billion. The drop in export revenues is projected to have a combined effect of 0.55 percentage points reduction in GDP (IMF, 2020).

In Tanzania, another remarkable area of risk is the interruption in the world market for fertilizers, given that Tanzania imports 90% of its annual supplies (cost USD 596.52 million in 2018) from countries such as Russia, Saudi Arabia, China and Morocco. Their factories are not optimally functioning, resulting in a 15% increase in prices in the first quarter of 2020 compared to 2019. Prolongs on importing at higher prices is most likely going to negatively affect productivity in 2020/21. Pesticides and chemicals are usually imported from mostly China, Italy, Turkey, and India, also affected by COVID-19 (ECA, 2020). In conclusion, Tanzania is likely to suffer from a double-edged sword impact of COVID-19 on international and domestic trade for agricultural products (World Bank, 2020).

In Pakistan, the global economy is expected to see an over 30% reduction in the volume of world trade as pointed out by the WTO. This will have a significant impact on Pakistan's exports. In addition, a 15% decline in remittances is expected in the second quarter of 2020. Besides, foreign direct investment is likely to drop substantially due to heightened risk perceptions. In the domestic market, it is expected that there will be a 10% reduction in the availability of domestically produced goods and of 15% in imported goods due to transport bottlenecks. Nonetheless, there is hope that the intensity of these negative factors will be less in 2020-21 (UNIDO, 2020).

In South Africa, since the national lockdown on the 25<sup>th</sup> March 2020 (level 5), the transmission in Gauteng and Eastern Cape provinces continued on the accelerated path that kicked off with the move to Level 4 and escalated in Level 3. In Gauteng, the number of cases nearly doubled over the week to reach 137 per 100 000 residents; in the Eastern Cape, the

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figure topped 200; and in the Western Cape, it was over 700. In the other provinces, the incidence remained under 30. Differences in provincial testing strategies make comparisons increasingly difficult, however. Government effectively reopened nearly all economic activities but continued to ban family gatherings except for funerals. It argued that relaxing restrictions on economic activity means individuals become responsible for limiting the spreading of the coronavirus. Government announced a new Ministerial Advisory Committee comprising religious and civil society representatives to promote behavioural change (Standard Bank, 2020).

South African government accelerated economic reopening largely in response to intense lobbying by businesses, often backed by the relevant Ministers (notably for mining, tourism and small enterprise). But it also reflected a conceptual contradiction: is COVID-19 like the flu, with an inevitable winter spike that equally predictably dissipates, or like HIV or TB, where behavioural changes can prevent transmission for long periods? If it is like flu, government should focus on bolstering the health system to deal with the surge in cases; if it is like HIV or TB, it should focus on changing behaviour plus tracing and isolating new cases (Health Department, 2020).

The economic bounce from Level 3 largely levelled out by mid-June and the banks now expect up to 10% impaired loans, compared to 6% in 2008/9. They have deferred payments for business and individuals on a large scale, but mostly only through June (Standard Bank, 2020). National Treasury announced the supplementary budget, promising fundamental restructuring to address the COVID-19 depression. It expects the GDP to return to 2019 levels only around 2023 (National Treasury, 2020).

Given South Africa's unusual inequalities, the economic-policy response to the pandemic imposes tough choices. Hotspots have emerged almost exclusively in the metros' dense townships and informal settlements, while workplace clusters mostly affect manual workers in mining, manufacturing, retail and public and private services. In contrast, higher-income professionals and managers can largely maintain physical distancing at work and while commuting, or even work from home. The state has effectively agreed to encourage businesses to reopen to boost incomes despite accelerating transmission, rather than extending the grants and UIF payments that enabled low-income households to avoid infections at work and in public transport (Health Department, 2020).

