IFPRI RWANDA

STRATEGY SUPPORT PROGRAM | WORKING PAPER 01 MAY 2021

Assessing the economywide impacts of COVID-19 on Rwanda's economy, agri-food system, and poverty

A social accounting matrix (SAM) multiplier approach

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ABSTRACT

Rwanda's policy response to COVID-19 has been widely praised for its rapid, systematic, and comprehensive approach to containing the pandemic. Although the economic consequences are unavoidable, the country expects to return its economy to its high-growth trajectory as the pandemic subsides. We use economic modeling tools designed to estimate the short-term economywide impacts of the unanticipated, rapid-onset economic shocks of COVID-19 on Rwanda.

- Results show that during the six-week lockdown that began in March, Rwanda's GDP fell 39.1 percent (RWF 435 billion; USD 484 million) when compared to a no-COVID situation in the same period.
- Results further show that Rwanda's GDP in 2020 will be between 12 and 16 percent lower than a predicted no-COVID GDP, depending on the pace of the recovery. The losses in annual GDP are between RWF 1.0 and 1.5 trillion (USD 1.1–1.6 billion).
- While GDP for the industrial and services sectors were estimated to have fallen during the lockdown period by 57 and 48 percent, respectively, exemptions of COVID-19 restrictions for the agricultural sector limited the decline in agricultural GDP to 7 percent compared to a no-COVID situation.
- During the lockdown period, the national poverty rate is estimated to have increased by 10.9 percentage points as 1.3 million people, mostly in rural areas, fell into temporary poverty. Poverty rates are expected to stabilize by the end of 2020, increasing only by between 0.4 and 1.1 percentage points. While these figures may be encouraging, they mask the impacts on poor households of the sharp poverty spike during the lockdown and the inherent complexity of poverty dynamics post-lockdown.

Looking forward, the speed and success of Rwanda's recovery will depend critically on the expansion of Rwanda's social protection programs, boosting enterprises of all sizes, support to the agri-food system, and restoration of international trade.

OVERVIEW

Rwanda has been aggressive in containing the spread of COVID-19, the disease caused by the SARS-CoV-2 virus, with its rapid, systematic, and comprehensive policy response to date (Beaubien 2020; Busari 2020). Even before the first COVID-19 case was confirmed on 14 March 2020, the Government of Rwanda introduced measures to contain the spread of the virus in the country. National lockdown policy measures introduced on 21 March and extended through 4 May effectively limited all economic activities in the country beyond those deemed to be essential. The lockdown policy was eased incrementally in the months that followed, although key public health measures – social distancing, wearing of face coverings, and nighttime curfews to discourage certain social activities – remained in place alongside targeted lockdowns of specific geographic areas experiencing some resurgence in infection rates.

By all accounts, Rwanda's policy measures to contain COVID-19 were a necessary and appropriate response to the pandemic and its high health risk to all Rwandans. Inevitably, the measures themselves also affected the economy, including incomes and livelihoods for a majority of Rwandan households and for many economic business activities in the country (Bizoza and Sibomana 2020). Recent surveys indicate that a majority of Rwandans are experiencing the adverse economic effects of these policy measures, though they also recognize the health risk of contracting COVID-19 (Debenedetti et al. 2020; Hutchinson et al. 2020).

Understanding the nature of those economic impacts is the first step to designing appropriate policy responses to protect the most vulnerable, aid in economic recovery efforts, and return Rwanda's economy to its high growth trajectory. This paper is the first in a series of assessments designed to estimate COVID-19's economywide impacts and to prioritize public policy and investment options for the recovery during the pandemic.

In this paper, we use a social accounting matrix (SAM) multiplier model to assess the effects of the COVID-19 pandemic. This assessment was conducted between April and September 2020, during a period when the economic impacts of COVID-19 were still unfolding in Rwanda.[1] The SAM multiplier model is a simulation tool that is ideally suited for measuring short-term direct and indirect economywide impacts of unanticipated, rapid-onset economic shocks, such as COVID-19. The multiplier model builds on a SAM, which is a database that captures resource flows associated with all economic transactions taking place in an economy, and represents the structure of the economy in a particular year showing the interlinkages and relationships between all economic actors (i.e., production activities, households, firms, governments, and relationships with the rest of the world) in terms of how they interact and affect each other. The Rwanda SAM captures 86 distinct economic activities or sectors characterizing the Rwandan economy in 2018.

We frame the COVID-19 pandemic effects as a result of both (1) external shocks to the Rwandan economy that affect exports and remittances, and (2) policy-induced shocks resulting from the Government's necessary response to containing the COVID-19 pandemic. We use the model to simulate (1) the effects of the six-week national lockdown[2] period; (2) a fast recovery scenario characterized by a strong economic rebound in the third quarter of 2020 and a return to

[1] Between the period during which this assessment was conducted and the publication of results, Rwanda experienced additional lockdowns that varied in geographic coverage, severity, and duration. Additional measures were also introduced across the country to contain the spread of the virus and, at the time of publishing this paper, many such measures were still in place. However, it is difficult, if not impossible, to assess the combined economic impact of each and every measure taken in Rwanda since March 2020. As such, this paper offers an illustrative insight into the methods used to understand such economic impacts, and is not an economic projection or forecast per se.

[2] Note that the term "lockdown" is a commonly understood term for the restrictions introduced by the Office of the Prime Minister on 21 March 2020. However, the term itself does not appear in the announcement and is not an official term used to describe the Government of Rwanda's policy response.

near normal (pre-COVID) economy by December 2020; and (3) a slow recovery scenario characterized by a modest rebound in the third quarter of 2020 but without a return to near-normal levels of economic activity in the fourth quarter. The results of our SAM modeling exercise are reported in comparison to a situation where the economy was not affected by COVID-19 during the same period.

The summary findings from our analysis are the following: First, during the six-week lockdown period, Rwanda's GDP falls 39.1 percent, equivalent to RWF 435 billion (USD 484 million) losses in GDP over this period. Industrial GDP falls 56.7 percent, driven primarily by large declines in mining (82.7 percent) and construction (74.2 percent). Services sector GDP falls 48.4 percent led by the closure of a wide range of non-essential service activities (Table 1).

Table 1: Economic costs of the COVID-19 pandemic in Rwanda, simulation results

	Six-week lockdown (March to May 2020)	Fast recovery scenario (Annual 2020)	Slow recovery scenario (Annual 2020)
	(% change from a no-COVID situation in the same period)		
Total GDP	−39.1	−11.5	−16.4
Agriculture sector	−7.3	−2.5	−3.3
Industrial sector	−56.7	−17.4	−24.1
Mining	−82.7	−32.3	−40.1
Manufacturing	−32.0	−9.9	−13.8
Construction	−74.2	−22.1	−31.9
Services sector	−48.4	−13.7	−20.0
Agri-food system	−12.6	−4.6	−5.8

Source: Authors, based on Rwanda SAM Multiplier Model results

Second, agricultural GDP falls only 7.3 percent during the lockdown period. Although the agricultural sector was largely exempt from the lockdown restrictions, economywide linkages affect the sector indirectly via reductions in intermediate demand from many nonagricultural sectors and from reductions in household and export demand. This is also reflected in a 12.6 percent fall in GDP for the broader agri-food system – comprising of agriculture, agro-processing, food trade and transport, and food services – during the same period.

Third, the Rwandan economy will likely rebound with policy restrictions now gradually being eased and with national economic recovery efforts starting to take shape. However, with uncertainty about the progression of the COVID-19 pandemic both domestically and internationally, it is difficult to predict the pace and duration of the recovery. Moreover, while Rwanda may experience a relatively rapid recovery post-lockdown with the economy returning towards some degree of normalcy, significant constraints along domestic value chains and in the global economy may slow down the pace of recovery.

Because of these factors, we consider two different recovery scenarios post-lockdown. Under a fast recovery scenario, Rwanda's GDP is expected to fall 11.5 percent in 2020 compared to a no-COVID situation, while under a slow recovery scenario, GDP will fall 16.4 percent. The total losses in GDP are between RWF 1.0 and 1.5 trillion (between USD 1.1 and 1.6 billion) in 2020.

In year-on-year comparisons, projections for Rwanda's economic outlook by the International Monetary Fund (IMF) indicated an expected –0.2 percent annual growth rate in 2020 – a significant decrease from the 9.4 percent growth rate achieved in 2019 (IMF 2020). We also conducted a similar exercise to compare our estimates of COVID-affected GDP growth in 2020 to actual GDP in 2019. Our assessment suggests that Rwanda is likely to have fallen into a recession in 2020 with negative GDP growth. Compared with the country's GDP in 2019, GDP in 2020 is expected to fall

by 3.8 percent under the fast recovery scenario and by 9.2 percent under the slow recovery scenario.

In fact, Rwanda's GDP fell by 3.4 percent, according to figures released by the National Institute of Statistics of Rwanda in March 2021 (NISR 2021). While results from our fast-recovery scenario track with NISR's actual figures closely, they should not be interpreted as an accurate projection or forecast, especially when compared to other, more appropriate projection and forecasting tools that have been used by the IMF and Ministry of Finance and Economic Planning (MINECOFIN).[3]

Forward-looking, scenario-based assessments such as ours differ from other foresighting exercises, such as forecasts, predictions, projections, and speculation. Scenario-based assessments are most useful in situations characterized by high levels of uncertainty within complex systems and hinge on the analysis of plausible alternative pathways along which events may occur (Msangi et al. 2012; Zurek and Henrichs 2007). Scenario analysis using structural models, in particular, is useful for isolating the outcomes of different shocks and policy changes – rather than focusing on combined impacts only – and for tracing impacts and spillover effects across different impact channels or pathways that link immediate shocks to the ultimate outcomes of interest.

Ultimately, the difference between the IMF outlook, NISR's actual figures, and our own assessment is largely a question of methodology, which we explain in detail later in this paper. Importantly, any economic outlooks – included those set forth in this analysis – face considerable uncertainty given the unprecedented nature of this global pandemic. This requires constant revisiting of the analysis when new data and information become available for the country and the global situation.

With significant losses in GDP under the two recovery scenarios, our model analysis shows that poverty rates are expected to increase by the end of 2020, though rather modestly. The expected poverty rate by the end of 2020 is about 0.4 percent higher under the fast recovery scenario and 1.1 percent higher with slow recovery. But these small changes mask the large spikes in temporary or transitional poverty during the six-week lockdown. During this period, the poverty rate is about 10.9 percentage points higher nationally than in a no-COVID situation during the same period, 11.6 points higher in urban areas and 10.8 points higher in rural areas. An additional 1.3 million people fall into poverty in this period, with most of these people residing in rural areas.

Already, the Government of Rwanda – through its various ministries and agencies, and in consultation with various economic stakeholders and development partners – is formulating and implementing plans to expand its social protection programs and to increase economic support for revitalizing the economy during the recovery period. The design of these policies will be critical to mitigating the negative shock of COVID-19, determining the speed of the economic recovery, and ensuring that the benefits are sufficiently broad to reach all affected households in Rwanda, especially the most vulnerable. Our modeling analysis under both fast and slow recovery scenarios, however, has not taken into consideration the implementation of these stimulus interventions, which potentially could help the economy recover significantly faster and stronger than our model assessments suggest.

