

# 'Not a Good Time': Economic Impact of COVID-19 in Africa

Hanan Morsy, Lacina Balma, and Adamon N. Mukasa



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## Abstract

The paper studies the effects of the COVID-19 pandemic on African economies and household welfare using a top-down sequential macro-micro simulation approach. The pandemic is modeled as a supply shock that disrupts economic activities of African countries and then affects households' consumption behavior, the level of their welfare, and businesses' investment decisions. The DSGE model is calibrated to account for informality, a key feature of African economies. We find that COVID-19 could diminish employment in the formal and

informal sectors and contract consumption of savers and non-savers, especially for savers. These contractions would lead to an economic recession in Africa and widen both fiscal and current account deficits. Extreme poverty is expected to increase further in Africa, in particular if the welfare of the poorest households grows at lower rates. We also use the DSGE model to analyze the effects of different fiscal policy responses to the COVID-19 pandemic.

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# **‘Not a Good Time’: Economic Impact of COVID-19 in Africa**

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## **1. Introduction**

What began as a simple health crisis in the city of Wuhan, in the Hubei province of China, has quickly turned into an unprecedented economic crisis, with disruptions taking a toll on both developed and developing countries and inflicting a still unfolding global economic downturn. Although the coronavirus disease (COVID-19) appeared in Africa later than in other parts of the world – the first case was confirmed in Egypt on February 14, 2020 – it has spread rapidly across the continent and triggered a series of stabilization policies and containment measures that have important economic implications.

The objective of this paper is to assess the macroeconomic and welfare effects of the on-going COVID-19 pandemic in Africa, which is unique in many ways, including the uncertainty of its future epidemiological evolution, the persistence of its economic disruptions, and how African economies can expect to recover from it (Wren-Lewis, 2020). Unlike the global financial crisis of 2008, the effects of which unfolded relatively slowly, the current crisis is causing a sudden drop in economic activity. And preventive actions taken by governments to limit the spread of the coronavirus, through total lockdown, social distancing, and restrictions on mobility, all of which are unprecedented in the modern era, have amplified the effect of the crisis on the economy (Barro et al., 2020; Baker et al., 2020).

The COVID-19 pandemic has revived interest in studies on the macroeconomic and distributional impacts of economic crises and triggered empirical research on the on-going crisis. Faria-e-Castro (2020), for instance, uses a dynamic stochastic general equilibrium (DSGE) model to simulate recession scenarios for the pandemic crisis on the United States and then consider the effects of a policy package to cushion the impacts on vulnerable households and businesses as well as to stabilize the economy. Eichenbaum et al. (2020) embed a canonical epidemiology model (the SIR model) into a real business cycle model. Since they endogenize the dynamics of the epidemic, their model allows them to study optimal health policy responses. Baker et al. (2020) adopt a forward-looking approach to document and quantify the increase in economic uncertainty induced by the pandemic crisis and its macroeconomic impact on the United States (US) economy. Yilmazkuday (2020) uses daily county-level mobility data within the US to investigate the welfare costs of reduced mobility due to the coronavirus pandemic. He finds that stay-at-home orders implemented by the US government and the corresponding negative effects on mobility have led to significant household welfare costs. In Africa, Nonvide

(2020) studies the short-term effect of COVID-19 on poverty assuming a 10%, 20%, and 30% contraction of household consumption. Sumner et al. (2020) applies a similar approach but uses 5%, 10%, and 20% contractions of household consumption.

There are three main knowledge gaps in the above studies on the macro and micro impact of COVID-19, which this paper aims to fill. First, almost all empirical research on the pandemic's macroeconomic impact has focused on developed economies, in particular the United States and Europe. But the magnitude of COVID-19's effect on African economies and its transmission channels might vary from that on developed economies, given for instance the predominance of the informal sector, the absence of unemployment insurance schemes for most workers, and available policy instruments in African countries. Second, the assumptions applied in most studies investigating the micro impact of COVID-19 in Africa are not grounded in economic literature or backed up by existing macroeconomic analyses. In addition, by imposing on all African countries a uniform set of assumptions on how household welfare could be impacted by COVID-19, these studies ignore heterogeneity between countries in the structure of welfare distribution and in the degree of vulnerability and resilience to shocks, as well as the importance of initial conditions. Finally, to the best of our knowledge, all existing studies analyze either the macroeconomic or the micro (household) effect of COVID-19 and never both together. As such, they present an incomplete picture of the effects of the COVID-19 crisis on aggregate economy-wide variables – such as employment, inflation, or real GDP growth –and on income distribution and poverty.

The objective of this paper is to assess the macroeconomic and welfare effects of the COVID-19 in Africa, drawing from previous analyses of similar shocks. The paper also fills the above gaps by adopting a macro-micro sequential simulation approach (Cockburn, 2006; Cogneau and Robilliard, 2006; Bourguignon and Savard, 2008; Habib et al., 2012) applied to African countries. To the best of our knowledge, this is the first empirical study to apply a top-down modeling approach to estimate the impact of the coronavirus pandemic in Africa. In this modeling approach, a dynamic general equilibrium model is first used to simulate the effects of the pandemic on macroeconomic aggregates (GDP growth, fiscal and current account balances, etc.) and estimate the effects of stimulus policy responses. The model is calibrated to account for a key feature of African economies: the existence of a large informal sector that employs non-saving households and low-skilled workers who live hand-to-mouth and consume all their disposal income each period (Colombo et al., 2019). In the modeling exercise, trade, financial flows, and tourism are considered as the main channels through which COVID-19

affects African economies. Macro projections from the DSGE model are then fed into household survey datasets to simulate changes in household welfare indicators such as poverty. Finally, different fiscal policy responses, including transfers and tax relief measures, are considered to analyze their mitigating effects on households (savers and non-savers).

Despite the lack of feedback from the micro side of the methodology (micro simulations based on household surveys) to the macro side (the DSGE model) (Bourguignon and Savard, 2008), this approach has been shown to be superior to alternative methods based, for instance, on the poverty elasticity of growth or to computable general equilibrium (CGE) models based on the representative household group (RHG) assumption (Bussolo et al., 2008). A similar approach has been applied, for example, by King and Handa (2003); Vos and De Jong (2003); Chen and Ravallion (2004), Cockburn (2006), and Bourguignon and Savard (2008) to investigate the macro and micro effects of previous economic and financial crises.

The rest of the paper is organized as follows. Section 2 discusses the sequential macro-micro simulation approach used to estimate the effects of COVID-19. Section 3 discusses the data used, while Section 4 presents and discusses the main simulation results. Section 5 extends the benchmark results to analyze the impact of policy responses to the pandemic and changes in within-country welfare distribution. The last section concludes. The technical calibration details of the DSGE model are in the Appendix.

## **2. Methodological Approach: A Macro-Micro Simulation Model**

We adopt a top-down simulation approach to estimate the macro- and microeconomic impacts of COVID-19 in Africa using different scenarios. First, we simulate the pandemic shock at the macroeconomic level through the transmission channels—both the supply-side shock resulting from domestic containment measures and the external shock caused by global trends. We assess the impact on key macroeconomic variables, which then serve as inputs for the micro-model to study the impact on poverty in Africa.

## 2.1. A dynamic general equilibrium model of the macroeconomic effect of COVID-19

### 2.1.1. Model description

#### *Supply side*

The model is an open-economy dynamic general equilibrium model that features the informal economy (Colombo et al., 2019). The supply side features three private sectors: tradable formal  $x$ , non-tradable formal sector  $n$ , and informal sector  $j$ . Each sector utilizes private capital; low- and high-skill labor; government-supplied infrastructure, which increases the productivity of all sectors; and land, which is specific to agriculture.

Furthermore, the model assumes that the productivity of low-skill labor depends on work effort versus leisure. This allows us to assume that with COVID-19 and the resulting confinement measures, workers' leisure is increasing relative to their work effort. The death toll on human capital is captured indirectly through a loss of productivity, while lockdowns and the confinement of workers at home are captured through increased leisure or decline in work effort.