## 4. Methodology

Three methods will be used in this study: The Computable General Equilibrium (CGE) model, Holt-Winters (HW) model and SARIMA model. The first method used in this study, the CGE model is based on the model developed by Alton, Arndt, Davies, Hartley, Makrelov, Thurlow, & Ubogu (2012). It is a dynamic model that implements the interaction between the different consumption and production behaviours while maintaining

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macroeconomic balances. It has been slightly modified to account for some of the key characteristics of South Africa's economy. First, the households have been classified according to socio-professional occupation. Second, we consider an imperfect mobility of the capital between sectors rather than sector specificity of capital. The second and third methodology is the time series model HW and SARIMA model, which depend on the historical pattern of the same variable of interest and assumed to capture the impact of the pandemic by giving more weight to the recent data/occurrences.

### 4.1. The computable general equilibrium (CGE) model

In the CGE model, the firms are expected to operate in perfectly competitive markets. Thus, the representative firm maximizes the profits subject to its production technology while considering the prices of goods, services and factors as given (price-taker behavior).

As soon as the level of production has been determined, it is assumed that this output is sold on both domestic and foreign markets, based on a CET (constant elasticity of transformation) function that allows for imperfect substitutability between goods produced for different markets. In the same way, a standard CES (constant elasticity of substitution) function – also known as an Armington function – governs the consumption choices for products according to their origin which can be local or imported (Lofgren, Harris & Robinson, 2001).

The model includes various agents such as households, government, firms, and the rest of the world. Households derive their income from remunerative factors (labour, capital, and agricultural land) and from net revenue transfer. Their expenditures consist of consumption spending and direct tax payments to the government. The difference between income and expenses constitutes household savings. The government collects direct and indirect taxes and makes current expenditures, transfers to other institutions, and public investments. The firms receive a portion of capital income, pay dividends to households and foreign countries, pay income taxes to the government, and save the rest (Somlanare, 2020).

The production function structure depicts that at the top level, there is a Leontief function that combines value added and an intermediate consumption aggregate. The two aggregate inputs are therefore considered to be strictly complementary, without any possibility of substitution. At the second level, the representative firm's value added consists of composite labour and composite capital, following a constant elasticity of substitution (CES) specification.

At the bottom level, on the value-added side, the model captures four categories of labour composed of labour with primary, middle, secondary and tertiary education. They are combined following a CES technique that reflects the imperfect substitutability between these types of labour. On the intermediate consumption side, aggregate intermediate consumption is made up of various goods and services. Intermediate inputs are therefore

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assumed to be perfectly complementary and are combined following a Leontief production function (Horridge, 1993).

The assumption of a small country with fixed international prices is considered in the model. The exchange rate is the numeraire, while the balance between supply and demand in the goods and services market is guaranteed by a tweaking in relative prices. The total investment is the sum of the various economic agents' savings. The current account balance, stock variation, and government spending are exogenous and evolve at the same pace as the population growth (Eichenbaum, Rebelo & Trabandt, 2020).

In the closure, we assumed that the foreign savings are fixed, the government savings with flexible taxation rates are fixed, and savings are driven investment.

### 4.1.1. The capital market

Capital is assumed to be sector specific in the CGE model. For the purpose of this study, we modified this hypothesis in favour of partial mobility in which three aggregate sectors are differentiated: primary sector (agriculture), secondary sector (industry), and tertiary sector (services). For instance, their mobility is partial in the sense that agricultural capital can be used alternatively for subsistence or cash-crop agriculture. Nonetheless, agricultural capital cannot migrate to non-agricultural sectors. Likewise, industrial capital can migrate between industrial subsectors but not to agriculture or to services. This modelling implies a rate of return on capital that is defined by the aggregate sectors of the economy and not by individual sectors. The closure of the capital market is modified accordingly. The conditions of capital market equilibrium now arise at the macro-sectoral level (Alton *et al.*, 2012):

Agricultural sector

$$\sum_{j1} KS_{k,j1,t} = \sum_j KD_{k,j1,t} \quad (1)$$

Manufacturing sector

$$\sum_{j2} KS_{k,j2,t} = \sum_j KD_{k,j2,t} \quad (2)$$

Services sector

$$\sum_{j3} KS_{k,j3,t} = \sum_j KD_{k,j3,t} \quad (3)$$

Where  $KS$  and  $KD$  symbolize the supply and demand of capital, respectively, while  $j1$ ,  $j2$  and  $j3$  represent the subsets of agriculture, industry, and services, respectively. These three equations determine the wage rates  $Rk$ ,  $agsec$ ,  $t$  at the macro-sectoral level (Kevin & Singham, 2020).