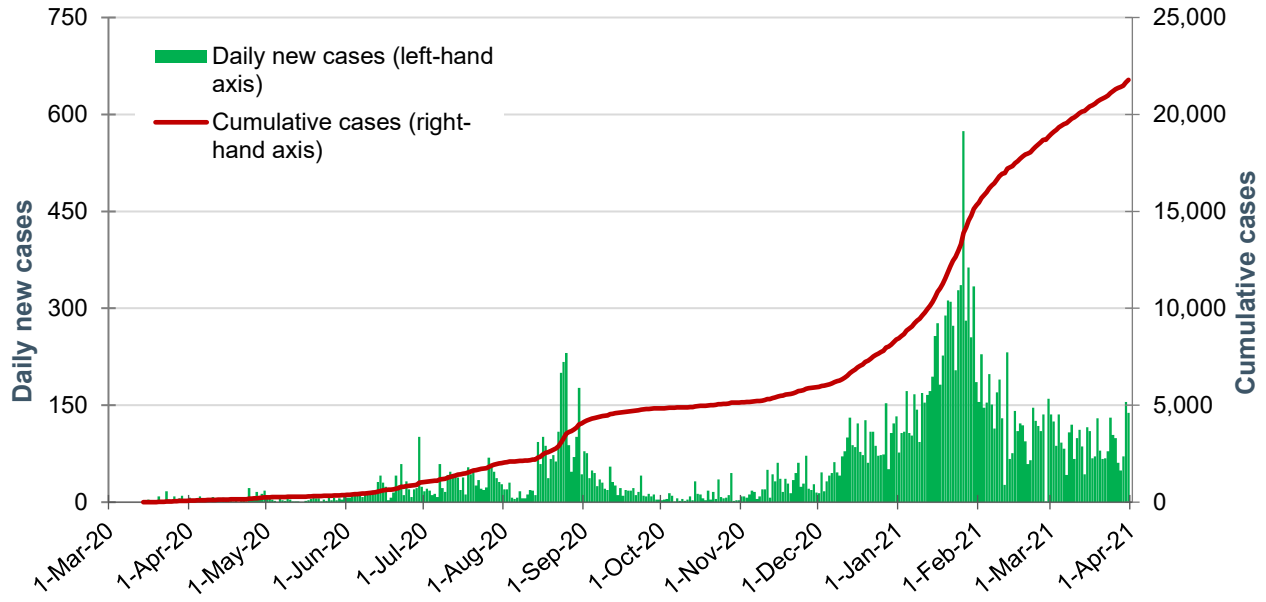
RWANDA'S POLICY RESPONSE TO COVID-19

Rwanda organized a rapid, systematic and comprehensive policy response to the COVID-19 pandemic relatively early. Rwanda's first coronavirus case was confirmed on March 14 when a

[3] In particular, we note that our assessed GDP losses for the second quarter of 2020 significantly exceed those of other assessments and the actual figures from NISR. This has implications for the overall economic and distributional outcomes generated by the SAM multiplier model assessment reported here.

foreign national who arrived in the country on March 8 tested positive. The first case of community transmission was confirmed on March 16 in a Rwandan national with no recent travel history. As of 26 April 2021, Rwanda had 24,593 confirmed cases (1,861 cases per million people), 330 confirmed deaths (25 deaths per million people), 22,941 recovered cases, and 1,322 active cases (Figure 1) (RBC 2021; Worldometers 2021; NISR 2020a).

Figure 1: New and cumulative cases of COVID-19 in Rwanda as of 01 April 2021



Source: RBC 2021; Worldometers 2021; NISR 2020a.

Rwanda's policy response to COVID-19 began prior to the identification of these first cases. The first set of far-reaching measures were introduced by the Office of the Prime Minister on 6 March 2020 and were incrementally expanded until a two-week "lockdown" was effectively declared on 21 March and repeatedly extended until 4 May. The measures during this six-week lockdown period quickly escalated from guidelines and directives related to hygiene and social distancing practices to health care system preparedness, restrictions on population movement, restrictions on educational institutions, the closing of non-essential offices and commercial activities, and closures of key ports of entry to travelers. These measures were accompanied by changes in finance and banking services, a shift in monetary policy to increase liquidity in the market, and the distribution of food items for social protection purposes. Rwanda's strong public health system, its extensive administrative apparatus, and recent experience with preventing the spread of an Ebola epidemic from neighboring Democratic Republic of Congo, are credited for Rwanda's exemplary response to the COVID-19 pandemic.[4]

In geographic and administrative terms, the measures were applied uniformly throughout the country during the six-week lockdown period. There are no indications of differences in enforcement intensity between urban and rural areas in Rwanda during the period, although differences in the composition of economic activity in these areas, i.e., farming versus services, implies that policies, such as closures and social distancing, required different levels of monitoring

[4] Google's analysis of mobility trends in Rwanda indicate a rapid reduction in movement beginning on or about March 16 (Google 2020), albeit for a non-representative sample of individuals using a device and application that allowed for mobility tracking. These mobility trends capture changes in visits and lengths of stay at different places compared to baseline levels during the five-week period between January 3 and February 6. As of April 5, mobility was 60 percent lower than baseline levels for retail and recreation, 54 percent for grocery and pharmacy, and 75 percent for transit hubs, with smaller changes observed for other categories (specifically, parks and workplaces). While the decreases are not as dramatic as those observed in highly affected countries, such as France and Italy (which introduced more severe lockdown measures), they do represent a significant response to the government's introduction of policy measures to contain viral transmission.

and enforcement. Only following the six-week lockdown were the restrictions targeted to particular districts and smaller administrative units as COVID-19 cases were identified and quarantined.

In broad economic terms, there are several pathways through which these policy measures are expected to affect economic output in the agriculture, industry, and services sectors of Rwanda's economy. *Restrictions on population movement and transportation* may have affected the ability of workers and managers to reach and carry out required functions at production facilities, project sites, administrative offices, and marketing outlets and may have also affected supply chain logistics that are essential to accessing raw materials, intermediate goods, and product markets. *Restrictions on finance and banking services* may have affected companies' short-term capacity to pay workers, suppliers, vendors, and other agents or otherwise manage their cash-flow requirements. *Restrictions on pricing* for certain categories of essential products may have affected companies' revenues, causing them to produce at or below costs of production. However, because these policy measures were not applied uniformly across all sectors of the Rwandan economy, each pathway needs to be considered by sector and activity.

Agriculture and agribusiness activities received a broad exemption during the six-week lockdown, with farming, processing, and marketing of agricultural commodities, inputs, and related services all permitted. To date, Rwanda has not imposed restrictions on farmers' movements, and there is no systematic evidence to suggest that farmers were unable to reach their fields during the six-week lockdown. Restrictions on movement and transportation exempted wholesale and retail markets for food and other essentials, albeit in compliance with requisite social distancing, hygiene, and sanitation measures. However, there are anecdotal reports that restrictions on movement and transportation during the lockdown may have presented significant challenges for migrant agricultural workers and extension services. Similar challenges were reported for supply chain logistics, for example, difficulties in quickly obtaining requisite travel permissions from local authorities. While the exact magnitude of these challenges is unknown, their effects were likely felt throughout the sector and across entire supply chains.

Industrial activities were closed under the six-week lockdown, with exceptions made for essential operations related to agro-processing, medical, pharmaceutical, hygiene, and sanitation products and for industries producing raw materials for these sectors. But even for these essential operations, restrictions on population movement and transportation may have affected the ability of workers and managers to reach and carry out required functions at production facilities, project sites, and administrative offices, and may have also affected supply chain logistics that are essential to accessing raw materials, intermediate goods, and product markets.

In the services sector, non-essential services were similarly closed by the six-week lockdown, although exemptions were provided for health-related activities, food production, wholesale and retail activities, essential transportation services, and other essential activities. Again, restrictions on population movement and transportation may have adversely affected workers, managers, and supply chains logistics in exempted sectors. Public administration activities, including both civil and military service, remained operational, although work-from-home orders for many categories of public workers are likely to have had a significant effect on their productivity.

These impacts provide a broad characterization of the channels through which Rwanda's policy measures to contain viral transmission are expected to affect the economy. One must also account for external effects transmitted through global markets – particularly decreases in export demand (including tourism) and remittances from abroad. These impact channels are introduced as exogenous shocks in the model, and we examine their direct and indirect effects using the model.

SIMULATING THE ECONOMIC IMPACTS OF COVID-19

In this section, we discuss the methodology used to simulate the economic impacts of the COVID-19 pandemic, including the modeling approach, data sources, scenarios, and assumptions underlying the analysis.

Modeling approach

As noted, the pandemic is expected to affect Rwanda's economy through several distinct channels. Here, we discuss how we analyze the short-term economywide impacts of COVID-19 using a SAM multiplier model for Rwanda.[5] Additional details on the methodology are provided in Annex 1.

SAM-based models are particularly well-suited to measuring short-term direct and indirect impacts of unanticipated, rapid-onset economic shocks, such as those associated with COVID-19. We used a 2018 SAM for Rwanda that captures resource flows associated with economic transactions taking place in the economy, showing the interlinkages and relationships between all economic actors (i.e., productive activities, households, firms, government, and the rest of the world) in terms of how they interact and affect each other. The SAM is further scaled up in the simulation analysis to represent the economy in 2019 or a predicted no-COVID economy in 2020 as a base for comparison.

The data used to build this SAM are drawn from both domestic sources, such as the National Institute of Statistics Rwanda (NISR) for household and enterprise data and the Ministry of Finance and Economic Planning (MINECOFIN) for national accounts and government accounts, and international institutions, including the IMF and the Food and Agriculture Organization of the United Nations (FAO). The 2019 mid-year exchange rate is used in this analysis to provide results in both Rwandan francs and US dollars.

The SAM multiplier model is a simulation tool for *ex ante* analysis. It is used here to simulate the economywide impacts of COVID-19 on highly detailed economic activities represented in the SAM that are then aggregated to the national or to aggregate sector levels, including for total and sectoral measures on GDP, employment, and incomes of different households. In other words, the SAM multiplier model takes a bottom-up approach with the economic shocks associated with COVID-19 in model simulations being imposed at detailed sector levels, taking into consideration their economywide interactions and linkages. In the model, prices are assumed to be fixed, and changes caused by the shocks in the simulations are all reported in real terms without a price effect. Such price-fixed approaches are common in assessing short-term shocks in which the shock inhibits the ability of markets to adjust to a new equilibrium through endogenous price adjustment processes.

Economic shocks caused by COVID-19 are simulated through two main channels in the model: (1) a set of shocks stemming from external factors, and (2) a set of shocks induced by the country's own lockdown restrictions and related measures taken to contain viral transmission. The shocks stemming from external factors are further categorized into shocks to (i) export demand, resulting from exogenous decreases in demand for Rwandan goods and services – including tourism – from the rest of the world (ROW); and to (ii) remittance inflows, resulting from reductions in the money transferred from Rwandan immigrants working abroad that directly affects households' consumption. See Annex 1 for additional details on how the model is used to analyze the economic impacts of COVID-19.

[5] Note that the 2018 SAM used for this study is an extended version of the 2015 SAM, incorporating updated national accounts and other macroeconomic data for the purpose of this study. Collaborative efforts are underway to estimate a new 2017 SAM using the most updated supply and use data, household data, and other information. We do not expect an updated SAM to significantly affect the results of the analysis presented here.