The production technologies  $q$  of the different sectors  $x$ ,  $n$  and  $j$  in period  $t$  are given as:

$$q_{x,t} = a_x z_{t-1}^{\psi_x} k_{x,t-1}^{\alpha_x} S_{x,t-1}^{\theta_x} H^{\chi} (e_{b,t} L_{x,t})^{(1-\alpha_x-\theta_x-\chi)} \quad (1)$$

$$q_{n,t} = a_n z_{t-1}^{\psi_n} k_{n,t-1}^{\alpha_n} S_{n,t-1}^{\theta_n} (e_{n,t} e_{b,t} L_{n,t})^{(1-\alpha_n-\theta_n)} \quad (2)$$

$$q_{j,t} = a_j z_{t-1}^{\psi_j} k_{j,t-1}^{\alpha_j} S_{j,t-1}^{\theta_j} (e_{b,t} L_{j,t})^{(1-\alpha_j-\theta_j)}. \quad (3)$$

All sectors utilize private capital  $k$ , low-skill labor  $L$ , high-skill labor  $S$ , and government-supplied infrastructure  $z$ . Infrastructure is a public good that enhances productivity in all sectors, and land or some natural resource  $H$  is a sector-specific input in sector  $x$ . The variable  $e_b$  links the quantity and quality of primary education to human capital of low-skill labor. In the formal sector, where efficiency wage considerations apply, the productivity of low-skill labor also depends on work effort  $e_n$ .

#### *Demand side*

The demand side of the model has two representative households: non-savers and savers, both of which derive their utility from consumer goods produced domestically in the formal sector, informal sector, and from imported traded goods.

The non-saving group comprises unemployed individuals and low-skill workers in the informal sector. They live hand-to-mouth and consume all their income each period and receive transfers from the government and their earnings in agriculture may include a share of land rents. The saving class comprises skilled workers and low-skill workers in the formal sector. They maximize an intertemporal utility function subject to a budget constraint. Unlike the non-savers, these households have access to capital and financial assets and/or liabilities and therefore the possibility to smooth their consumption subject to a discount factor that measures their preference for the future or the present.

On the spending side of their budget constraint, savers pay tax on capital income, on land rent, and on wage income in the formal sector. In addition, they pay user fees charged on infrastructure services. Furthermore, they face adjustment costs in accumulating capital, and portfolio adjustment costs in accumulating debt. The spending side of non-savers' budget constraint is similar except that they are exempt from payment of user fees on infrastructure services and do not accumulate capital or debt.

The budget constraint of the representative non-saver is given by:

$$P_{c,t}c_{1,t} = (1 - f_{wx})(w_{x,t}L_{x,t} + \sigma r_h H) + (1 - f_{wj})w_{j,t}L_{j,t} + a_t T_t, \quad (4)$$

where  $L_{x,t}$  and  $L_{j,t}$  are the supply of low-skill labor in the formal tradable and informal sectors, respectively;  $L_{j,t}$ ;  $w_{x,t}$  and  $w_{j,t}$  are the corresponding real wages;  $f_{wx}$  and  $f_{wj}$  are ad valorem taxes on low-skill wage income; and  $c_1$  is consumption by non-savers;  $T_t$  represents public transfers; and the coefficient  $a_t$  measures the share of transfers going to non-savers, with  $(1 - a_t)$  the share of transfer going to the counterpart savers.

The savers maximize the following intertemporal utility function:

$$V = \sum_{t=0}^{\infty} \beta^t \frac{c_{2,t}^{(1-1/\tau)}}{1-1/\tau} \quad (5)$$

subject to the following budget constraints:



$$P_t b_t - b_{f,t} = (1 - f_w)(w_{n,t}L_{n,t} + w_{s,t}S_{t-1}) + \sum_{q=j,n,x} [r_{q,t} - f_q(r_{q,t} - \delta P_{q,t})]k_{q,t-1} + (1 - f_h)(1 - \delta)r_{h,t}H + (1 - a_t)T_t - \frac{1+r_f}{1+g}b_{f,t-1} + \frac{1+r_{t-1}}{1+g}P_t b_{f,t-1} - P_{k,t} \sum_{q=j,n,x} (i_{q,t} + AC_{q,t}) - \frac{\eta}{2}(b_{f,t} - \bar{b}_f)^2 - P_{c,t}c_{2,t} - \mu_t z_{t-1} \quad (6)$$

And for each sector  $q$  with  $q = j, n, x$ :

$$(1 + g)k_{q,t} = i_{q,t} + (1 - \delta)k_{q,t-1} \quad (7)$$

The term  $AC_{q,t}$  in the budget constraint captures costs incurred in changing the capital stock in sector  $q$  and expressed as  $AC_{q,t} = \frac{v}{2} \left( \frac{i_{q,t}}{k_{q,t-1}} - \delta - g \right)^2$ . The term  $\frac{\eta}{2}(b_{f,t} - \bar{b}_f)^2$  measures portfolio adjustment costs associated with the deviations of foreign loans from their steady state level.

### *The public sector*

The public sector collects revenues from different sources and spends them on investment in education, infrastructure, and transfers. The model allows for different government financing options. Grants, aid, foreign direct investment (FDI), concessional borrowing and other financial flows, and oil revenues are exogenously given, as is public investment in infrastructure and human capital.

Absent additional financing sources, the government adjusts taxes and/or transfers to finance the fiscal gap. Moreover, the model assumes that external commercial borrowing and domestic borrowing help meet the financing gap, with taxes and transfers responding to stabilize debt levels over time. Withdrawals from oil funds and earnings on investments made by the fund constitute additional sources of revenues for the government.

The public sector budget constraint is expressed as follows:

$$P_t \Delta b_t + \Delta d_{c,t} + \Delta d_t = \frac{r_d - g}{1+g} d_{t-1} + \frac{r_{dc} - g}{1+g} d_{c,t-1} + \frac{r_{t-1} - g}{1+g} P_t b_{t-1} + P_{z,t} l_{z,t} + P_{z,t} m_t + T_t + P_{s,t} i_{s,t} - \mu_t z_{t-1} - h_t (P_{n,t} c_{n,t} + g_j P_{j,t} c_{j,t} + g_x c_{x,t} + g_m c_{m,t}) - \sum_{q=j,n,x} [f_q (r_{q,t} - \delta P_{q,t}) k_{q,t-1} + f_{wq,t} w_{q,t} L_{q,t}] - f_{wq,t} w_{s,t} S_t - f_{h,t} r_{h,t} H, \quad (8)$$

where  $\Delta b_t = b_t - b_{t-1}$ ,  $\Delta d_{c,t} = d_{c,t} - d_{c,t-1}$ ,  $\Delta d_t = d_t - d_{t-1}$ , and  $r_d$  and  $r_{dc}$  are interest rates (in US dollars) on concessional debt  $d$  and commercial debt  $dc$ , respectively, and  $r_t$  is interest rate on domestic debt  $b$ .

The term  $P_{z,t}I_{z,t}$ , where  $I_{z,t} = \mathcal{H}_t(i_{z,t} - i_{z,0}) + i_{z,0}$ , determines the absorptive capacity constraint in the public sector for investment spending..

### *Closure rule*

The model is closed by the accounting identity that growth in the country's net foreign debt equals the current account deficit. This offers the possibility of a twin deficit. On the external financing of the fiscal gap, the government sector borrows on concessional and non-concessional terms and accumulates assets from investment in oil revenues. Claims on the government include interest costs on external commercial debt, on domestic debt, and on concessional debt, plus principal. Interest rate on external commercial debt is a function of risk-free interest plus an endogenously determined risk premium. The private sector pays an exogenously determined risk premium in addition to what the government incurs. The interest rate is determined through the uncovered interest rate parity, namely, the interest differential between domestic bonds and foreign loans. When the capital account is perfectly open, the interest rate on domestic debt is equal to that of foreign loans. In a closed capital account, the differential is determined by portfolio adjustment costs.