### 4.1.2. The data

The Social Accounting Matrix (SAM) on which we based the analyses was developed in 2015 by Erero (2015). It reflects the economic situation of

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South Africa for the year 2015. This matrix includes 45 sectors of activity producing 45 goods and services with the possibility for a sector to produce more than one product and for one good to be produced by several activities. Six production factors are identified: primary labour, middle labour, secondary labour, tertiary labour, land (used only in agriculture), and capital. The matrix includes fourteen household categories distinguished according to the main occupation of the head of the household (Erero, 2015).

### 4.1.3. The COVID-19 scenarios

We set one pessimist scenario representing a reduction in the productive capacities of the production sectors by -50% as well as a contraction in world demand for South Africa's exports by 50%. A reduction in the productive capacities of the sectors by 50% in the pessimist scenario seems realistic when we consider the slowdown and even the discontinuance of business in several productive sectors over many months. A six-month shutdown theoretically assumes that the production will represent 50% of potential production. Nonetheless, the national firms have so far demonstrated an ability to adapt to the new situation through significant reorganizations of their operation (rotation system, reduction of staff and all other measures allowing for the continuity of their activities). These adaptations thus minimize production losses (Atkeson, 2020). Likewise, the hypothesis of a drop in world demand for South Africa's exports is justified given the decline in growth or even recession in the world economy, leading to a reduction in the purchasing power of foreign consumers.

## 4.2. Holt-Winter and SARIMA models

### 4.2.1. Holt-Winters Model

The Holt Winters (HW) models are the lighter time series model and known to predict the continuation of time series data having both trend and seasonality with high precision. These types of models assumes that all explanatory variables are embedded in the past occurrence of the same univariate time series of interest, giving more weight to the recent data. It is for this reason the univariate time series forecast are considered unbiased.

Holt-Winters methods are an extension of simple exponential smoothing and Holt's trend corrected exponential smoothing method. Simple exponential smoothing is used to forecast series when there is no trend or seasonal pattern, while Holts trend corrected exponential smoothing is applicable when a time series displays a changing level (mean) and the growth rate (slope) for the trend (Hyndman, *et al.*, 2002). The pattern can assume the additive or multiplicative modelling.

$$Y_t = S_t + T_t + E_t \quad (\text{Additive Model}) \quad (4)$$

$$Y_t = S_t * T_t * E_t \quad (\text{Multiplicative Model}) \quad (5)$$

Holt-Winters Methods give weights  $(\alpha, \beta, \gamma)$  to the mean, trend and the seasonal components of the time series respectively and allow us to control

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these components for prediction. These models are represented in (a.) and (b.) below.

(a). Holt-Winter's Additive seasonality model

$$\begin{aligned}
 L_t &= \alpha(Y_t - S_{t-s}) + (1-\alpha)(L_{t-1} + b_{t-1}) \\
 b_t &= \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \\
 S_t &= \gamma(Y_t - L_t) + (1-\gamma)S_{t-s} \\
 F_{t+m} &= L_t + b_t m + S_{t-s+m}
 \end{aligned} \tag{6}$$

(b). Holt-Winter's Multiplicative seasonality model

$$\begin{aligned}
 L_t &= \alpha \frac{Y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + b_{t-1}) \\
 b_t &= \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \\
 S_t &= \gamma \frac{Y_t}{L_t} + (1-\gamma)S_{t-s} \\
 F_{t+m} &= (L_t + b_t m) S_{t-s+m} \\
 \alpha, \beta, \gamma &\in [0,1]
 \end{aligned} \tag{7}$$

Where:

$Y_t$ ,  $F_{t+m}$ ,  $S_t$ ,  $b_t$ ,  $m$ ,  $L_t$  represent the series to be forecasted, variable(s) of interest, represent the seasonal adjustment component of the series seasonal component, represent the number of periods ahead to be forecasted, represent the trend component, the forecast for m periods and S is the length of seasonality (e.g., number of months or quarters in a year).