Both external and domestic lockdown-induced shocks are modeled on the demand side in a manner that then lowers the supply of goods and services produced in the affected sectors directly. Many of Rwanda's economic sectors and activities are hit hard by such direct effects. These effects are further amplified by the input-output linkages among economic sectors, as almost all economic sectors require intermediate inputs produced by other sectors. The input-output linkages generate indirect effects that can be rather large, particularly for those sectors whose production or services are mainly used as intermediate inputs.

The model is named a "multiplier" model precisely because it captures these interlinkage effects among economic sectors. Furthermore, the SAM multiplier model considers the linkage effects between productive sectors and final demand, which is made up of household demand, government demand, investment demand, and exports. These interactions between production activities and institutional accounts further enhance the multiplier effects. The model's ability to capture such indirect effects is a key merit of a SAM model compared to a traditional input-output model. The assumptions on direct demand shocks at the sector level and interactive relationship between exogenous and endogenous SAM accounts are discussed below, with robustness checks provided in Annex 2.

Scenarios and assumptions

We consider the following three main scenarios in our simulations: (1) the period of the six-week *national lockdown*; (2) a *fast recovery scenario* post-lockdown, characterized by a strong economic rebound in the third quarter of 2020 and a return to near normal (pre-COVID) economy in the fourth quarter of 2020; and (3) a *slow recovery scenario* characterized by a modest rebound in the third quarter of 2020 with economic activity remaining at below pre-COVID levels in the fourth quarter. In the two recovery scenarios, we assume that the easing of restrictive policy measures to contain the spread of COVID-19 is a gradual process beginning in May 2020 and speeding up through the remaining months and quarters of 2020. The fast and slow recovery scenarios are stylized given the difficulty in predicting how the post-lockdown period will evolve. The assumptions applied to these two recovery scenarios are detailed below and summarized on a monthly and quarterly basis in Table 2.

Table 2: Recovery scenarios for Rwanda's economy

Quarter	Month	Faster recovery	Slower recovery	Global shocks
Q1	January to March	Pre-COVID-19 period without any shocks		
Q2	April	**Six-week lockdown period starts in late March**		Decline in remittances and export demand
	May	Lockdown shocks eased by 25%	Lockdown shocks eased by 25%	
	June	Lockdown shocks eased by 50%	Lockdown shocks eased by 25%	
Q3	July to Septem-ber	Lockdown shocks eased by 90% (transport by 80%, hotels/bars & sports by 60%)	Lockdown shocks eased by 50% (transport, hotels/bars & sports by 30%; construction by 70%)	Declines in remittances and export demand reduced by 50%
Q4	October to December	Direct shocks eased by 100%	Direct shocks eased by 90%	Declines in remittances and export demand reduced by 75%

Source: Authors
Note: Only Q2 is modeled in a monthly progression. All other quarters are modeled on a quarterly time-step.

Several points on the definition and operationalization of these scenarios are important to note at the outset.

- We model the six-week lockdown for the national economy. This is consistent with Rwanda's experience between March and May 2020. The SAM multiplier model we use is not a spatially explicit model that would allow for provincial or district-level simulations.
- The restrictive policy measures are simulated as shocks on final demand that lead to falls in the production of affected sectors. While directly shocking the supply side of the economy is feasible with the model, with either approach, the model generates similar results. See Annex 2 for details.
- The assessed economic costs resulting from our simulations do not reflect the policy responses that Rwanda may pursue to mitigate economic losses through, for example, monetary policy stimuli, mobilization of foreign assistance and lending, postponement of interest payments or forgiveness on debt to multilateral development finance institutions, or other tools of macroeconomic policy.
- These economic costs do not account for the mitigation actions of households and firms in responding to the crisis. For example, consumers may shift their consumption and expenditure choices in response to changes in prices and other economic factors, and firms may switch operational areas to capture new business opportunities. In an *ex ante* analysis designed to assess the short-term effects of the COVID-19 pandemic on Rwanda's economy, these factors are not readily taken into consideration.
- Finally, this analysis does not address the fundamental uncertainty in either the domestic or global economy or in the trajectory of COVID-19 itself, which is beyond the capacity of the *ex ante* simulation model used in the analysis.

Export demand. Exports were equivalent to about 20 percent of Rwanda's GDP in 2019 (IMF 2020). Earnings from mining, manufacturing, agricultural, and service exports are vulnerable to many external factors beyond the country's control given the nature of the global COVID-19 pandemic. Export demand for mining products and some other manufacturing products is expected to fall significantly. However, exports of Rwanda's two major agricultural products, coffee and tea, are expected to experience a relatively smaller impact. Declines in livestock exports (specifically, cattle) are expected to be significant due to border closures.[6] Thus, the exogenous shocks on export demand in the model focus on exports of mining, livestock, business services, transportation, and others tourism related services, while exports of coffee and tea are not shocked exogenously.

Tourism, a key contributor to export earnings, warrants additional attention. Revenue from tourism accounted for about a quarter of Rwanda's export earnings in 2018, equivalent to about 6 percent of GDP (UNWTO 2020; World Bank 2020b). As in most other countries, Rwanda's tourism sector was among the most immediately affected economic sectors when international meetings, conferences, events, and exhibitions (often referred to as MICE, "meetings, incentives, conferences, events and exhibitions", in Rwanda) were all cancelled immediately when the pandemic became a global threat. External demand for export-oriented services fell dramatically beyond MICE to quickly include the entire tourism sector. The tourism sector was further hit by movement restrictions when the lockdown started, which led to cancellations of almost all hotel and sightseeing reservations. While tourism is an important economic activity, there is typically no economic sector classified as tourism in a SAM, because tourists typical spend money on various commodities and services produced by other economic sectors defined in a SAM. Thus, the

[6] Exports of other livestock products such as small ruminants, poultry, and eggs were also affected by the closure of entry points to traders. However, a significant share of these products is traded across borders – most notably, across the border with the Democratic Republic of Congo – by small-scale traders who cross into Rwanda to purchase products and then carry them across the border for sale in local markets. This value of this small-scale trade activity is typically not reported in the national accounts or national trade statistics.

external shocks on tourism are modelled as shocks on exports of transportation and hotels and accommodations and as decreases in demand for a wide range of tourism-related services in domestic markets, including for transportation, hotels and accommodations, restaurants and food services, tourism-related business services, and arts and entertainment.

Remittances. Remittance inflows account for nearly 3 percent of incomes for Rwandan households as a whole and are a non-negligible contribution to household consumption and consumption smoothing, particularly among the poor. While detailed information on changes in remittance flows resulting from the pandemic is not available for Rwanda, a World Bank study (Ratha et al. 2020) estimates a 23 percent decline in remittance inflows for sub-Saharan Africa as a whole (see also Kuhlcke and Bester 2020). In recognition of the income shocks faced by Rwandans working in foreign countries and frictions in money transfer networks worldwide, the reduced remittance inflows are modeled as exogenous declines in household consumption demand for various commodities and services proportional to the fall in remittance incomes.

Agricultural sector. Farming and agribusinesses were exempted from restrictive policy measures during the lockdown period. Therefore, we do not impose direct exogenous shocks on Rwanda's agricultural sector other than the shocks to capture the fall in livestock export demand and declines in consumer demand proportional to the fall in remittance incomes. However, the indirect effect from COVID-related policies and exogenous shocks on other sectors do impact the agricultural sector through economywide linkages, as will be discussed later.

It is worth noting that Rwanda's six-week lockdown was fortuitously introduced at a point in the agricultural calendar when the country was possibly least susceptible to a shock of this magnitude, at least in the short run. The majority of the Season A (September to December) food staple production had been harvested. This helped check a higher-than-usual food price inflation rate observed in the months preceding the pandemic (see NISR 2020b). At the same time, inputs for the subsequent cropping season had been procured and largely distributed to farmers throughout the country. But while this timing may be fortuitous, there are considerable risks and uncertainties going forward, as input procurement and preparation activities advance for subsequent seasons.

Industrial sector. The restrictive policy measures during the six-week lockdown period were expected to significantly affect the industrial sector. For mining, most manufacturing, and construction activities deemed non-essential, the six-week lockdown was fairly comprehensive, with little or no work being performed for many activities in these non-essential industrial sectors. However, we maintain an assumption that some degree of intermediate activities continued – for example, the importation of essential intermediate goods, inventory maintenance, and very basic management operations.

We do not introduce direct exogenous shocks on essential activities, such as pharmaceutic and agro-processing. However, anecdotal evidence suggests that there were substantial transaction costs incurred by agro-processing businesses in obtaining permission from local authorities to allow continued movement of workers, inputs, goods, and services, as well as other less obvious transaction costs incurred as a result of bank branch closures and the shift in financial transactions to digital channels and contactless mobile payments. These costs may have weighed heavily on agro-processing activities, which often rely on long and complex supply chains to bring produce from the farmgate for storage, processing, and packaging. However, because the prevalence and magnitude of these shocks is unknown, we do not exogenously shock agro-processing directly in the model.

On the other hand, a large exogenous shock is imposed on the demand/supply of other manufacturing sectors (except for essential activities related to the preparation of agricultural chemicals, hygiene products, and pharmaceuticals), and on mining, and construction activities. We

further assume that the lockdown does not have a direct effect on energy production and water service provision, for which we do not impose direct exogenous shocks in the simulations.

Services sector. Severe direct effects are expected on various services sectors as a result of the six-week lockdown and some restrictions that continue post-lockdown. This includes exogenous shocks on hotels and other accommodation services, restaurants, cafes and bars, business services, transportation, wholesale and retail, and arts and entertainment. Some trade and transport activities were exempted from the lockdown, and in these cases, we assume a relatively modest shock, such as, for example, to wholesale, retail, and freight transport.

In the services sector, we do not introduce direct exogenous shocks for health, public administration, and education. Although demand for health services is anticipated to increase as COVID-19 infection rates increase, this may be offset by decreased demand for non-urgent or elective services. For public administrative services, we assume that salaries and wages remain unchanged as staff continue providing essential services, shift their work to COVID-19 monitoring, change to a work-from-home modality, or otherwise remain in service. Similarly, while demand for educational services declined precipitously with the closing of all primary and secondary schools, technical and vocational schools, and universities, we assume that the majority of educators and other staff retained their salaries and wages through the six-week lockdown period and subsequent months. When health, administrative, and educational workers continue to receive salaries and wages, they generally maintain their demand for goods and services in the economy.