### **2.1.2. Macro-modeling of COVID-19 shocks and fiscal policy responses**

The supply-side shock is modeled as a sudden loss of productivity of the unwell workers as well as in terms of a decline of their work effort or increase in involuntary leisure. The falling productivity along with the loss of work effort lead to a contraction of sector output and employment, which depresses real wages. If other components of households' income remain unchanged, households would face a loss of income with some attendant effects on consumption. In addition to the shocks originating from direct human cost and preventive measures, African economies are also being hit by global trends. In particular, the slowdown in global activity and disruption of global supply chains are affecting these economies through a contraction of trade, tourism, and financial flows. The degree of Africa's exposure and vulnerability to the global trends depends on how well the continent is integrated into the rest of the world as well as the contribution of each channel to the individual economies.

Regarding the trade channel, more than 85% of Africa's trade is with the rest of the world, with Europe, China, and the United States accounting for 56% of Africa's total trade in 2018. For net oil-exporting countries such as Nigeria, Angola, Gabon or Algeria, the fall in oil prices induced by COVID-19 will significantly reduce their export revenues and weaken their trade balance, while net importers will experience a relative improvement of their trade balance. On tourism, Africa has the second-fastest-growing tourism sector in the world, representing 8.5% of the continent's GDP and employing 24.3 million people or about 6.7% of total employment. Between 2017 and 2018, Africa's travel and tourism sectors grew by 5.6%, compared with the global average of 3.9%, and contributed about US\$194.2 billion to Africa's GDP in 2018. But the COVID-19 outbreak has brought a sudden stop to these sectors and the associated economic activities around hospitality, entertainment, and logistics.

Africa's financial inflows (FDI, overseas development assistance (ODA), portfolio investments, and remittances) are also likely to contract due to the coronavirus pandemic. In particular, the recent increasing trend in FDI inflows to Africa, which grew by 11% in 2018 – the fastest growth in the world – could stall in 2020 because of the pandemic as investors might postpone or even cancel their investment plans amid increased global uncertainty. Diaspora remittances – the largest source of financial inflows to Africa, could also be reduced as migrants' financial resources are affected by job losses, salary cuts –and increased household expenditures and healthcare costs. Planned portfolio investments, especially from China, in key sectors such as construction, transportation (roads, railroads, airports, and harbors), and energy could also be affected if global uncertainty continues because of the COVID-19 pandemic.

We model these global trends as exogenous external shocks along with the health (or productivity) shock and assess their impact on African economies. However, although high frequency data provide some indicators, the uncertainty surrounding the depth and the breadth of the pandemic in African countries makes it difficult to assess with certainty the macro- and micro-economic impacts of COVID-19. We therefore consider two possible scenarios regarding the depth and duration of the shock to these variables: the baseline and worse-case scenarios summarized in Table 1. Cognizant of these challenges, we caution that the results reported in this paper should be regarded as scenario analyses or simulations, and not as projections.

**Table 1. Summary of scenario assumptions**

Scenario	Duration and spread of COVID-19 outbreak	Scenario assumptions
Baseline scenario	First half of 2020, with lockdowns ending by middle of the year	<ul style="list-style-type: none"> <li>• Oil and commodity prices drop by 60% from their level in January 2020.</li> <li>• Financial flows (FDI, loans, portfolio investments, and remittances) to Africa decline by 60%</li> <li>• Tourism to Africa declines by 80% as a result of travel restrictions.</li> <li>• Capacity utilization and total factor productivity decline by 60% due to lockdown of cities, absenteeism due to the lockdown, postponement of construction activities, and disruption in supply chains.</li> </ul>
Worse-case scenario	The whole year 2020, with lockdowns extending beyond the middle of 2020.	<ul style="list-style-type: none"> <li>• Oil and commodity prices drop by 80% from their level in 2020, following fall in global demand and excess supply. Thus, oil prices are assumed to be \$15–20/barrel</li> <li>• Financial flows (FDI, loans, portfolio investments, and diaspora remittances) to Africa decline by 80%, as a result of investor flight to safety and constrained liquidity</li> <li>• Tourism to Africa halts completely as a result of the total ban on travels and social separation.</li> <li>• Capacity utilization and total factor productivity declines by 80% due to lockdown of cities, absenteeism due to the lockdown, postponement of construction activities, and disruptions in supply chains.</li> </ul>

Furthermore, we study the impact of different fiscal policy adjustment instruments in the spirit of Faria-e-Castro (2020) to alleviate the impacts of the pandemic on household and businesses, as well as stabilize the economy. One of the most obvious venues through which governments can cushion the impact of COVID-19 on the most affected households and businesses is by providing tax relief and public transfers. Tax relief in the form of exemptions from consumption and income tax and public transfers would attenuate household income losses while exemptions from taxes on profits would stabilize businesses' balance sheets and prevent their exit from the market. In a fiscally constrained situation, the policy response package will widen the fiscal gap. We propose the following fiscal policy adjustments to close the gap or allow a temporary widening of the fiscal gap: i) close the fiscal gap by reducing non-productive public spending and thus improving the efficiency of allocation ; ii) create a temporary deficit; and iii) introduce grants and concessional borrowing similar to that in rescue packages offered by multilateral institutions.

## 2.2. Linking macro- and micro-simulation models

The macroeconomic effects of COVID-19 are transmitted to households mainly through the following channels. First, in labor markets, COVID-19 leads to reductions in employment and wages due to business closures, declining economic activity, while the inability of infected and/or convalescent workers to do their jobs as usual and undertake other income-generating activities significantly reduces their revenues. Households in the informal sector are particularly vulnerable as they are not covered by social and financial protection mechanisms in most African countries. Second, unbudgeted health expenditures, most of them out-of-pocket, induced by the pandemic (for instance, purchases of protective items such as gloves, hydroalcoholic gels, and face masks) can exacerbate the welfare conditions of vulnerable households already living on the edge of poverty and increase inequality between the rich and the poor. Finally, by disrupting domestic and international distribution channels of inputs and outputs and amplifying consumer's hoarding behavior, the COVID-19 shock has provoked price increases of agricultural and other commodities in some countries, thereby reducing households' purchasing power. This could pose a major risk to the food security of poor households, especially if prices of essential goods remain high, and therefore unaffordable, for the rest of the year.

In our micro-simulation approach, in line with models developed by Bourguignon et al. (2008) and Ferreira et al. (2008), we superimpose macroeconomic projections from the dynamic general equilibrium model on pre-crisis household data to extrapolate post-crisis household welfare and, thus, poverty levels. Formally, let  $w_{ij,-t}$  and  $w_{ij,t}$  be the welfare of a household  $i$  (approximated here by real per capita household consumption) in an African country  $j$  observed respectively before and after the coronavirus pandemic outbreak. The corresponding welfare distributions  $D_{j,-t}$  and  $D_{j,t}$  of households in that country before and after COVID-19 can be defined as :

$$D_{j,-t} = \{w_{1j,-t}; w_{2j,-t}; \dots; w_{ij,-t}; \dots; w_{Nj,-t}\} \quad (9)$$

$$D_{j,t} = \{w_{1j,t}; w_{2j,t}; \dots; w_{ij,t}; \dots; w_{Mj,t}\}, \quad (10)$$

where  $N$  and  $M$  are the total population of the country before and after the COVID-19 outbreak. The impact of the pandemic can then be obtained by comparing the welfare distribution in (9) and (10):

$$I_{j;t} \equiv D_{j;t} - D_{j;-t} = \{w_{1j;t}^* w_{2j;t}^* \dots; w_{ij;t}^* \dots; w_{Mj;t}^*\}, \quad (11)$$

where  $w_{ij;t}^*$  is the impact of COVID-19 on the welfare of household  $i$ .