### 4.2.2. SARIMA model

Seasonal Autoregressive Moving Averages (SARIMA) models assume that all explanatory variables are included in the historical records of the same variable. This assumption eliminates the biasness when forecasting the continuation of the historical patterns. In this respect, the relationship is not given in terms of cause and effect but in terms of the randomness embodied in the process (Pindyck & Rubinfeld, 2010). The SARIMA model is mathematically represented in the equation array 8 (Shumway & Stoffer, 2006).

$$\begin{aligned}
 \Phi(B^s)\phi(B)\nabla_s^D\nabla^d y_t &= c + \theta(B)\Theta(B^s)\eta_t \\
 \nabla_s^D\nabla^d y_t &= c + \frac{\theta(B)\Theta(B)}{\phi^{-1}(B)\Phi^{-1}(B)}\eta_t
 \end{aligned} \tag{8}$$

Where:  $y_t$  is the output variable,

$c$  is a constant term,  $s$  is the frequency of the data, it could be 4 for quarterly data or 12 for monthly data,  $D$  is the seasonal differencing and,  $d$  the normal differencing, where;

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$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p$  is non-seasonal AR components of order  $p$ ,

$\Phi(B^s) = 1 - \Phi_1 B^s - \Phi_2 B^{2s} - \dots - \Phi_p B^{ps}$  is seasonal AR components of order  $P$ ,

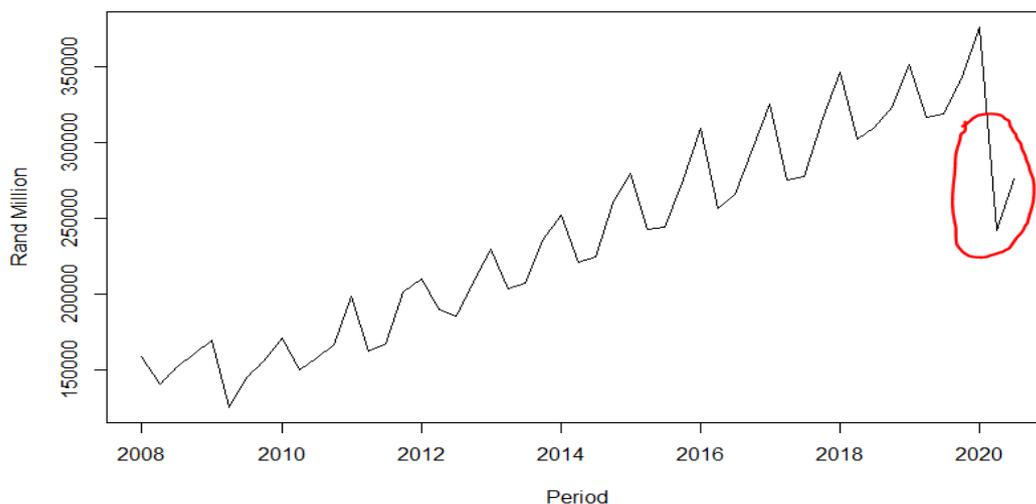
$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q$  is the non-seasonal MA components of order  $q$ ,

$\Theta(B^s) = 1 - \Theta_1 B^s - \Theta_2 B^{2s} - \dots - \Theta_Q B^{Qs}$  represent the seasonal MA components of order  $Q$ ,  $\eta_t$  is the error term at time  $t$ , and  $B^n$  is the back shift operator with the following effect on  $\eta_t$  and  $y_t$ :  $B^n(\eta_t) = \eta_{t-1}$  and  $B^n(y_t) = y_{t-1}$