ASSESSING THE ECONOMIC COSTS OF THE COVID-19 PANDEMIC IN RWANDA

In this section, we present simulation results of Rwanda SAM multiplier model. We first focus on the macroeconomic costs to Rwanda of the COVID-19 pandemic measured by GDP and aggregate sectoral GDP. As explained in the methodology section, the SAM multiplier model is a bottom-up approach, which is a different approach taken in macroeconomic models that are often used for such analysis at GDP level. The aggregate GDP and other economywide effects presented in this section are, in fact, the aggregation of impacts at the detail sector level. In the discussion of the simulation results, we use a predicted no-COVID situation for the economy in 2020 as the base, and all results are reported in comparison to this normal (no-COVID) situation in 2020.[7]

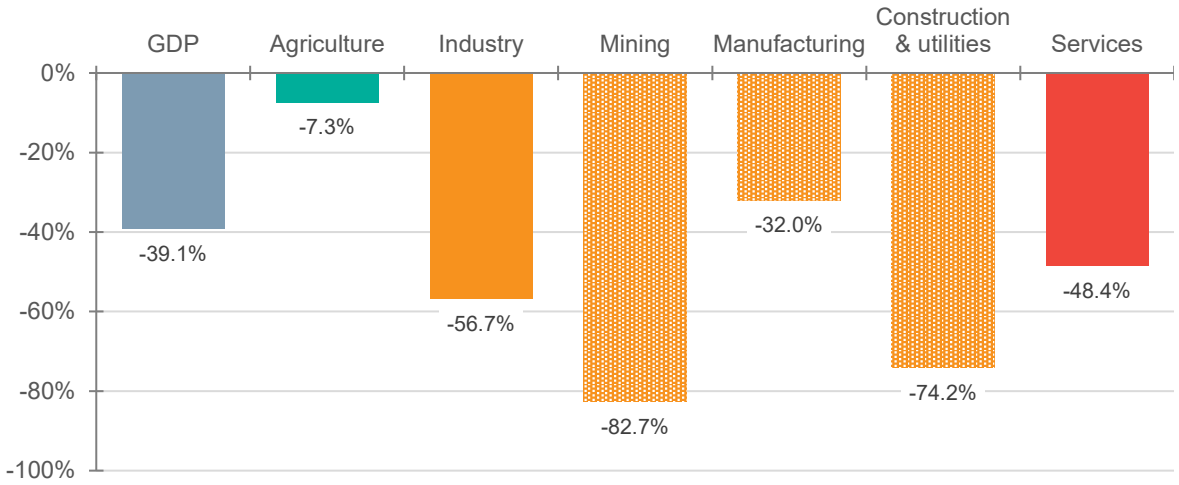
Economic costs of the lockdown period

Impacts on total and sectoral GDP

Our simulation results show that, compared to a normal (no-COVID) economic situation during the same period, Rwanda's GDP fell 39.1 percent during the six-week lockdown period. Industrial GDP fell 32.0 percent, driven primarily by large declines in the mining and the construction and utilities sub-sectors. Agricultural GDP fell only 7.3 percent, while services GDP fell by 48.4 percent (Figure 2).

[7] It is important to distinguish the "no-COVID scenario" in 2020 from past performance in 2019 as the point of comparison in these results. The former is consistent with how SAM multiplier model results are commonly reported, while the latter is more consistent with standard reporting of macroeconomic indicators by, e.g., MINECOFIN and other government ministries and agencies.

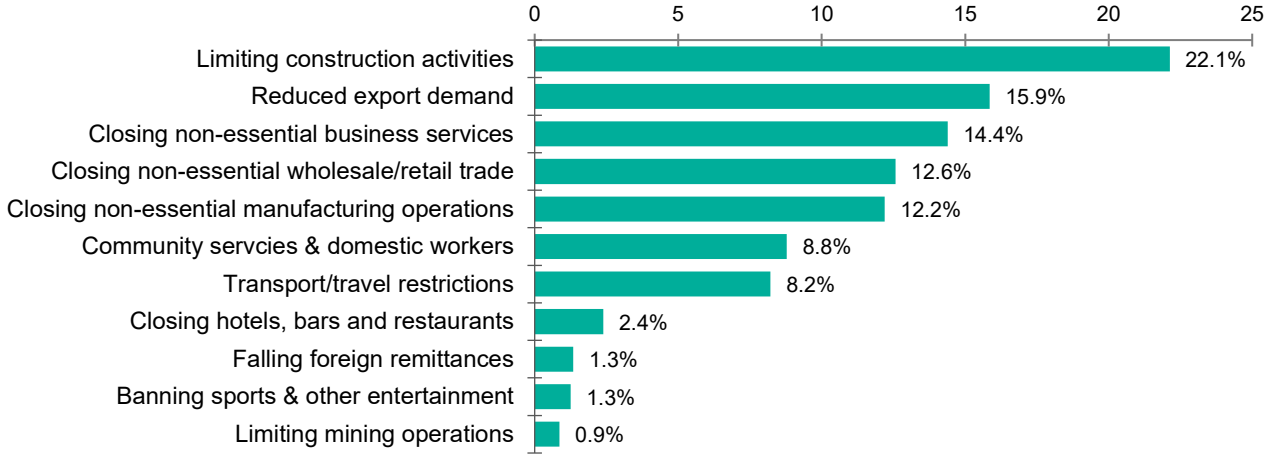
Figure 2: Change in total and sectoral GDP during six-week lockdown period



Source: Authors' calculations based on Rwanda SAM Multiplier Model results
Note: Results are reported in comparison to a normal (no-COVID) situation during the same period.

Figure 3 reports the key impact channels underlying the 39 percent decline in GDP during the six-week lockdown period. Each impact channel captures both the direct effect from the restrictive policy measures during the lockdown period and the indirect effects through economywide linkages. Closing construction sites is expected to have had the largest impact on the economy, accounting for 22 percent of total GDP losses during the lockdown. Falling export demand has the second largest impact, accounting for an additional 16 percent of total GDP losses. Closures of non-essential business services and wholesale/retail trade rank third and fourth and together account for a further 27 percent of total GDP losses.

Figure 3: Percentage contribution of key impact channels to GDP losses during the six-week lockdown period (sums to 100 percent)



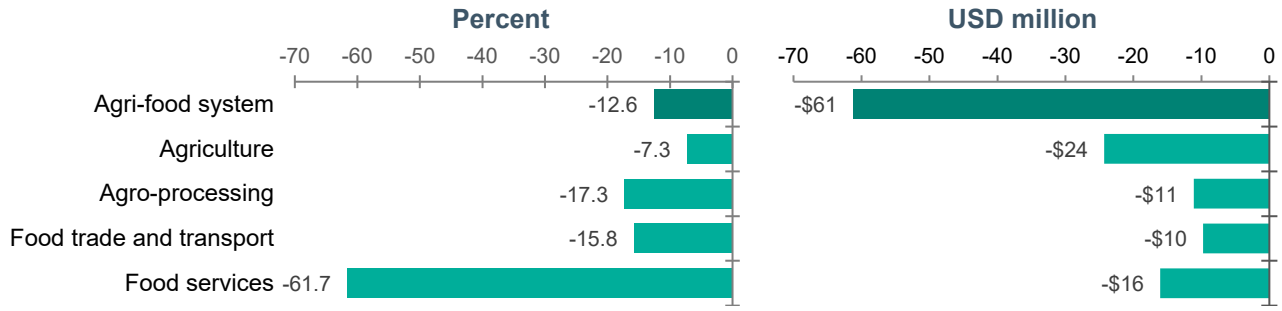
Source: Authors' calculations based on Rwanda SAM Multiplier Model results

Impacts on the agri-food system

Our simulation results also capture the impact of COVID-19 on Rwanda's agri-food system (AFS) during the six-week lockdown period. AFS is defined here as comprising all economic activities related to agriculture, including agriculture, agro-processing, food trade and transport, and food services. It accounts for 41 percent of Rwanda's total GDP, or approximately RWF 3.7 trillion

(USD 4.1 billion), in a normal year.[8] Again, the simulation results for AFS under COVID-19 are reported relative to a no-COVID situation during the same time period.

Figure 4: Change in agri-food system GDP during the six-week lockdown period, by percentage share and value



Source: Authors' calculations based on Rwanda SAM Multiplier Model results
Note: Results are reported in comparison to a normal (no-COVID) situation during the same period.

Simulation results indicate a 12.6 percent (RWF 55 billion; USD 61 million) fall in AFS GDP during the six-week lockdown period (Figure 4). Within AFS, the percentage decline in agricultural GDP is modest. However, it is the main contributor to losses in AFS, amounting to RWF 22 billion (USD 24 million). Food services GDP experiences the largest percentage decline with a 61.7 percent fall. But because food services is the smallest component of AFS in absolute value terms, it contributes only RWF 14 billion (USD 16 million) to the total losses in AFS GDP. Agro-processing and food trade and transport GDP fall by 17.3 percent and 15.8 percent, respectively. In absolute value terms, their contributions to the losses in AFS are similar.

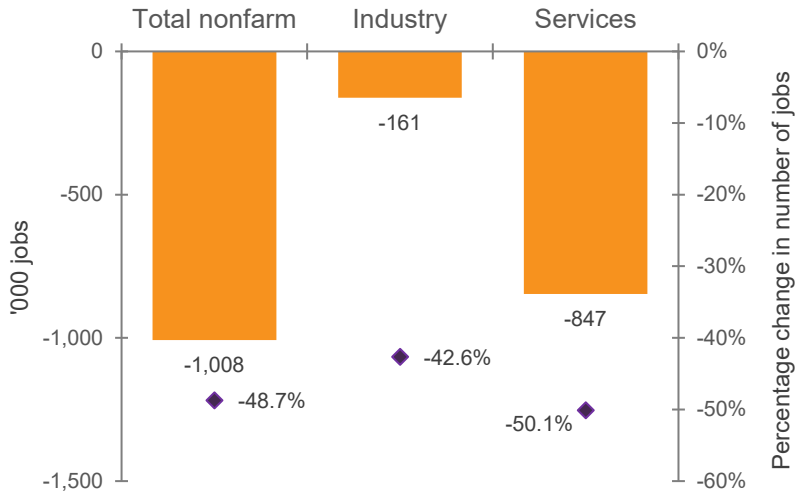
Impacts on employment

Our simulation results also show how the economic shocks caused by COVID-19 affect employment during the six-week lockdown period. We focus specifically on non-farm employment (Figure 5). Simulation results show a 49 percent fall in nonfarm employment during the lockdown period, with approximately 1.0 million people losing their jobs. The services sector, which includes self-employed enterprises, faced a 50 percent decline in employment, which left more than 0.8 million workers jobless.[9]

[8] Note that in national accounts, agro-processing is a sub-sector of the manufacturing sector, while food trade and transport and food services are sub-sectors of the services sector. The purpose of combining these sub-sectors together is to provide a more complete picture of the close linkages between agricultural production and other agriculture- and food-related activities in a manner that national accounting typically does not provide.

[9] The estimated loss of 0.8 million non-farm jobs resulting from our simulations is higher than the unemployment figures (about 0.4 million) released by the National Institute of Statistics of Rwanda (NISR) for the second quarter of 2020 (NISR 2020c). The difference in the estimates may partly arise from the fact that we include those self-employed in the informal sector in our calculation whereas official unemployment estimates include only formal sector employment.