The micro-simulation approach consists of assessing how  $D_{j;-t}$  would change to  $D_{j;t}$  due to COVID-19, given the parameters obtained from the DSGE model. To link the macro and micro models, we assume that growth of real per capita household consumption derived from household surveys is correlated with real per capita GDP obtained in national accounts and used in the macroeconomic model (Ravallion, 2003; Deaton, 2005; Pinkovskiy and Sala-i-Martin, 2016), so that:

$$w_{ij;t} = (1 + \beta g_{j;t}^s) * w_{ij;-t}, \quad (12)$$

where  $g_{j;t}^s$  is the simulated real per capita GDP growth obtained from the DSGE model and  $\beta$  is the estimated passthrough between growth rates of per capita GDP and consumption using historical data. To get  $\beta$ , we follow Ravallion (2003) and estimate the following equation:

$$g_{s;t} = \alpha + \beta * g_{j;t} + \gamma * X_{j;t} + \varepsilon_{s;t}, \quad (13)$$

where  $g_{s;t}$  is the annualized growth rate of per capita consumption between two adjacent household surveys and  $g_{j;t}$  is real per capita GDP growth from national accounts over the same period.  $X_{j;t}$  is a vector of control variables such as the annualized growth rate of GINI index or population growth.  $\varepsilon_{s;t}$  is the error term. The intercept  $\alpha$  is constrained to 0 (Ravallion, 2003; Lakner et al., 2019). The coefficient  $\beta$ , our parameter of interest, represents the estimated fraction of real per capita GDP growth that is passed through to the real per capita consumption growth obtained in the surveys.

With the growth rates obtained from the DSGE model under different scenarios, the estimated passthrough  $\beta$ , the pre-crisis household surveys and projected population by country, it becomes straightforward to simulate the impact of COVID-19 on poverty and number of poor. To do so, we take the difference between the simulated poverty rates and number of poor (defined as those living on less than US\$1.90 a day) in the baseline and worse-case scenarios (COVID-19 scenarios) and the poverty rates and number of poor that would have been observed had the coronavirus not occurred (the no-outbreak or pre-COVID-19 scenario).

### **3. Data**

Most of the parameters' values used for the baseline calibration of the dynamic general equilibrium model are drawn from existing literature. Moreover, the calibration of cost shares and factor shares builds on data from the Global Trade Analysis Project (GTAP), International Food Policy Research Institute (IFPRI), and World Bank databases (see the calibration in Appendix for more details). To assess the poverty implications of COVID-19 in Africa, we use household surveys of 50 African countries from the World Bank's PovcalNet datasets<sup>2</sup>. These nationally representative data are standardized as far as possible with regards to the method of data collection and computation of welfare indicators and poverty measures. Our starting point is the latest available survey for each African country. The surveys span 2008–18, with 2015 as the mean survey year. Before performing the poverty simulations, we first apply the distribution of real per capita consumption (our proxy of household welfare) to 2019. To do so, we use equation (13) and assume that real per capita consumption grew following each country's growth rate of real per capita GDP without changing the consumption distribution (Lakner et al., 2019). In other words, we assumed that growth has been distribution-neutral between the year of the latest available data and 2019.

### **4. Results and Discussions**

#### **4.1. Macroeconomic impacts of COVID-19 in Africa**

In Figure 1, we plot the response of key macroeconomic variables to the COVID-19 shock derived from the DSGE model under the scenario assumptions in Table 1. Under the baseline scenario, the combined COVID-19 shocks are estimated to cause in 2020 a 34%, 39.1%, and 26.2% drop in employment in the informal sector, the formal service sector, and the formal tradable sector, respectively. The contraction widens further in the worse-case scenario, with close to a 43.2% drop in employment in the informal sector, 51.1% in the formal non-tradable sector, and 32.3% in the formal tradable sector. The loss of these jobs triggers a drop in consumption by non-savers by almost 8.3% in the baseline scenario and 16.4% in the worse-case scenario. Savers – who are assumed to behave in a rational and forward-looking manner and therefore prefer to save more and postpone consumption for precautionary reasons – see a more pronounced dip in their consumption levels by almost 18% in the baseline scenario and

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<sup>2</sup> Data are not available for Libya, Equatorial Guinea, Eritrea, or Somalia.

24% in the worse-case scenario. Private investment decision of businesses follow suit with a 13.4% (drop in the baseline scenario or 17.2% in the worse-case scenario. These combined effects would lead to a contraction in Africa's real GDP growth rate of  $-1.7\%$  in 2020 in the baseline scenario and  $-3.4\%$  in the worse-case scenario.

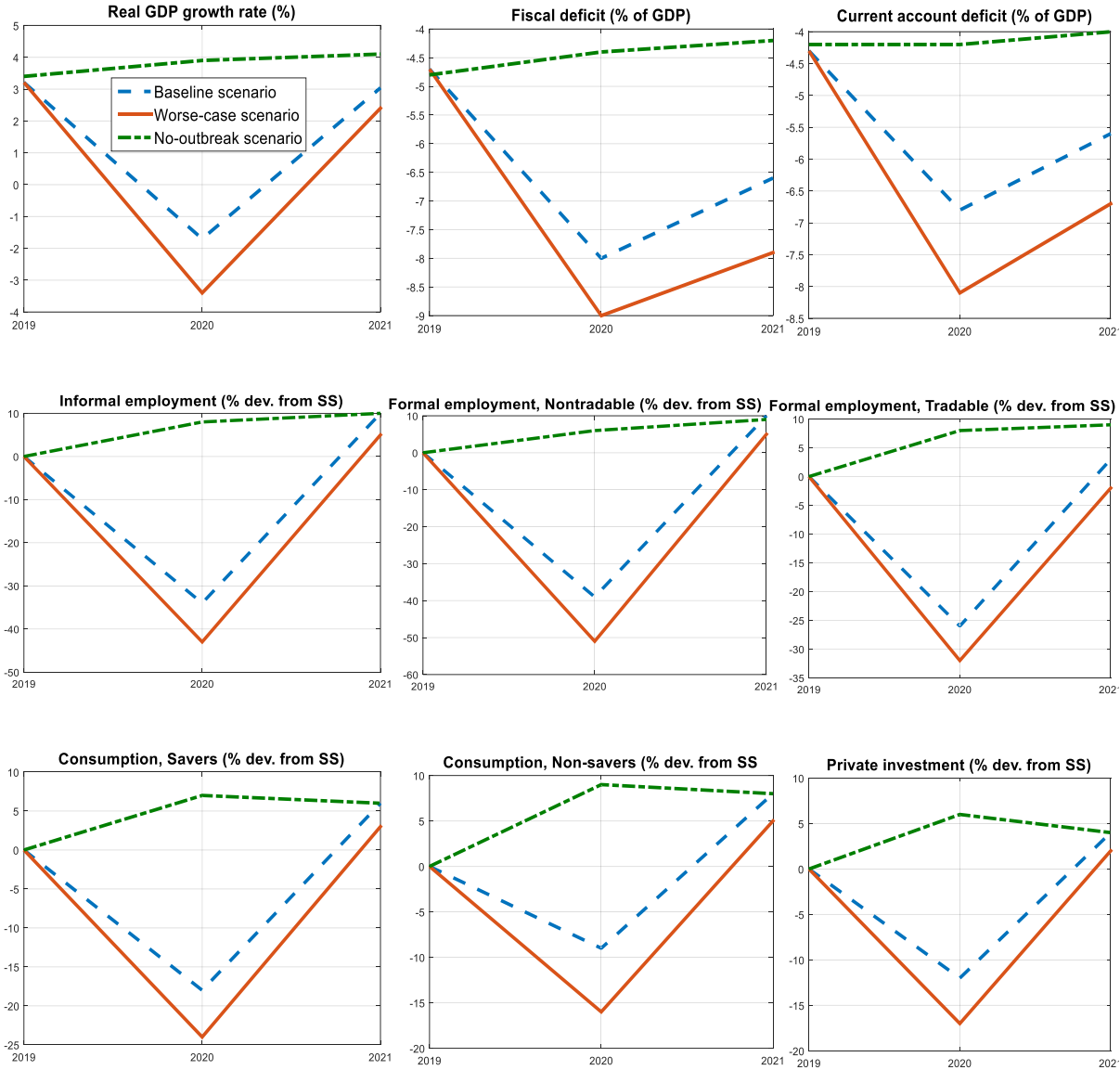
The combined COVID-19 shocks would squeeze fiscal space as fiscal deficits are estimated at 8% and 9% in the baseline and worse-case scenarios, respectively, in 2020. Indeed, the contraction of real GDP leads to a contraction in government revenues through lower foreign exchange receipts, especially for commodity exporters. The economic downturn also reduces the ability of governments to mobilize revenues through taxes as a result of the drop in GDP. On the expenditures side, governments face a pressure to spend more to improve health infrastructure and protect and provide for vulnerable segments of the society. Therefore, governments increase health-related spending while setting up fiscal policy response packages for vulnerable households and businesses (see Section 5.1 for details).