The time series models are widely used in the world for model fitting and forecasting of revenue. This is due to the fact that they are not time consuming, they generate unbiased estimates or forecasts and they are precise when compared to the actual data. Some of the studies involve the works of Jayesekara & Passty (2009), Pelinescu, Anton, Ionescu & Tasca (2010), Hyndman, Makridakis & Wheelwright (1998) and many more.

### 4.2.3. Data used

The overall revenue data from quarter 1, 2008 to quarter 3, 2020 (calendar year) for total tax was obtained, recorded in rand million for the purpose of modelling and forecasting annual revenue using the time series models (HWand SARIMA model). An increasing trend and a strong seasonal pattern was observed in Figure 1 for the period January 2009 to March 2020. The impact of COVID-19 on revenue was observed starting April 2020 and deepened in May 2020, though the pandemic started towards the end of 2019. However, there was a slight increase in the revenue collection though it is lower than the normal historical pattern in quarter 2 (July – September 2020) of calendar year 2020 due to gradual reopening of the economy.



**Figure 1.** Total Tax Revenue in Rand Million

Source: National treasury

## 5. Findings

### 5.1. Results from the CGE model

As indicated earlier, we set one pessimist scenario representing a reduction in the productive capacities of the production sectors by -50% as well as a contraction in world demand for South Africa’s exports by 50%. A reduction in the productive capacities of the sectors by 50% in the pessimist scenario seems realistic when we consider the slowdown and even the discontinuance of business in several productive sectors over many months. A six-month shutdown theoretically assumes that the production will represent 50% of potential production. However, the national firms have so far demonstrated an ability to adapt to the new situation through significant reorganizations of their operation (rotation system, reduction of staff and all other measures allowing for the continuity of their activities). These adaptations thus minimize production losses. Likewise, the hypothesis of a drop in world demand for South Africa’s exports is justified given the decline in growth or even recession in the world economy, leading to a reduction in the purchasing power of foreign consumers.

The simulation results from the CGE model are presented in table’s forms. These are percentage variations compared to a hypothetical baseline scenario without the Covid-19.

#### 5.1.1. Macroeconomic impacts

Table 1 indicates that at the macroeconomic level, the COVID-19 crisis resulted in a significant drop in the economic growth rate across all the macroeconomic variables. The Gross Domestic Product (GDP), exports and private consumption dropped by 7.10%, 13.07% and 7.10%, respectively. This represents a loss of real Gross Domestic Product (GDP) by R338 billion in 2020. Even though the social accounting matrix used in this paper is the most recent, it dates back almost a decade (2010). We have therefore re-run the simulations by recursively updating it to get a SAM for the year 2020.

**Table 1.** *Impact of covid-19 on the macroeconomic results*

Variables	Description	Base (2015 R billion)	Covid-19
ABSORP	Absorption	1574	-7.2303
PRVCON	Private consumption	527	-7.1015
FIXINV	Investment	-3	-20.1692
DSTOCK	Stock	591	0.0000
GOVCON	Government consumption	645	-3.2033
EXPORTS	Exports	-676	-13.0719
IMPORTS	Imports	2659	-16.2802
GDPMP	GDP (Market prices)	287	-7.1009
NETTAX	Net indirect tax	2372	-4.1401

**Source:** Simulation results from the CGE model

The inflation, especially for agricultural products and the fall in employment – leading to a reduction in nominal incomes – did lead to a sharp deterioration in the purchasing power of households for all socio-economic professional categories. Revenue collection dropped across all tax categories with the hardest hit included sales tax (-10.31%), import duty (-

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8.42%) and direct revenue excluding dividend tax (-7.02%) as presented in Table 2.