Figure 5: Change in nonfarm employment during the six-week lockdown period, number and percentage share



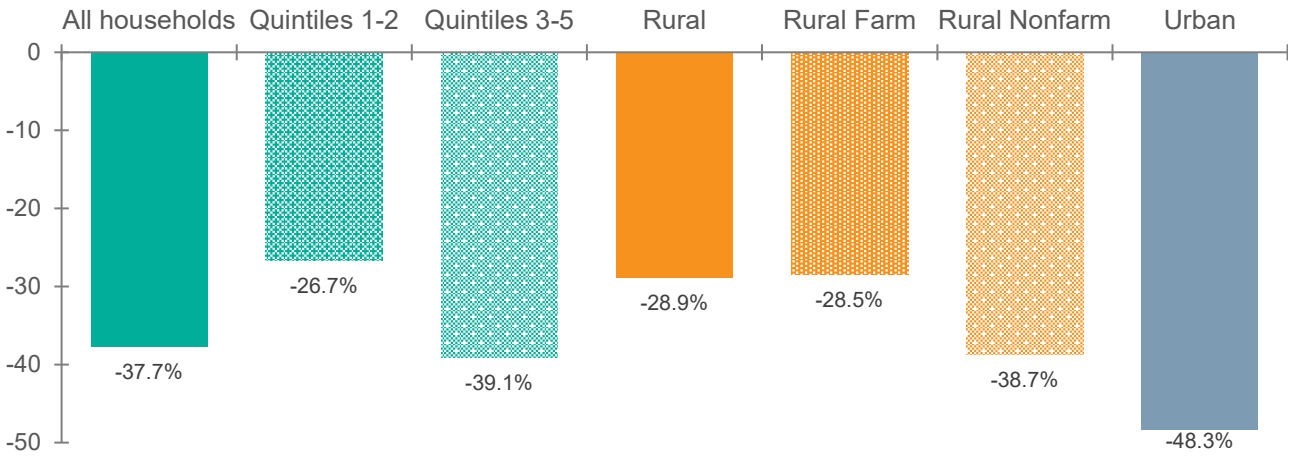
Source: Authors' calculations based on Rwanda SAM Multiplier Model results
Note: Columns denote the number of nonfarm jobs lost; point markers denote the percentage change in the number of jobs. Results are reported in comparison to a normal (no-COVID) situation during the same period.

Impacts on household incomes and poverty

With falling production and lost jobs, our simulation results necessarily show that household incomes are affected by COVID-19. The model includes 15 household groups defined by welfare quintiles in three settings: rural farm, rural nonfarm, and urban households. Figure 6 reports household income effects for all households, the poorest two welfare quintiles as a group, the upper three quintiles as a group, rural households as a whole, rural farm and non-farm households respectively, and urban households as a whole.

Several notable findings emerge from these results. First, incomes of households in the top three quintiles are more adversely affected that poorer households, as their income fell 39 percent during the lockdown period. Second, incomes of urban households are affected more than rural households, with income for urban households as a whole falling by 48 percent compared to 29 percent for rural households. Third, among rural households, rural nonfarm households are affected more than farm households with income falling by 39 percent for rural nonfarm households and 28 percent for rural farm households. Taken together, Figure 6 illustrates the nature of the lockdown in that most economic activities that were shut down were located in urban areas or off the farm, thus affecting those who are more dependent on non-farm employment and non-farm enterprise activities.

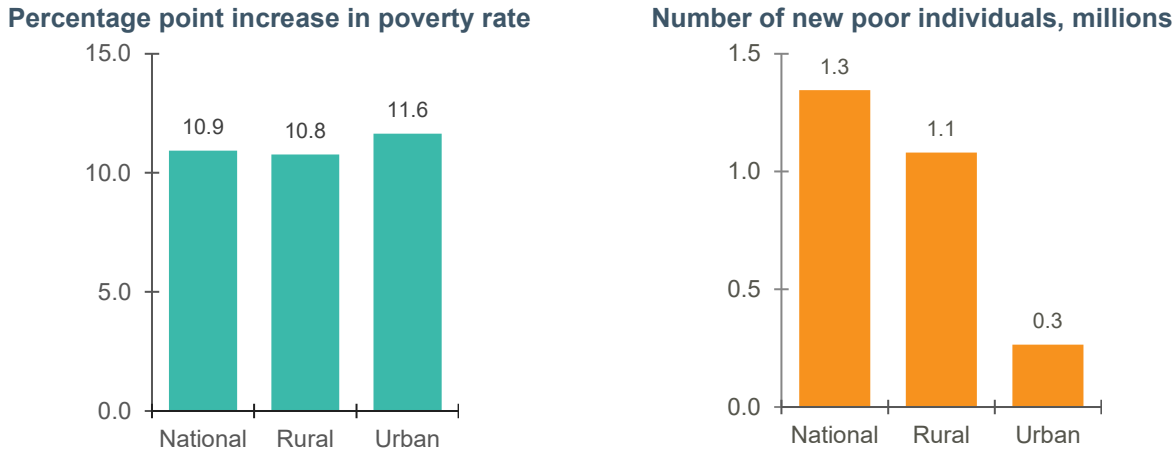
Figure 6: Percentage change in household income during six-week lockdown period



Source: Authors' calculations based on Rwanda SAM Multiplier Model results
Note: Results are reported in comparison to a normal (no-COVID) situation during the same period.

During the six-week lockdown period, the simulation results indicate a 10.9 percentage point increase in the national poverty rate: an 11.6 point increase in urban areas, and a 10.8 point increase in rural areas (Figure 7).[10] This temporary increase in poverty amounts to 1.3 million more people falling into poverty nationally, with 0.3 million additional poor in urban areas and 1.1 million in rural areas during the six-week lockdown period. Note, however, that these results represent only temporary or transitional poverty increases from short-run losses to household income. Nonetheless, they may further affect household consumption post-lockdown and, hence, longer-term poverty levels. We discuss both income and poverty effects during the post-lockdown periods later in the paper.

Figure 7: Change in poverty during six-week lockdown period



Source: Authors' calculations based on Rwanda SAM Multiplier Model results

Economic impacts of fast and slow recovery scenarios

The six-week lockdown period ended in early May, and Rwanda's economy started its recovery process immediately following the easing of key restrictions. However, continuing uncertainty associated with the COVID-19 pandemic both domestically and globally makes it challenging to simulate an economic recovery. We therefore consider two scenarios: a fast recovery scenario,

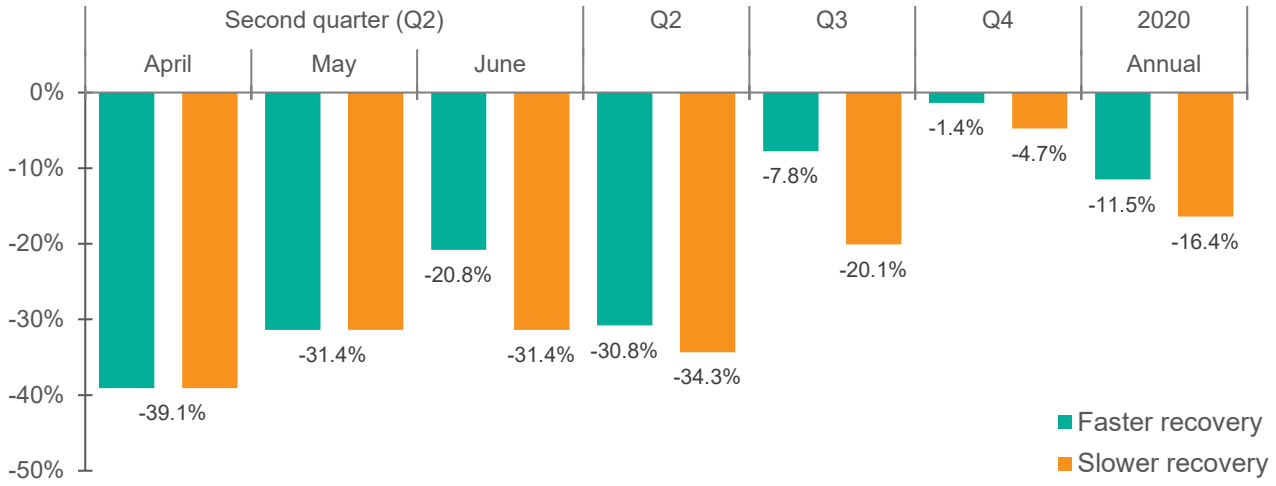
[10] The national poverty line in Rwanda is RWF 159,375 (USD 178) per adult equivalent per year in constant (January 2014) prices. Our simulations are based on this poverty line, and account for household consumption smoothing from savings when calculating the change in poverty.

which is characterized by a strong economic rebound in the third quarter of 2020 and a return to near normal (pre-COVID) economy in the fourth quarter of 2020; and a slow recovery scenario, which is characterized by a modest rebound in the third quarter of 2020 and economic activities that remain below pre-COVID levels through the remainder of 2020. Even with these scenarios in mind, it remains important to note that with the end of the six-week lockdown period and a return to some level of normal economic activity, the heavy losses caused by the lockdown are unlikely to be fully recovered by the end of 2020 even under a fast recovery scenario.

Impacts on total and sectoral GDP

The simulation results indicate that under the fast recovery scenario, Rwanda's GDP in 2020 is expected to be 11.5 percent lower than under a no-COVID situation, and under the slow recovery scenario, 2020 GDP is expected to be 16.4 percent lower (Figure 8). In absolute value terms, the economic losses in GDP for 2020 are expected to total RWF 1.0 trillion (USD 1.14 billion) in a fast recovery, and RWA 1.5 trillion (USD 1.63 billion) in a slow recovery. While most losses are due to the lockdown in the second quarter, losses will continue to accumulate in the third and fourth quarters.

Figure 8: Percentage change in monthly, quarterly, and annual GDP under the two recovery scenarios

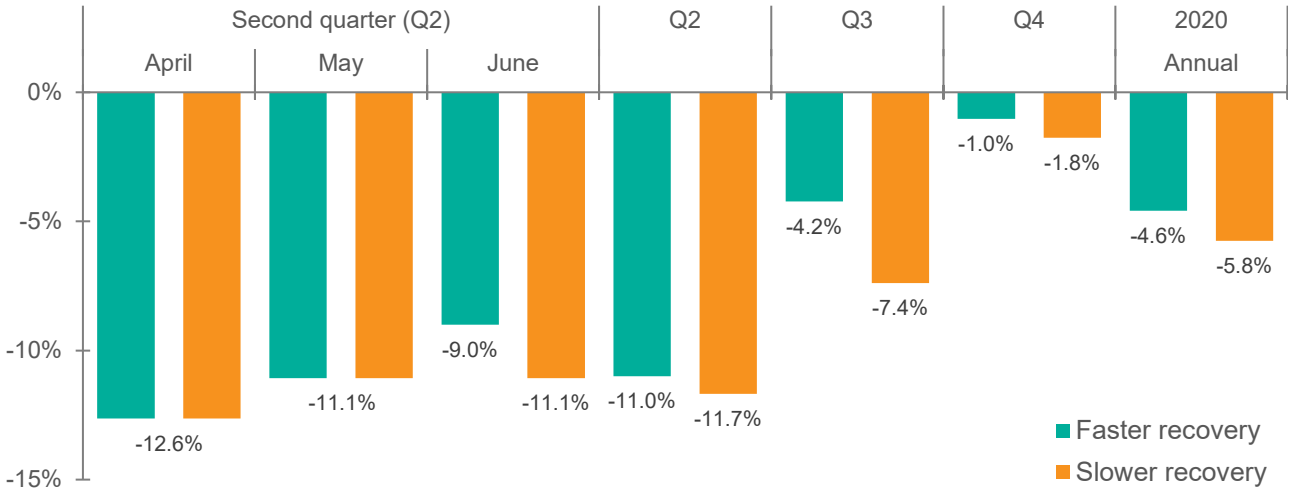


Source: Authors' calculations based on Rwanda SAM Multiplier Model results
Note: Results are reported in comparison to a normal (no-COVID) situation during the same period.