External balances would also be hit hard by the combined COVID-19 shocks, with the 2020 current account deficit estimated at 6.8% to 8.1% in the baseline and worse-case scenario, respectively. The important driver of these estimated deficits is the weakening of Africa's terms of trade with the rest of the world and loss of competitiveness of Africa's exports. Together with the low demand for exports, the expected reductions in remittances, and the economic downturn, these combined effects explain the estimated widening of the current account balance.

A V-shaped recovery is expected in 2021 for the selected variables, with the speed of the recovery different among variables. The recovery is expected to be faster in informal low-skill employment, followed by employment in service sectors, but slower in the tradable sector. Accordingly, consumption and investment behavior adjust, with consumption by both classes of households and private investment returning to positive territory by 2021.



**Figure 1. Responses to negative shocks under different COVID-19 scenarios**



Note: SS for steady state

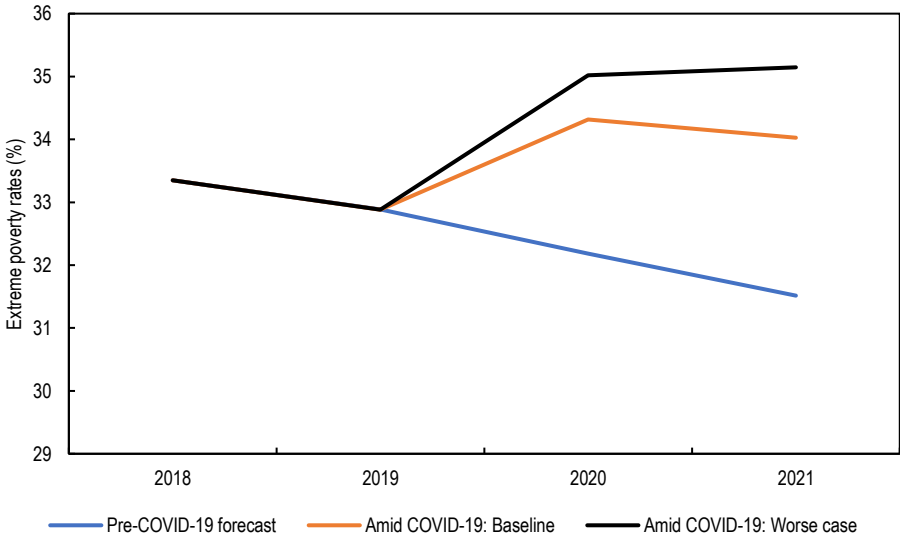
**4.2. Poverty effects of COVID-19 in Africa**

In the absence of COVID-19, estimates from the micro simulations show, Africa’s extreme poverty rates (share of people living on less than US\$1.90 per day) would have declined from 32.89% in 2019 to 32.18% in 2020 and 31.52% in 2021. This represents a reduction in extreme poverty rates of 0.71 and 0.67 percentage point in 2020 and 2021, respectively (Figure 2). However, when the effect of the coronavirus pandemic is accounted for, extreme poverty would now increase in 2020 by 2.14 and 2.84 percentage points in the baseline and worse-case

scenarios, respectively. And the poverty effect of COVID-19 would widen even further in 2021, to 2.51 and 3.63 percentage points in the baseline and worse-case scenarios, respectively. This means that if the coronavirus pandemic is not addressed, many African countries are likely to be pushed further off track from the Sustainable Development Goal (SDG) of eliminating extreme poverty by 2030.

Oil-exporting countries<sup>3</sup> are expected to be hit harder due to declining oil prices. Collectively, these countries will experience in 2020 an increase of 2.5 percentage points (or an additional 14.9 million poor) in the rate of extreme poverty under the baseline scenario, compared with an increase by 1.9 percentage points (or an extra 13.3 million poor) in oil-importing countries. Due to travel restrictions, poverty in tourism-dependent countries<sup>4</sup> such as Mauritius, Cabo Verde, and São Tome and Príncipe will also be significantly affected by the coronavirus pandemic. In particular, simulations show for instance that in 2020, rates of extreme poverty could almost double in Mauritius in the baseline scenario and increase by 46.7% in Cabo Verde and by 37.4% in São Tomé and Príncipe.

**Figure 2. Impact of COVID-19 on Africa’s extreme poverty rates**



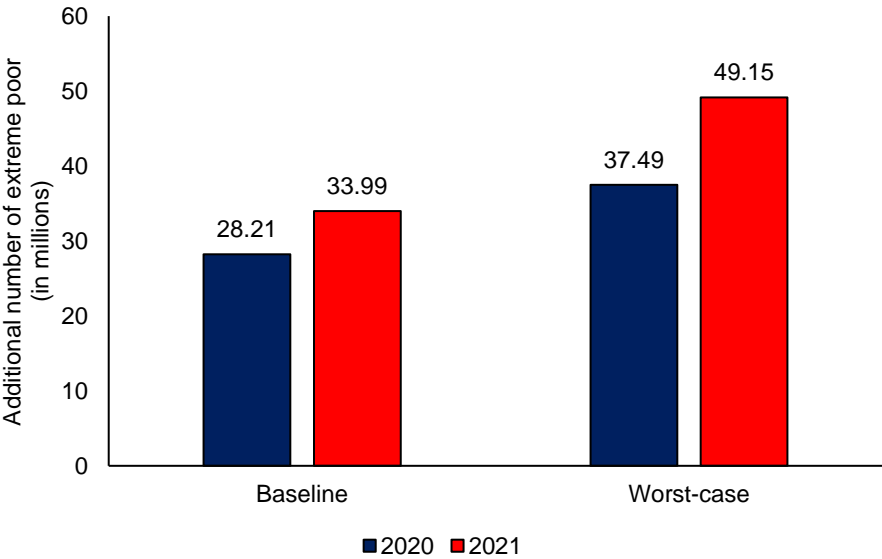
Note: Projected extreme poverty rates and numbers of extreme poor are measured using the poverty line of \$1.90 a day at 2011 purchasing power parity.

<sup>3</sup> We define oil-exporting countries as those for which net oil exports represent 25% or more of total exports – namely, Algeria, Angola, Cameroon, Chad, Republic of Congo, Egypt, Equatorial Guinea, Gabon, Libya, Nigeria, and South Sudan.

<sup>4</sup> The tourist-dependent countries – Cabo Verde, Comoros, Mauritius, São Tomé and Príncipe, and Seychelles – are defined as those to which tourism contributes more than 5% of GDP and accounts for 30% of exports.

The number of people living in extreme poverty is expected to rise due to the coronavirus. Under the no-outbreak scenario, 425.2 million people were projected to be in extreme poverty in Africa in 2020. COVID-19 could increase that figure to 453.4 million in the baseline scenario or as high as 462.7 million under the worse-case scenario, meaning an additional 28 million or 37.5 million people, respectively (Figure 10). In 2021, the number of poor could increase by up to 49.2 million due to COVID-19 as GDP growth continues to fall below population growth rates (Figure 3).

**Figure 3. Additional number of extreme poor in Africa due to COVID-19 (in millions)**



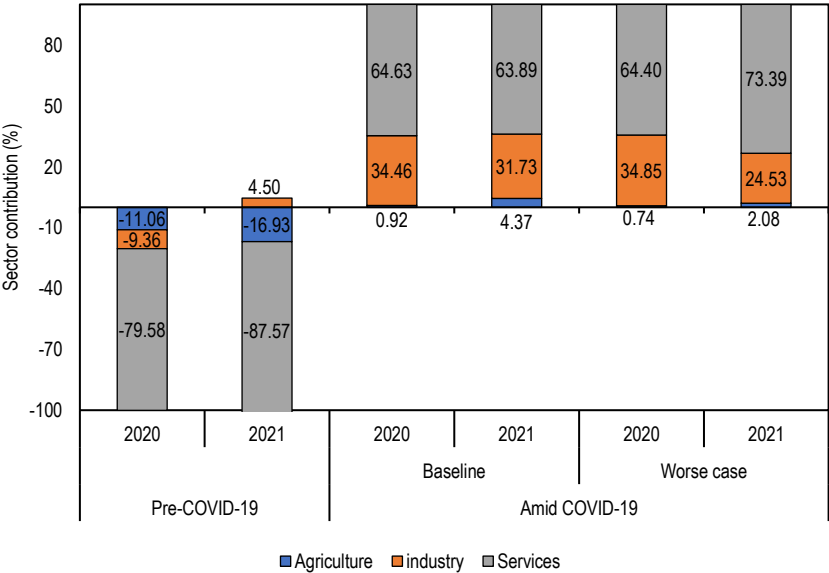
Note: Projected extreme poverty rates and numbers of extreme poor are measured using the poverty line of \$1.90 a day in 2011 purchasing power parity.