**Table 2.** *Impact of covid-19 on the government revenue*

Description	Base (2015 R billion)	Covid-19
Direct revenue excluding dividend tax	396	-7.0218
Activity tax revenues	38	-2.4102
Import duty revenues	23	-8.4254
Sales tax revenues	226	-10.3104
Transfers received from factors	52	-3.0105
Transfers received from ROW	-30	-3.2079

**Source:** Simulation results from the CGE model

Table 3 indicates that the contraction of the sectoral production did lead to an increase in unemployment as some companies were forced to release a significant part of their employees to survive the crisis. We know that the formal, and especially informal, private service sectors are the major providers of jobs in South Africa. These sectors did undoubtedly suffer the effects of the COVID-19 crisis. This therefore have negative effects on employment across all labour categories. The hardest hit was labour completed secondary school education (-8.7%).

**Table 3.** *Impact of covid-19 on employment*

Variables	Description	Base (2015 R billion)	Covid-19
flab-p	Labour with primary school education (grades 1-7)	0.03	-5.2511
flab-m	Labour with middle school education (grades 8-11)	0.06	-7.2438
flab-s	Labour completed secondary school education (grade 12)	0.08	-8.7224
flab-t	Labour with tertiary education (certificates, diplomas or degrees)	0.16	-3.5214
fcap	Capital	0.36	0

**Source:** Simulation results from the CGE model

Table 4 highlights the impacts of covid-19 on the six main sectors namely agriculture, mining, manufacturing, other industries, private services and public services. The impact of the covid-19 is negative on all sectors of the economy. The agriculture, mining and manufacturing were the most affected. Still the agricultural sector suffered severely from the crisis. The negative effect on agriculture stems from the difficulties encountered by the industrial sector for which it is a supplier of raw materials and is at the same time dependent on the latter which supplies it with agricultural inputs.

**Table 4.** *Impact of covid-19 on the sectors*

Sectors	Base (2015 R billion)	Covid-19
Agriculture	2	-8.1498
Mining	10	-6.3137
Manufacturing	14	-7.0915
Other industries	6	-4.0297
Private services	48	-3.0456
Public Services	19	-0.0217

**Source:** Simulation results from the CGE model

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Table 5 indicates that all the income groups experienced drop in the consumption except the high-income group. The contraction of domestic supply of the production sectors, as well as the international trade restriction due to the protectionist policies adopted by South Africa and other countries caused a surge in consumer prices. The expected increase was stronger for agricultural prices and the price of catering. The slight increase in non-agricultural prices can be explained by the fact that, given the negative shock to real incomes, households did devote most of their resources to spending on essential (agricultural) goods to the detriment of non-agricultural goods.