While not shown in the figure above, the simulation results also show declines in sector GDP throughout 2020. For the industrial sector, GDP is expected to fall by 17.4 percent in 2020 under a fast recovery and 24.1 percent under a slow recovery, while services sector GDP is expected to fall by 13.7 percent under the fast recovery scenarios and 20.0 percent under the slow recovery scenario. The declines in annual GDP for the agricultural sector are modest, with an expected fall of 2.5 percent and 3.3 percent in these fast and slow recovery scenarios, respectively.

We further assess the impact of COVID-19 on the whole agri-food system through 2020. Because of relatively small declines in annual agricultural GDP, the fall in agri-food system GDP is also expected to be relatively modest at 4.6 percent under a fast recovery and 5.8 percent under a slow recovery (Figure 9). Under both scenarios, agri-food system growth remains negative throughout 2020, but with a relatively more modest magnitude compared with the two nonagricultural sectors.

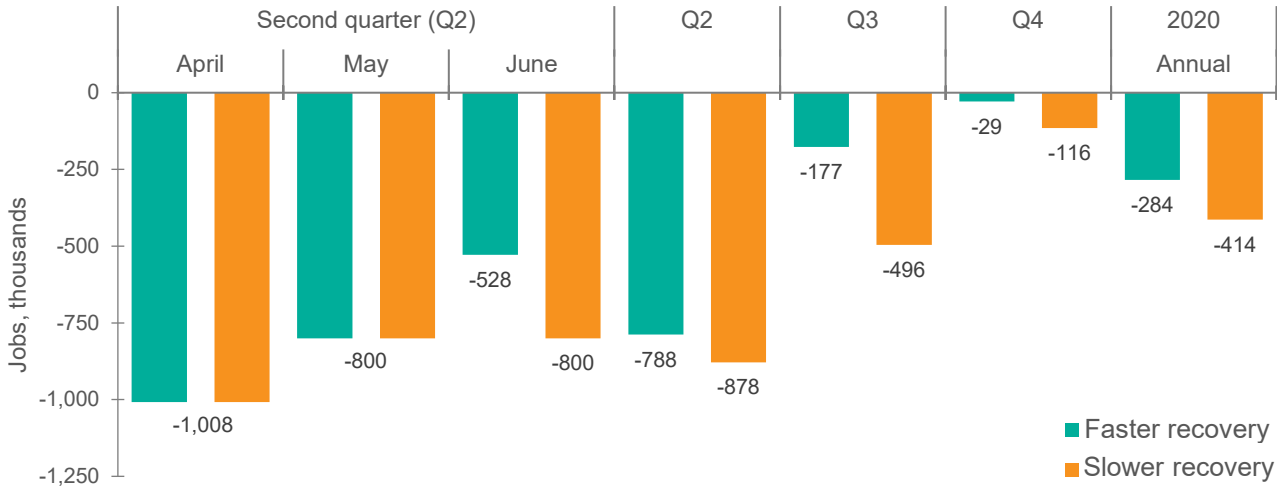
Figure 9: Percentage change in monthly, quarterly, and annual agri-food system GDP under the two recovery scenarios



Source: Authors' calculations based on Rwanda SAM Multiplier Model results
Note: Results are reported in comparison to a normal (no-COVID) situation during the same period.

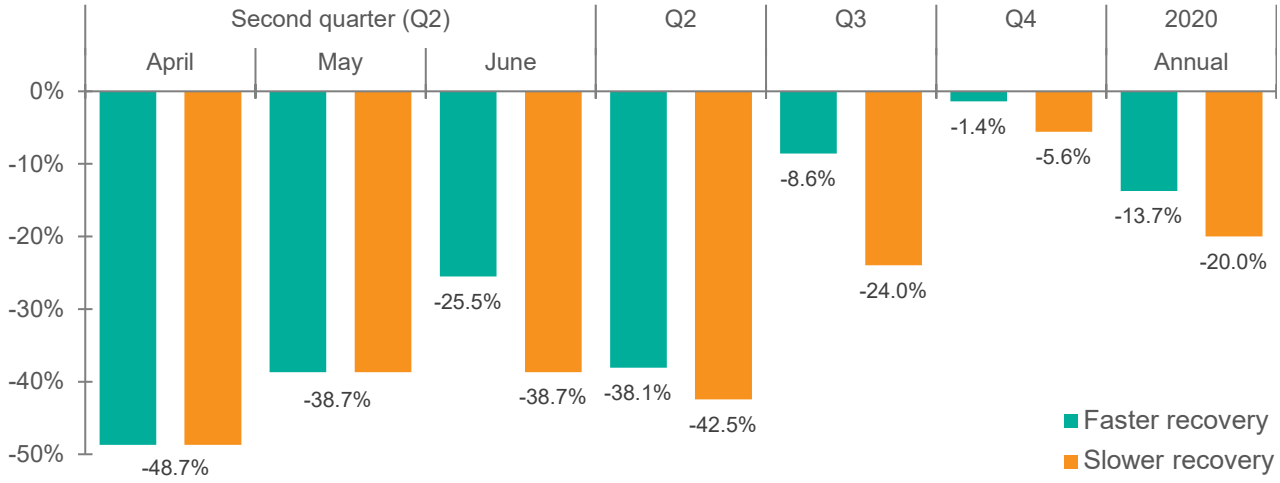
We also examine post-lockdown impacts on non-farm employment. With the economy recovering and businesses starting to reopen, Figures 10 and 11 show non-farm employment stabilizing by the fourth quarter of 2020 after precipitous job losses in the second and third quarters. By the end of 2020, the economy is expected to have experienced a loss of an estimated 29,000 jobs with a fast recovery and 116,000 jobs with a slow recovery when compared to 2019 employment levels (Figure 10). This is equivalent to a 1.4 and 5.6 percent decrease in employment opportunity, respectively, over the same period (Figure 11). We expect that the pace of job recovery will differ across sectors depending on varying speeds of economic recovery across the sectors and the sectorally targeted stimulus policies pursued by government. Overall, by the end of 2020, it is expected that there will be 284,000 newly unemployed people with a fast recovery and 414,000 with a slow recovery. As young people continue to newly enter the job market, unemployment is expected to be one of biggest challenges for Rwanda's economy in 2020 and beyond.

Figure 10: Change in non-farm employment under the two recovery scenarios



Source: Authors' calculation based on Rwanda SAM Multiplier Model results
Note: Columns denote the number of nonfarm jobs lost in comparison to a normal (no-COVID) situation during the same period.

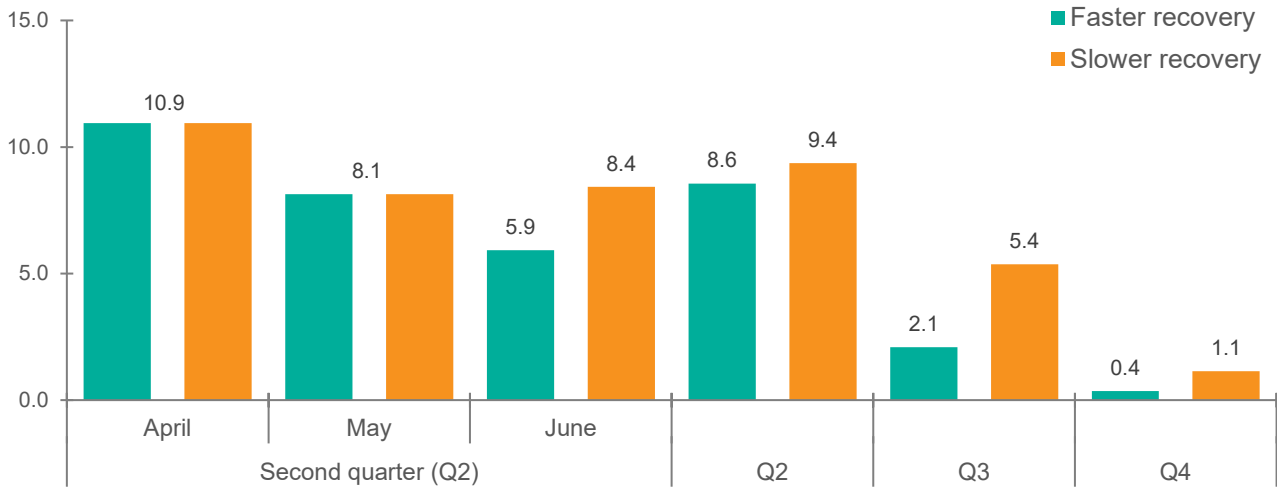
Figure 11: Percentage change in non-farm employment under the two recovery scenarios



Source: Authors' calculation based on Rwanda SAM Multiplier Model results
Note: Columns denote the percentage change in the number of jobs and are reported in comparison to a normal (no-COVID) situation during the same period.

We also assess the poverty effects post-lockdown through 2020. The poverty rate is expected to stabilize by the end of 2020 with more people returning to work and small businesses reopening, generating incomes for households that were negatively affected during the earlier lockdown period (Figure 12). By the end of 2020, the poverty rate is expected to increase by only 0.4 percentage points under a fast recovery and 1.1 points under a slow one. These are much smaller increases compared to those expected from the lockdown period during the second quarter (10.9 percentage points). While the post-lockdown income and poverty trends are encouraging, they mask possible long-last effects of the sharp spike in temporary poverty during the six-week lockdown period and the complexity of long-term poverty dynamics that may leave many households significantly more vulnerable than before the pandemic.

Figure 12: Percentage point change in national poverty under the two recovery scenarios



Source: Authors' calculations based on Rwanda SAM Multiplier Model results

2020 GDP in comparison to 2019

Finally, we assess the impacts of COVID-19 on Rwanda's economic growth by comparing the simulation results with actual GDP in 2019, which is a more commonly used measure in the macroeconomic policy community. Our simulation results indicate that, while positive growth may

expect to return in the third and fourth quarters, Rwanda is likely to fall into a recession with negative annual GDP growth overall in 2020. Under the fast recovery scenario, annual GDP in 2020 is expected to fall by 3.8 percent from that in 2019 and fall by 9.2 percent under the slow recovery scenario.

These results differ from the IMF's projection that indicates a −0.2 percent GDP annual growth rate in 2020 (IMF 2020), but are on par with NISR's actual figures of −3.4 percent in 2020 (NISR 2021). Still, it would be incorrect to compare our results with projections, forecasts, or actual figures, each of which is prepared in a different context, for a different purpose, and with a different methodology.

The methodological differences are particularly important to note. Unlike the macroeconomic models used by the IMF for country economic growth projections, the SAM multiplier model used in our analysis relies on a bottom-up approach. In this approach, total GDP is aggregated from model results at a detailed economic sector level, with 86 such sectors captured in the model. At this level of detail, our assessment indicates that a rebound in strong and rapid growth is unlikely for many important sectoral activities that have been engines of rapid growth in the past. These activities include construction, many manufacturing activities, and, importantly, many export-oriented service activities.

However, it is important to recognize that any economic outlooks – including those set forth in this analysis – face considerable uncertainty given the unprecedented nature of this global pandemic. This requires constant revisiting of growth assessments and continuous revision when new data and information become available for the country and the global situations. Hence the inclusion of both the IMF (2020) projections and the actual figures from NISR (2021).

Already, the Government of Rwanda – through its various ministries and agencies, and in consultation with various economic stakeholders and development partners – has formulated and implemented plans to expand its social protection programs and to revitalize the economy. These policies will be critical not only for mitigating the negative shock of COVID-19, but also in determining the speed of the economic recovery. Our modeling analysis under both fast and slow recovery scenarios, however, has not taken into consideration the implementation of these stimulus interventions, which could significantly help the economy recover faster and stronger than indicated in the assessments here.