Nearly all sectors of the economy are expected to be adversely impacted by the COVID-19 crisis, and in particular sectors that are highly dependent on international trade or severely hit by confinement measures to contain the pandemic. When we account for the forecast sectoral composition of GDP growth and the estimated sectoral employment shares by the ILO’s Key Indicators of the Labour Market (KILM) dataset, our simulations suggest that increases in extreme poverty would be concentrated in the services sector. Hence, of the 2.14% increase in extreme poverty under the baseline scenario in 2020, 64.6% would originate from the services sector and 34.5% from industry (Figure 4). Service sectors such as transport and communication, accommodation, real estate, and financial services are affected by measures of social and physical distancing, closures of non-essential businesses and curfew imposed by most African countries, and a reduction of domestic demand. In the industry sector, and

especially the oil and mining sector, important declines in domestic production due to disruptions of international demand are the main driving factor of the rise in extreme poverty.

Finally, though the agricultural sector represents around 50% of total employment in Africa, its contribution to the increase of extreme poverty is very marginal (less than 1%) regardless of the scenario, for four main reasons. First, there have been relatively low disruptions in local agricultural value chains as most retail markets of agricultural products, supermarkets, and other open-air commercial areas remain functional during the pandemic. Second, most domestic agricultural production originates from rural areas, in which only a few reported cases of the virus have been reported in most African countries and confinement measures were relatively soft. Third, the observed increases in the prices of some agricultural products fueled by consumers’ hoarding behavior could have benefited net sellers and partly offset lower household consumption. Finally, the collapse of agricultural export earnings due to imposed travel restrictions could have stimulated domestic production, thus also contributing to increased domestic production (Laborde et al., 2020).

**Figure 4. Sector contribution to changes in rates of extreme poverty under different scenarios**



Note: Projected extreme poverty rates and numbers of extreme poor are measured using the poverty line of \$1.90 a day in 2011 purchasing power parity.

## 5. Additional Experiments

### 5.1. Fiscal policy responses to the pandemic

In the previous sections, the DSGE model exercise did not account for the effects of the different policy responses that various African countries are implementing to contain the spread of the virus and support their economies. In this section, we carry out additional experiments and study the impacts of activating the following fiscal policy response packages to mitigate the pandemic shock:

- Public transfer increases,  $T_t$  (see Eq. 4).
- Consumption tax cut,  $h$ .
- Low-skill wage income (in tradable and informal sector) and high-skill wage tax cut,  $f_{wx}$ ,  $f_{wj}$  and  $f_w$  (see Eq. 4 and 6).

The immediate implication of the response package is a widening of the fiscal gap, unless there is an offsetting fiscal adjustment. For each instrument of the package, we adopt the following fiscal adjustments by countries: i) allow a temporary fiscal deficit; ii) close the fiscal gap by reducing public infrastructure spending; and iii) finance the gap through grants and concessional borrowing similar to the rescue packages offered by multilateral institutions.

#### 5.1.1. Public transfer increases $T_t$

This experiment takes the form of direct transfer payments handed out by governments to the two classes of households. We calibrate the coefficient  $a_t$  in Eq. 2 such that non-savers are entitled to 60 of the transfers while their counterpart savers receive the remaining 40%. The intervention consists of a one-time increase in transfers of 4.6%, similar to the percentage point increase of fiscal deficit in Africa under the worse-case scenario. The key finding to note is that public transfer increases of this size alleviate the impact of the pandemic on households' consumptions. We find that the contraction of consumption of non-savers in the worse-case scenario is reduced by 8.3 percentage points in 2020 from its 16.4% level such that net fall in consumption is about 8 percent; for savers, the intervention lessens the contraction by 6.2 percentage points from its 24% level such that net fall in consumption is about 18 percent.

The overall economic impact of this instrument depends on how the resulting fiscal gap will be closed. First, we assume that governments will close the deficit by reducing

infrastructure spending by a corresponding amount. This substitution of productive spending with non-productive spending (transfers) does not harm the overall economy, given the short time horizon of only 2 years). Within this time horizon, the overall impact on the economy is measured in terms of Keynesian spending effects, with attendant demand-related pressures and, accordingly, minimal pressure on prices. Our results show that the spending effect is the result of the positive impact of transfers in cushioning the effect of the pandemic on households' consumption. Finally, we assume that governments are able to secure grants and concessional debt-financing to finance the fiscal deficit. We find that such alternative financing source goes a long way toward making the deficit fiscally viable. It indicates that the adjustment does not create any unintended effects on the economy in the short term. The qualitative results are similar to that with the previous fiscal adjustment. However, under this adjustment, private consumption is higher by another 0.24 percentage point for non-savers and 0.11 percentage point for savers.

### **5.1.2. Consumption tax cut $h$**

This experiment consists of a one-time lowering of the consumption tax rate by 20%. The effects of the consumption tax cut are found to be progressive between the two classes of households. It results in a 10.7 percentage point lessening of the contraction of non-savers' consumption and 7.6 percentage point for savers. This finding is in line with the general belief that cutting consumption taxes tends to be progressive in countries where the poor spend a large share of their income on consumption goods compared with high-income households. The quantitative results remain unchanged, irrespective of the strategies used to close the fiscal gap.

### **5.1.3. Low-skill and high-skill wage income tax cut**

This intervention consists of a one-time 20% cut in the low-skill income tax and a 10% cut in the high-skill income tax. The rationale is to make the intervention as progressive as possible. The tax cuts help sustain households' income, which in turn results in a higher consumption level. In particular, we find that a 20% cut in low-skill income tax reduced the drop in consumption observed in the worse-case scenario by 6.6 percentage points for non-savers. And a 10% cut in high-skill income tax reduced the drop in the level consumption of savers by 3.7 percentage points. The overall economic impact, including on GDP growth and employment, is mild thanks to the short time horizon.

## 5.2. Changes in within-country welfare distribution

Our micro-simulation results have so far considered that COVID-19 would be distribution-neutral and therefore equally affect poor and rich households. However, it is very likely that poor households will be more affected than others given their elevated risk of losing their jobs as a result of COVID-19. In addition, most poor households are subsistence farmers and/or are employed in the informal sector and have thus no access to public insurance schemes or other unemployment benefits. Finally, as shown in the previous section, emergency policy packages such as public cash transfers or consumption and wage tax cuts can support households and increase their consumption, which could help mitigate the effects of the coronavirus pandemic.

One way of accounting for differential changes in the welfare distribution within countries is to assume that, given their higher vulnerability to economic shocks, real per capita consumption of the poorest will grow more slowly than that of the rest of the population. Formally, the mean welfare growth of households  $\bar{w}_{jt}$  in a country  $j$  can be written as a weighted sum of the mean growth among the poorest  $k\%$  and the richest  $(100 - k)\%$  such that:

$$\bar{w}_{jt} = s_k * w_{kt} + (1 - s_k) * w_{(100-k)t}, \quad (14)$$

where  $s_k$  is the welfare share of the poorest  $k\%$  used as weight, with  $k \in [0; 100]$  and  $s_k \in [0; 1]$ .