**Table 5.** *Impact of covid-19 on the Household*

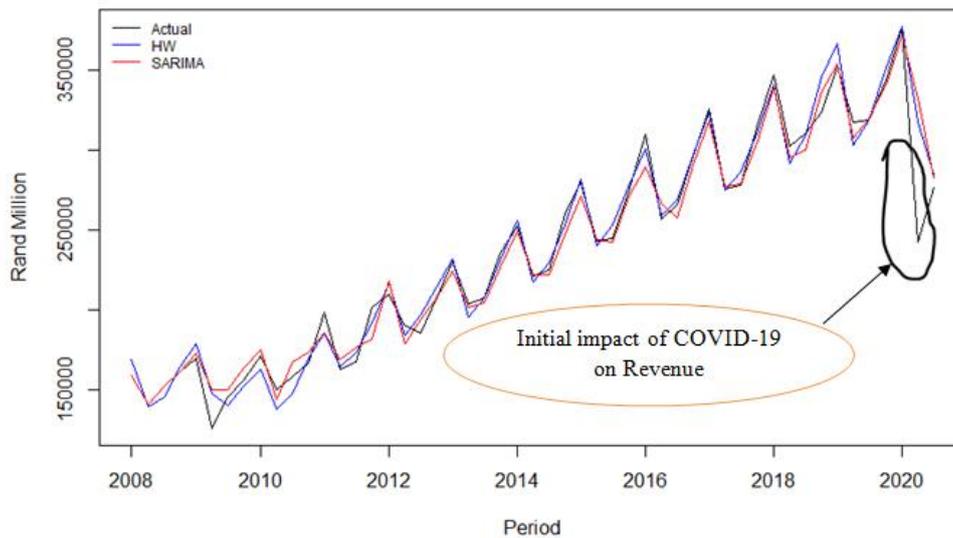
Variables	Description	Base (2015 R billion)	Covid-19
hhd-0	Decile 1	27	-0.8656
hhd-1	Decile 2	46	-0.7671
hhd-2	Decile 3	56	-0.6799
hhd-3	Decile 4	64	-0.8721
hhd-4	Decile 5	76	-0.9749
hhd-5	Decile 6	88	-0.9763
hhd-6	Decile 7	107	-0.3282
hhd-7	Decile 8	150	-0.4322
hhd-8	Decile 9	287	-0.4340
hhd-91	Percentile 90-92	84	-0.5369
hhd-92	Percentile 92-94	98	-0.1048
hhd-93	Percentile 94-96	117	0.0437
hhd-94	Percentile 96-98	142	0.7666
hhd-95	Percentile 98-100	229	1.5424

**Source:** Simulation results from the CGE model

### 5.2. Results for HW and SARIMA models

Figure 2 below shows the monthly total tax revenue against the fitted values from the time series models (Holt-Winters and SARIMA). The HW multiplicative HWs' method with multiplicative errors (ETS(M,A,M)) and  $SARIMA(1,0,0)(0,1,1)_4$  models fitted to the data simulate the trend and the seasonality movements in the actual collection for the variables of interest on the in- sample used. However, the models did not capture the initial impact of the pandemic, as it was an unusual turning point in the normal pattern over the years. Lower revenue collection becomes the new normal as the pandemic remains and the country lockdown was implemented. Nevertheless, the gradual introduction of economic activity showed a slight increase in revenue in the second quarter of fiscal year 2020/21 (July – September 2020).

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**Figure 2.** Total Tax Revenue and models fitted values in Rand Million

Source: National Treasury and own computation

The models fitted on the data was then used to derive the expected values for the full fiscal year 2020/21 with the data ending October 2020. Assuming the gradual relaxation of the lock-down and the re-opening of the economy from the COVID-19 impact, the state revenue is expected to be around R1 104.5 trillion from HW model and R1 210 from SARIMA model. On average R1 157 trillion from the two models is expected.

**Table 6.** Forecast for fiscal year 2020/21 in rand million

Quarter	HW			SARIMA			AVG Forecast
	Fofecast	Lo 95	Hi 95	Fofecast	Lo 95	Hi 95	
Q01	242 265.0			242 265.0			242 265.0
Q02	518 562.0			518 562.0			518 562.0
Q03	809 547.6	777 296.9	841 798.3	842 284.7	810 438.9	874 130.5	825 916.2
Q04	1 104 814.4	1 034 735.9	1 174 893.0	1 210 070.9	1 141 430.8	1 278 711.0	1 157 442.7

Source: Own computation, NB\*: April – October 202 figures are actual revenue

In fact, when using the two models and revising the data to end march 2020 (no shock assumption in Table 7) the collected revenue collection was expected to be R1 423.1trillion on average for 2020/21. This translate to loss in revenue expectation at a region of R213.0 billion to R318.2 billion from SARIMA and HW models, respectively for the same period.