POLICY RECOMMENDATIONS AND CONCLUDING REMARKS

The initial and continuing policy measures taken by the Government of Rwanda to contain the transmission of COVID-19 are, by all accounts, both a necessary and appropriate response to the pandemic. Despite the short-term economic costs of the six-week lockdown period, it is highly possible that these measures will allow Rwanda to embark on a fast recovery and a return to economic normalcy in short order. The design and implementation of economic stimulus policies will be critical to the success of this recovery, and will require that we revisit our analysis soon, hopefully with new data and information that suggests more optimistic growth possibilities for the country.

A critical element in this path to recovery is the Government of Rwanda's National Economic Recovery Plan (GoR 2020). A detailed analysis of how the investments chalked out in this plan to support the country's recovery is urgently needed. Additional analysis also is needed to understand the impact of the various policy response options available to the Government of Rwanda, while several of the results presented above are worth considering further.

An important first-order result from our analysis here is that the negative impact of the COVID-19 pandemic on agriculture and agribusiness occurs primarily through indirect channels that result from linkage effects with Rwanda's economy. Because the agri-food system accounts for almost 40 percent of GDP, excluding agriculture and agribusiness from the restrictions introduced in March helped to lower the negative impact of the COVID-19 pandemic not only for agriculture but also for the entire economy. *Continued policy support to the agri-food system is critical to ensuring that the incomes derived from farming and agribusinesses continue as a stabilizing influence on Rwanda's economy.* This means ensuring that policies continue to facilitate farm and livestock management, trading activities in agricultural input and output markets, food processing, agri-food-related transportation, and the provision of extension and other services.

An equally important result is that many activities in the manufacturing and services sectors were affected both by the direct lockdown measures and through economywide linkage effects. Thus, mining, construction, and many services sector activities were hit hard by the six-week lockdown. The recovery of these sectors and activities depend acutely on many micro-, small-, and medium-sized firms. Stimulus packages to help small and large firms in these badly affected sectors are needed not only to protect the livelihood of workers and entrepreneurs earning income from such activities but also to advance the economic recovery.

Next, there is a high likelihood that Rwanda's social protection programming will have to extend well beyond coverage of the lowest *Ubedehe* categories or other targeted groups. The nature of the economic shock from COVID-19 suggests that the income effects may be heterogeneous across households in several dimensions. Attention must be paid to the most vulnerable households, but also to those relying on nonfarm small businesses in both rural and urban areas and to those that had higher income levels before the pandemic but have substantially lost their income sources during the pandemic. The expansion of Rwanda's social protection programs is essential to preventing large numbers of households from falling into poverty.

Finally, our results suggest that efforts to minimize negative impacts on Rwanda's economy will partly depend on restoring regional and international trade – especially trade in agricultural commodities – with neighboring countries. There is a need to keep Rwanda's international borders as open as public health and safety measures can allow. This will enable both imports and exports, particularly of agricultural commodities, to flow over Rwanda's borders with the Democratic Republic of Congo, Uganda, Tanzania, and Burundi through both formal and informal channels.

Each of these recommendations is accompanied by one essential, overarching recommendation: continued analysis based on emerging new information and data and discussion between researchers and policymakers. Relevant and timely analysis and broad policy engagement are critical not only to understanding the pandemic's effects on livelihoods and the country's economic growth trajectory, but also to designing effective policies and programs to protect those livelihoods and to return Rwanda to its encouraging growth trajectory.

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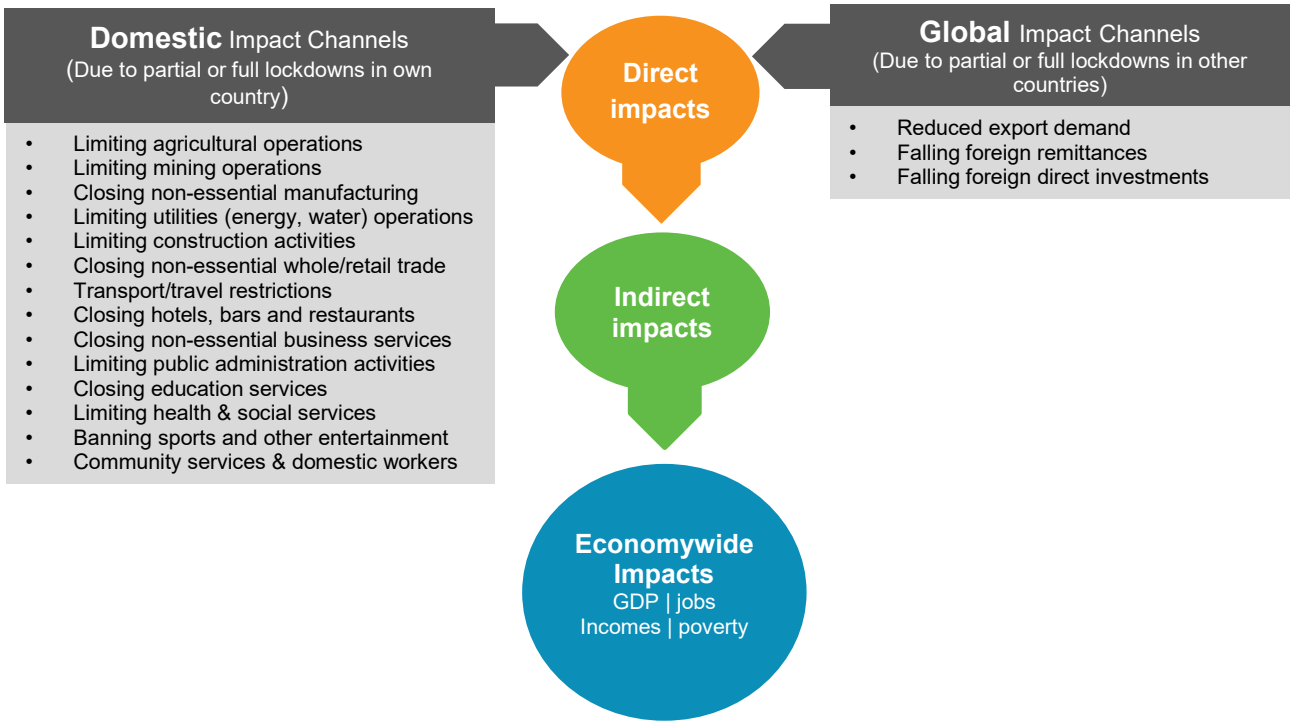
ANNEXES

Annex 1: Detailed methodology and data

Social Accounting Matrix (SAM) multiplier models are ideally suited to measuring short-term direct and indirect impacts of unanticipated, rapid-onset demand- or supply-side economic shocks, such as those caused by the COVID-19 pandemic. At the heart of the multiplier model is a SAM, an economywide database that captures resource flows associated with all economic transactions that take place in an economy. The SAM represents the structure of the economy in a particular year, showing the relationships between actors (i.e., productive activities, households, government and foreign institutions) in terms of how they interact and transact via commodity and factor markets.

Figure A1 provides a framework for conceptualizing how the impacts of COVID-19 are captured in a SAM multiplier model. The SAM multiplier model provides a mechanism for estimating the effects of an external shock which, in this case, is the unprecedented shock of the global COVID-19 pandemic. The shock is often modeled as a set of exogenous changes in some of the variables in the SAM. In the framework, we consider two major categories of impact channels: (1) domestic impact channels, referring to channels directly associated with domestic lockdown measures; and (2) global impact channels, including shocks coming from outside of the country.

Annex Figure A1: Framework for analyzing COVID-19 in a SAM multiplier model



Source: Authors, adapted from IFPRI analyses of COVID-19 impacts on key countries and regions. See https://www.ifpri.org/COVID-19.

The various domestic impact channels have distinguishable effects on the economy. In Rwanda, it is likely that lockdown measures will cause considerable exogenous shocks on mining, construction, non-essential manufacturing, and trade and business services, while the agricultural sector and some services, such as health, utilities (energy and water service provision) and public administration, remain operational at a close to normal level.

For the global impact channels, we consider only a fall in export demand and decline in remittances for Rwanda. The fall in demand for Rwanda's exports is due to restrictions on business activities by trading partners and slowdowns in the global economy. Remittance flows decline as

employment opportunities and incomes of Rwandans in the rest of the world are challenged by the pandemic.

Impact channels are modeled through exogenous shocks on several accounts in the SAM. In our model, the shocks are imposed on the demand side by exogenously lowering final demand of households, investment, and exports. For example, the closure of construction sites as an exogenous shock is modeled as a decline in demand for the construction sector's output used as investment, while falling export demand is modeled as an exogenous decline in export demand for mining, livestock, and several other export commodities and services. Such demand-side shocks immediately affect supply of the shocked sectors directly, e.g., construction sector supply falls when demand for its output from investment falls, while mining production falls when demand for mining exports is reduced.

The direct effects from these shocks then generate indirect effects through input-output linkages and linkages between productive sectors and institutional accounts of the SAM, including households, government, saving-investment, and the rest of the world. The more the economy is interlinked, the larger the indirect effects. This is particularly true when the model has highly disaggregated sectors and where many of these sectors are primarily producing intermediate inputs for other sectors.

Both direct and indirect effects occur simultaneously in the model across all detailed SAM sectors or institutional accounts. Since the SAM captures all economic activities and their interactions, changes among the detailed sectors can be aggregated to the economywide level so that changes in total or aggregate sector GDP, employment, and household incomes can be estimated. The SAM is then linked to a microsimulation model constructed on household level data drawn from the Fifth Integrated Household Living Conditions Survey 2016/17 (EICV5), conducted by the National Institute of Statistics of Rwanda (NISR).

In this microsimulation model, all sample households of the EICV5 are included. In fact, the 15 household groups in the SAM are aggregated from the EICV5's sampled households with their corresponding weights. The explicit mapping relationship from individual households in the microsimulation model to the 15 household groups in the SAM allows changes in consumption among the 15 household groups in the model to transfer to changes in consumption at the household level in the microsimulation model, which allows us to further assess the poverty impact of the shocks.

Mathematically, we can express a multisectoral equilibrium of commodity and income flows as a vector of total output and income supplies that equals the sum of endogenous demands plus exogenous demands:

$$\boldsymbol{Z} = \boldsymbol{A_a Z} + \boldsymbol{E} \quad (1)$$

where **Z** is the vector of quantities of all endogenous accounts of a SAM, **E** is the vector of exogenous accounts, $\mathbf{A_a}$ is the shares matrix, which expresses the endogenous production, value-added, household, government, saving-investment, and ROW expenditures as shares of total expenditure.

Rearranging Eq. (1) as follows

$$\boldsymbol{Z} = \boldsymbol{A_a Z} + \boldsymbol{E} = (\boldsymbol{I} - \boldsymbol{A_a})^{-1}\boldsymbol{E} = \boldsymbol{M_a E} \quad (2)$$

such that endogenous accounts, $\mathbf{Z}$, can be explicitly expressed in a relationship with exogenous accounts, $\mathbf{E}$ through matrix $\mathbf{M_a}$. In Equation (2), $\mathbf{I}$ is the identity matrix, $\mathbf{M_a}$ or $(\mathbf{I} - \mathbf{A_a})^{-1}$ is the inverse matrix of $\mathbf{I} - \mathbf{A_a}$, i.e., $\mathbf{M_a}$ is the so-called SAM multiplier matrix.