If the poorest  $k\%$  grows at a lower rate  $i$  than the growth  $j$  of the rest of the population without changing the weighted mean growth, then (14) can be re-written as:

$$\bar{w}_{jt} = s_k * w_{kt} + \frac{[1 + i(1 + p)]}{(1 + i)} (1 - s_k) * w_{(100-k)t}, \quad (15)$$

where  $j = i(1 + p)$  and  $|j| > |i|$ .  $p$  is the growth penalty of the poorest  $k\%$ <sup>5</sup>.

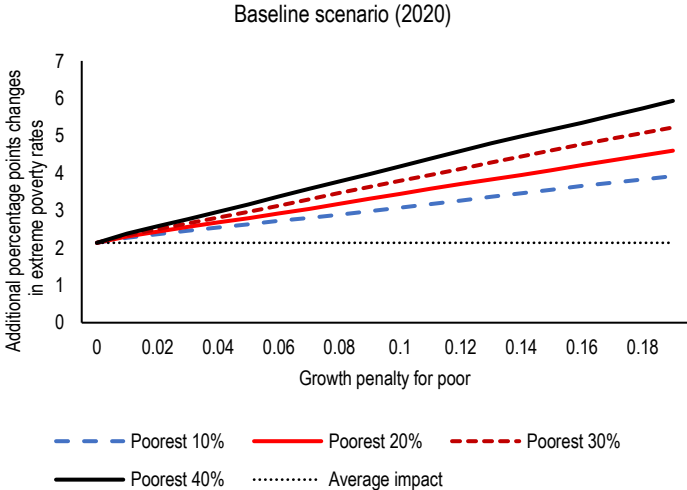
Figure 5 reports the results of the micro-simulation exercise when the real per capita consumption of the poorest 10% to 40% grows by up to  $p = 20\%$  slower than the rest of the population in 2020 under the baseline scenario. This lower growth for the poorest – the growth penalty – will amplify the impact of COVID-19 for the same level of mean growth. At lower levels of growth penalty  $p$ , the difference is imperceptible with an equally distributed growth

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<sup>5</sup> If the growth penalty  $p = 5\%$  and  $k = 10$ , then growth of real per capita consumption of the poorest 10% is 5% lower than growth of the remaining 90% of the population while keeping the mean growth unchanged.

(the horizontal line) but becomes larger as the penalty increases and a bigger share of the poorest is considered. For instance, if the welfare of the poorest 10% grows in 2020 on average by 1%, 5%, and 10% slower than the rest of the population, then the impact of COVID-19 would increase from 2.14% (horizontal line) to 2.27%, 2.63%, and 3.08%, respectively, in 2020 under the baseline scenario. When we consider the poorest 40%, then the poverty impact of COVID-19 would rise to 2.38%, 3.16%, and 4.18%, respectively. This result underscores the important of accounting for the differential effects of COVID-19 on poor and rich segments of the African population when simulating its poverty implications.

**Figure 5. Impact of COVID-19 under different levels of growth penalty for African poor**



Note: Growth penalty refers to the difference between the mean of the poorest X% (with X ranging from 10% to 40%) and the rest of the population. It implies that real consumption of the poorest grows more slowly than for the rest of the population. The average impact refers to an equally distributed growth of real per capita consumption within countries.

**6. Conclusion**

This paper simulates the impacts of COVID-19 in Africa using a sequential macro-micro simulation approach. This top-down methodology allows us not only to account for the interdependent effects of shocks to different sectors of African economies using a COVID-19 calibrated DSGE model but also to link them to household surveys and simulate the microeconomic impacts of the pandemic. The study adopts two scenario assumptions on the size and persistence of COVID-19 shocks due to the uncertainties of the depth and duration of the pandemic both in Africa and globally. The baseline scenario assumes that the coronavirus



pandemic will not go beyond the first semester, with lockdowns ending by mid-2020, while the worse-case scenario assumes COVID-19 will hit African countries all year with lockdowns extending beyond the middle of 2020.

The simulation results show that the pandemic will slow Africa's economic growth and exacerbate extreme poverty. In particular, depending on containment measures and their duration, the pandemic could push African countries into recession, with real GDP growth rates estimated at  $-1.7\%$  and  $-3.4\%$  in 2020 under the baseline and worse-case scenarios, respectively. The contraction of real GDP is a direct consequence of the health shock or negative productivity shock to the economy and disruptions in the global economy induced by the pandemic. This leads to significant drops in employment in the formal and informal sectors as workers lose their jobs, the contraction of consumption as household income-generating activities are halted, and the decline of private investment as the business environment becomes highly uncertain. In particular, the continent could record an increase in the rate of extreme poverty by 2.14% or 2.84% under the baseline and worse-case scenarios, respectively, which translates to an additional 28.2 million or 37.5 million people sliding into extreme poverty.

The paper also analyzes different types of fiscal policy packages being implemented by African countries to limit the impact of COVID-19 on their economy. These policy response packages include transfers to households, cuts in consumption taxes, and cuts in labor income tax. We find that, irrespective of how the government closes the fiscal gap in response to each instrument, all the policy responses succeed in increasing household consumption and income and therefore mitigating the effects of COVID-19. In addition, we find the consumption tax cut and differentiated low-skill and high-skill income tax cut to be progressive among poor and rich households. Finally, we find that a fiscal adjustment whereby the deficit is closed through grant financing is superior to an expenditure switching strategy that entails a corresponding cut in infrastructure spending.

There are, however, three important caveats to note in this study. First, the modeling exercise assumes a one-time rather than a persistent shock; if such persistence materializes, it could have serious implications for demand and supply disruptions. In addition, the shocks are assumed to be one-time perfect foresight fiscal impulses. In practice, fiscal policy packages are likely to be persistent and implemented over a certain horizon. Second, the size of the shocks is assumed to be fixed in each scenario. In practice, a range of values for the size and confidence interval is necessary. Finally, our model is grounded on fiscal policy, so we abstract from

monetary policy and liquidity injections in the response package. As a result, firms are excluded from the response package. This could be an important area for future research.

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## Appendix A.1: Technical Appendix

### Base case calibration of the model

The calibration of the model requires data on the structure of the economies, elasticities of substitution, depreciation rates, tax rates, debt stocks, and the returns on infrastructure and education capital at the benchmark equilibrium. Once values are set for these parameters, all other variables that enter the model can be deduced by budget constraints, the first-order conditions associated with the solution to the private agents’ optimization problems, and various adding-up constraints.

Table A.1 gives the value of key parameters of the model. These parameter values have been calibrated to the average African economies; the data reflect the structure of the economies prior to the pandemic crisis. Below we discuss the values assigned to the key parameters.

- *The consumption shares for the formal nontraded good ( $\gamma_n$ ), the informal good ( $\gamma_j$ ), the imported consumer good ( $\gamma_m$ ), and the traded good ( $\gamma_x$ ):* The data on consumption shares for these categories of goods are taken from the GTAP Africa social accounting matrix<sup>6</sup>. Formal nontraded goods, imported goods, and traded goods account for 40%, 10%, and 30% of total household consumption, respectively. By deduction we obtain the consumption share for informal goods: 20%. These consumption shares and the values assigned to other parameters imply GDP shares of 31.8%, 25.5%, and 42.7% for the formal non-tradable sector, the informal sector, and the tradable sector, respectively.
- *Intertemporal elasticity of substitution ( $\tau$ ):* According to estimates in Agénor and Montiel (2015), the value of this parameter for less-developed countries lie between 0.15 and 0.75. For the base case calibration, we choose the value of 0.40, which is close to the average estimate for low-income countries in Ogaki et al. (1996).