**Table 7.** Forecast for fiscal year 2020/21 in rand million (no shock assumption)

Quarter	HW			SARIMA			AVG Forecast
	Fofecast	Lo 95	Hi 95	Fofecast	Lo 95	Hi 95	
Q01	332 723.0	314 634.6	350 811.4	335 017.6	318 385.6	351 649.6	333 870.3
Q02	669 342.3	632 082.5	706 602.1	675 363.4	640 636.5	710 090.3	672 352.9
Q03	1 031 277.7	973 820.8	1 088 734.5	1 034 088.5	979 913.6	1 088 263.4	1 032 683.1
Q04	<b>1 423 069.0</b>	<b>1 344 438.5</b>	<b>1 501 699.3</b>	<b>1 423 080.6</b>	<b>1 348 192.7</b>	<b>1 497 968.4</b>	<b>1 423 074.8</b>

Source: Own computation

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### 5.2.1. Comparison with other institutions

From various methods used to assess the impact of Covid-19 on the South African economy, we noticed the following:

- The CGE model used in this paper depicts that the GDP will decline by R338 billion,
- while time series estimated a maximum decline of R318.2 billion,
- National Treasury estimated a decline of R304 billion, and
- IMF predicts that the world economy would shrink by 3%, with a 8% drop in the global world. For comparison, during the global financial crisis in 2009, the global GDP contracted by less than 0.1%.

In this present case there is no wrong answer but it can just be said that the short fall will be within a range of R300 billion and R330 billion.

### 5.2.2. Planning for post-covid-19

The important question in the mind of the South African government in the midst of the evolving pandemic is how affected communities will bounce back and in a sustainable manner recover from the disaster. The economic distress associated with the pandemic, health implications to those affected especially most vulnerable in the community, strain on service delivery infrastructure and the societal cost in terms of well-being could be colossal. Any post-COVID-19 recovery strategy will need to re-establish the conditions for a quick return to a path of economic growth, improved social contract, and overall human development that can foster more inclusive societies in the time to come. The survivors and others directly affected by the disease must be assisted to regain their dignity and the affected communities supported to recover their source of revenue. This will require investment in innovative approaches for restoration of health systems; co-creation of culturally sensitive protection and community, peace and cohesion building measures that integrate recovery of lost incomes. A conflict-sensitive approach in such a case will be critical in the identification of risk and opportunities to ensure strategies do not worsen existing fragility, but rather help strengthen social cohesion if possible.

## 6. Conclusion

The objective of this paper was to analyse the impact of the Covid-19 on the economy of South Africa. The results indicate significant impacts on both macroeconomic and sectoral level, employment and on the households' well-being. First, at the macroeconomic level, the COVID-19 outbreak resulted in a significant drop in the economic growth rate across all the macroeconomic variables. The Gross Domestic Product (GDP), exports and private consumption dropped by 7.10%, 13.07% and 7.10%, respectively. This represents a loss of real Gross Domestic Product (GDP) by R338 billion. Moreover, the unemployment increased considerably across all labour categories because of a sharp drop in sectoral productions. In addition, our findings reveal a contraction of sectoral exports. In this respect, the rise of consumer prices and unemployment did greatly dampen the purchasing power of households.

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However, the time series models project the state revenue to be around R1 104.5 trillion from HW model and R1, 210 from SARIMA model. On average R1 157 trillion from the two models is expected. Besides, the model anticipate the loss in revenue at a region of R213.0 billion to maximum of R318.2 billion from SARIMA and HW models, respectively for the same period.

In addition to health consequences of the Covid-19, a socio-economic disaster could ensue if South African government did not adopt the appropriate measures to restore the national economy. As a first reflection, we believe that it will be necessary to think on a global, structuring, and endogenous strategy of economic recovery, which will be based on the internal capacities of the country and on the needs of the economic agents. To do this, it would be necessary to implement measures both on the demand and the supply sides. Thus, the government should provide temporary and targeted support to households, particularly the most vulnerable ones. Then, financial support could be granted to companies and sectors with labour intensive which are exceedingly in difficulty. Nonetheless, beyond these specific actions partially implemented, it is fundamental to focus on the restructuring of the country's productive system so as to make it dedicated essentially to respond to the domestic demand, which is mainly supplied by local raw materials.

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