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<sup>6</sup> See this link for more details: <https://www.gtap.agecon.purdue.edu/databases/Africa/v2/default.asp>

- *Elasticity of substitution in consumption between traded goods and other goods ( $\epsilon_1$ ):* This parameter is calibrated to 0.5, in line with Lluch et al. (1977), Deaton and Muellbauer (1980), Blundell (1988), and Blundell et al. (1993), who find that estimates of compensated elasticities of demand tend to be small at high levels of aggregation, especially when food claims a large share of total consumption.
- *Elasticity of substitution in consumption between the composite formal nontraded good and the informal good ( $\epsilon_2$ ):* Most of the estimates of demand systems do not distinguish between goods produced by formal and informal firms. The correct value for  $\epsilon_2$  depends on whether firms in the formal and informal sectors sell in similar or distinct product markets. The sectoral overlap between formal and informal firms seems to suggest that both high and low values of  $\epsilon_2$  are plausible. For the base case calibration, we set  $\epsilon_2 = 0.5$  to reflect the fact that in low-income countries, informal firms operate in services and commerce while formal firms dominate in manufacturing. Alternatively, a higher value can be assigned to  $\epsilon_2$  to reflect the fact that both types of firms sell in similar product markets.
- *Wages in the formal and informal sectors ( $w_s$ ,  $w_n$ , and  $w_j$ ):* The wage for skilled labor ( $w_s = 3$ ) agrees with data on wages for workers with high versus low levels of education in Latin America (Joumard and Velez, 2015) and with empirical estimates that each additional year of upper-level education raises earnings 11%–13% (Peet et al., 2015). Data on the wage differential between formal low-skilled labor and informal labor are highly country-specific and rare. For the base case we choose 40% wage differential between the two types of labor, i.e.,  $w_n = 1$  and  $w_j = 0.60$ .
- *Factor shares in the formal nontradable sector ( $\alpha_n$  and  $\theta_n$ ):* Data on factor shares are found in World Bank Enterprise Surveys and in social accounting matrices assembled by GTAP and IFPRI. These sources suggest a capital share of 40%–60% in low-income countries. The data in Thurlow and Wobst (2004) and Perrault et al. (2010) suggest similar numbers. Accordingly, we set  $\alpha_n = 0.50$ .

There are no hard data on factor shares by skill or education level. Therefore, we set the cost share for high-skill labor to be consistent with data on the share of high-education (secondary+) workers in the formal sector. The values assigned to  $\theta_n$  (0.30) and the wage rates  $w_s = 3$  and  $w_n = 1$  give an employment share of 33.3% for high-skill labor. By comparison, the employment share for high-skill labor is 35.6% in Côte d'Ivoire (Gunther and Launov, 2012) and 32.9% in Egypt (Harati, 2013).

- *Factor shares in the informal sector ( $\alpha_j$  and  $\theta_j$ ):* Good, sensible data are not readily available for factor shares in the informal sector. We chose cost shares to match data on the share of high-education workers in the informal sector and the share of the informal sector in total non-agricultural employment. High-education workers account for 6.2% of informal sector employment in Côte d'Ivoire (Gunther and Launov, 2012) and 7% in Egypt (Harati, 2013). The informal sector share in non-agricultural employment is 75% in Sub-Saharan Africa and 70% in South Asia and Southeast Asia (OECD, 2009). For the base case values  $\alpha_j = 0.20$  and  $\theta_j = 0.20$ , the high-skill employment share is 6.3% in the informal sector and 74.1% in non-agricultural employment.
- *Factor shares in formal tradable sector ( $\chi$ ,  $\alpha_x$  and  $\theta_x$ ):* In the GTAP database, the cost share for land in less-developed countries ranges from 12% to 51%, while Fuglie (2010) cites studies that place the cost share between 22% and 29% in India, Indonesia, China, Mexico, and Sub-Saharan Africa. The common 50-50 split in sharecropping contracts (Otsuka, 2007) suggests a cost share of 50% for labor and 30%–35% for land (the landowner usually provides equipment and structures in addition to land). Therefore, we set the cost shares for land, capital, and high-skill  $\chi = 0.30$ ,  $\alpha_x = 0.20$  and  $\theta_x = 0.05$ , respectively.

**Table A.1. Calibration of the model**

Parameter/Variable	Value in Base case
Consumption shares of the imported consumer good and the formal and informal goods ( $\gamma_m, \gamma_n, \gamma_j$ )	$\gamma_n = .40, \gamma_m = .10, \gamma_j = .20,$ $\gamma_x = 1 - \gamma_n - \gamma_m - \gamma_j = .30$
Intertemporal elasticity of substitution ( $\tau$ )	.40
Elasticity of substitution between good x and goods n, j, and m ( $\epsilon_1$ )	.5
Elasticity of substitution between the formal and informal traded goods ( $\epsilon_2$ )	.5
Elasticity of substitution between the imported consumer good and the formal good ( $\epsilon_3$ )	.5
Wages in the formal and informal sectors ( $w_s, w_n, w_j$ )	$w_s = 3, w_n = 1, w_j = .6$
Factor shares in the formal sector ( $\alpha_n, \theta_n$ )	$\alpha_n = .50, \theta_n = .30$
Factor shares in the informal sector ( $\alpha_j, \theta_j$ )	$\alpha_j = .20, \theta_j = .20$
Factor shares in agriculture ( $\chi, \alpha_x, \theta_x$ )	$\chi = .30, \alpha_x = .20, \theta_x = .05$
Depreciation rates ( $\delta, \delta_z, \delta_b, \delta_u$ )	$\delta = \delta_z = \delta_b = \delta_u = .05$
Real interest rate on concessional + semi-concessional loans ( $r_d$ )	.013



Real interest rate on external commercial debt ( $r_{dc}$ )	.06
Trend growth rate ( $g$ )	.023
Ratio of user fees to recurrent costs ( $f$ )	.5
Consumption VAT rates ( $h, g_b, g_x$ ) <sup>1</sup>	$h = .20, g_j = .30, g_x = .10$
Taxes on profits, wages, and land rents ( $f_n, f_j, f_x, f_w, f_{wj}, f_{wx}, f_h$ )	$f_n = .15, f_j = .03, f_x = .02$ $f_w = .12, f_{wj} = f_{wx} = f_h = .01$
Efficiency of public investment ( $s$ )	1
Absorptive capacity constraint ( $\phi$ )	0
Return on infrastructure ( $R_z$ )	.20
Real interest rate on domestic bonds ( $r$ )	.10
Real interest rate on foreign loans held by the private sector ( $r_f$ )	.10
Interest elasticity of private capital flows ( $\Gamma$ )	1
Ratio of maintenance spending to GDP ( $P_{zm}/GDP$ )	.01644
Ratio of infrastructure investment to GDP ( $P_{zj}/GDP$ )	.06
Ratios of investment in education to GDP ( $P_{sib}/GDP, P_{siu}/GDP$ )	$P_{sib}/GDP = .028, P_{siu}/GDP = .012$
Ratio of domestic public debt to GDP ( $b/GDP$ )	.15
Ratio of private foreign loans and concessional and non-concessional public external debt ( $b_f, d, dc$ ) to initial GDP	$b_f/GDP = 0, d/GDP = .32,$ $dc/GDP = .06,$
q-elasticity of investment spending ( $\Omega$ )	2.5
Return on maintenance relative to new investment in infrastructure ( $R_{mz}$ )	$R_{mz} = 1$
Share of new high-skill workers drawn from the pool of low-skill workers in sector x-j ( $\Delta_{xj}$ ) and fraction of newly created/vacant formal sector jobs filled by workers from sector x-j ( $\xi$ )	$\Delta_{xj} = .80, \xi = .5$
Unemployment rate ( $u$ )	$u = .06$
Elasticity of the real wage in the formal sector with respect to the unemployment rate ( $g_3$ ) and the real informal sector wage ( $g_2$ )	$g_2 = .1, g_3 = .5$
Cost shares of nontraded inputs in the production of capital goods ( $\alpha_{ij}, \alpha_{in}, i = s, z, k$ )	$\alpha_{kj} = \alpha_{zj} = .35, \alpha_{kn} = \alpha_{zn} = .15$ $\alpha_{sj} = .60, \alpha_{sn} = .20$
Returns to education ( $R_u, R_b$ ) <sup>2</sup>	$R_u = .30, R_b = .30$
Ratio of elasticities of sectoral output with respect to the stock of infrastructure ( $\psi_n/\psi_x, \psi_j/\psi_x$ )	1
Long-run targets for domestic debt ( $b_{target}$ ) and external commercial debt ( $dc_{target}$ )	$b_{target} = b_o,$ $dc_{target} = dc_o$
Division of fiscal adjustment between expenditure cuts and tax increases ( $\lambda$ )	.5
Residual financing of the fiscal gap ( $\lambda_{dc}$ )	.30