Armed with Equation (2), the SAM multiplier matrix can directly give us a change in **Z** resulting from a change in **E**, since $\Delta\mathbf{Z} = \mathbf{M_a}\Delta\mathbf{E}$.

Typically, exogenous accounts are those determining final demand, which is made up of household final demand, investment demand, and export demand, i.e., E as a vector can have elements at sector level, (E_c), where each c represents a sector in the SAM. Household accounts can be treated either endogenous or exogenous in SAM multiplier models, depending on the underlying condition surrounding the economy and also the modeler's preferences. For the analysis at hand, we assume household accounts to be exogenous. That is, while household incomes can be endogenously affected after the shock, such endogenous changes in incomes will not transfer into a secondary round of changes in consumption demand of households, which is exogenous. With such a setting, it permits us to directly simulate an exogenous change in household consumption, while avoiding an over-estimation of the multiplier effects, which is a common concern when households are treated as endogenous (Haggblade and Hazell, 1989).

A commonly used variant of the standard SAM multiplier model is a "semi-input-output" or "supply constrained" SAM multiplier model. Under a semi-input-output specification, supply in one or more sectors (e.g., Z_k, $k \in c_1, \ldots, c_n$) is treated as exogenous, with the associated final demand component (E_k) becoming endogenous. Theoretically, such a model "closure" can be used to simulate a supply-side shock. However, a reduction in supply due to the closure of a mine or factory would implicitly require that demand then be satisfied through a reduction in net-exports, but this is not realistic in a COVID-19 context where global supply chains are constrained. Since many of the restrictive policy measures to contain the spread of COVID-19 are simultaneously supply- and demand-side measures, i.e., supply is constrained through restrictions imposed on productive activities and on people's freedom to purchase goods and services they want, we use demand-side shocks to simulate direct restrictions on demand and to approximate the effect of restrictions imposed on production.

There is one important limitation to the approach we adopt. In instances where a sector mainly supplies intermediate inputs, i.e., the final demand component is relatively small, a supply constraint in that sector may induce a supply constraint in other sectors that utilize those inputs. An example might be a food processor (an essential industry) lacking access to packaging materials (a non-essential industry). If the expected supply shock is larger than the final demand component, the simulation will push final demand into negative territory. However, the multiplier model will treat negative final demand as an increase in imports, and hence intermediate inputs (packaging materials) will continue to be available to the food processing sector. In these (rare) instances, we approximate the overall effect by (also) shocking final demand in the sectors that use the intermediate inputs (i.e., food processors, in our example here).

A final point worth noting is that the short-run analysis here assumes that technical input-output relationships, output choices of producers, and consumption patterns of households do not change in the short-run in response to the simulated shock. SAM multiplier models therefore are fixed-price models. Since flexible prices and behavioral responses are incorporated into general equilibrium models, such models are often considered superior to fixed-price models. However, considering that the COVID-19 shocks constitute an almost catastrophic lockdown of demand and economic activities rather than shocks to equilibrium where adjustments work through price-endogenous market mechanisms, the SAM multiplier framework is appropriate in this context, at least in the short-run analysis. For more on SAM multiplier models, see Breisinger et al. (2009) and Round (2003).

Annex 2: Robustness checks of the Rwanda SAM multiplier model and model results

This section summarizes a series of robustness checks conducted using the model described above. As explained earlier, the SAM multiplier model used in the current analysis is essentially an extended input-output model with most elements of final demand being exogenous. By shocking final demands from Households (C), Investment/Savings (I-S), Government (G), and Exports (X), the SAM-multiplier model leads to a fall in the "supply" side, which then can be used to measure changes in sector GDP and total GDP to capture the lockdown effect that reduces supply from production. Since final demands are exogenous and demand for factor inputs and intermediate inputs is endogenous, the model cannot create "double" shocks by its very nature.

If we simultaneously shock final demand for all sectors at the same rate, we expect total GDP to fall in an exactly similar way only when we do not allow indirect feedback effects to occur, i.e., all institutional accounts of a SAM (the households, government, investment-savings, and rest-of-the-world (ROW) accounts) have to be treated as exogenous. When all institutional accounts are treated as exogenous, there is no multiplier effect captured after a shock. Thus, it is common in a multiplier model to allow at least one institutional account to be treated endogenously such that feedback effects result from the change in the exogenous shock (the change in final commodity demand) to changes in production, factor payments (value added), then to changes in "institutional" income (households, government, investment/savings) and exports/imports, and then finally back to induced changes in total demands for commodities. Capturing these feedbacks or "knock on" effects is what differentiates SAM multiplier models from standard input-output models.

Standard practice among economists using SAM for multiplier analyses is to choose some institutional accounts other than the households account as endogenous, while keeping households accounts exogenous. This assumes that affected households' incomes cannot further affect households' consumption demand that is shocked exogenously. However, other institutional accounts can be treated endogenously. Once accounts for government, investment/savings, and ROW are endogenous, the model captures feedbacks from these institutional accounts to the economy, creating the multiplier effects. With more institutional accounts being treated endogenously, feedbacks increase, and larger multiplier effects are captured.

Based on this explanation, we have run five different simulations as robustness checks on the original set of results. In all simulations, we exogenously shock the final demand of C, I-S, G, and X by a negative 30 percent for all commodities/services produced in the Rwanda SAM (i.e., there are 76 sectors that have domestic production in the SAM), while we choose different institutional accounts as endogenous under different simulations. Specifically:

Simulation 1 (S1): Only the household (C) account is exogenous, while accounts for investment/savings (I-S), government (G), and exports (X), are endogenous.

Simulation 2 (S2): Both C and G are exogenous, while I-S and X are endogenous.

Simulation 3 (S3): C, G, and I-S are exogenous, while only X is endogenous.

Simulation 4 (S4): C and X are exogenous, while G and I are endogenous.

Simulation 5 (S5): All C, G, I-S, and X are exogenous.

Annex Table A1 reports percent changes in sector value-added and total GDP under the five simulations. The general findings can be summarized as follows:

1. With a 30 percent negative shock simultaneously imposed on all final demand including C, I-S, G, and X across all sectors, total GDP and sectoral GDP all fall by exactly 30 percent only when all institutional accounts, i.e., accounts for households, government,

investment/savings, and ROW, are assumed to be exogenous, i.e., the model does not allow any feedback effects coming from an institutional account, so production changes proportionally to the demand shock.

2. Once we allow some institutional accounts to be endogenous, feedbacks occur, creating multiplier effects. With any institutional account being treated endogenous, GDP falls more than 30 percent. The more institutional accounts are endogenous, the more feedback effects are allowed, larger multiplier effects are captured, and greater declines in total GDP are estimated
3. Among government, investment/savings, and ROW accounts, the ROW account seems to have a more important role for such feedback effects. That is, once ROW is treated exogenously, limited multiplier effects can be created (see column S4). This is understandable, as multipliers become large through the feedbacks from the ROW account affecting on domestic production. When the ROW account is treated exogenously, we cut off such feedback channels. Together with household account being exogenous, a negative 30 percent uniform final demand shock across all sectors results in the fall in GDP by 32.7 percent, a fall much closer to negative 30 percent than treating other accounts exogenously (e.g., columns S2 and S3).
4. With feedback effects from endogenizing some institutional accounts, declines in sector value-added differ across sectors. While there are sectors with value-added falling close to the negative 30 percent shock, there are many sectors where value-added falls much more than the negative 30 percent shock.

   Annex Table A2 tries to explain why changes in value-added vary across sectors when the shock is uniform and simultaneous and when some institutional accounts are chosen to be endogenous.
5. The Rwanda model used in this paper follows the assumption similar to Simulation 1 in Annex Table A1, i.e., only the household account is exogenous, while government, investment/savings, and ROW accounts are endogenous to allow feedback effects. This allows the model to capture multiplier effect after the shocks.

Annex Table A1: Percent changes in total GDP and sector value-added from a simultaneous 30 percent negative shock on final demand across all sectors with different endogenous and exogenous institutional accounts

Endogenous accounts:	Gov, I-S, ROW	I-S, ROW	ROW	Gov, I-S	None
Exogenous accounts:	HH	HH, Gov	HH, Gov, I-S	HH, ROW	HH, Gov, I-S, ROW
Simulation:	S1	S2	S3	S4	S5
Total GDP	−45.3	−39.9	−33.9	−32.7	−30.0
Maize	−34.5	−33.4	−32.4	−30.4	−30.0
Sorghum and millet	−39.2	−36.3	−34.0	−31.1	−30.0
Rice	−37.3	−36.1	−35.5	−30.0	−30.0
Wheat and barley	−60.1	−52.5	−48.2	−31.9	−30.0
Pulses	−30.4	−30.3	−30.3	−30.0	−30.0
Groundnuts	−30.2	−30.2	−30.1	−30.0	−30.0
Other oilseeds	−31.1	−30.8	−30.7	−30.0	−30.0
Cassava	−30.7	−30.1	−30.1	−30.2	−30.0
Irish potatoes	−30.3	−30.2	−30.2	−30.0	−30.0
Sweet potatoes	−30.1	−30.0	−30.0	−30.0	−30.0
Other roots	−30.0	−30.0	−30.0	−30.0	−30.0
Leafy vegetables	−30.4	−30.4	−30.3	−30.0	−30.0

Endogenous accounts:	Gov, I-S, ROW	I-S, ROW	ROW	Gov, I-S	None
Exogenous accounts:	HH	HH, Gov	HH, Gov, I-S	HH, ROW	HH, Gov, I-S, ROW
Simulation:	S1	S2	S3	S4	S5
Other vegetables	−30.2	−30.1	−30.1	−30.0	−30.0
Sugarcane	−37.0	−33.3	−32.7	−31.5	−30.0
Tobacco	−30.0	−30.0	−30.0	−30.0	−30.0
Bananas and plantains	−30.8	−30.2	−30.2	−30.2	−30.0
Other fruits	−31.9	−30.8	−30.7	−30.5	−30.0
Leaf tea	−79.1	−72.4	−64.2	−30.1	−30.0
Coffee	−80.2	−73.4	−65.1	−30.0	−30.0
Cocoa	−71.8	−65.5	−58.7	−30.4	−30.0
Cattle	−37.0	−35.8	−33.6	−30.4	−30.0
Raw milk	−31.2	−30.9	−30.7	−30.1	−30.0
Poultry	−34.2	−33.0	−32.4	−30.3	−30.0
Eggs	−35.0	−33.6	−32.9	−30.4	−30.0
Small ruminants	−32.3	−31.6	−31.3	−30.2	−30.0
Other livestock	−39.3	−37.5	−36.0	−30.3	−30.0
Forestry	−47.3	−44.1	−30.4	−33.0	−30.0
Aquaculture	−30.0	−30.0	−30.0	−30.0	−30.0
Capture fisheries	−30.8	−30.7	−30.5	−30.0	−30.0
Other mining	−75.3	−68.6	−52.7	−32.2	−30.0
Meat processing	−53.8	−47.1	−43.8	−31.9	−30.0
Fish and seafood processing	−35.2	−34.5	−33.6	−30.0	−30.0
Dairy	−44.8	−41.8	−39.5	−30.5	−30.0
Fruit and vegetable processing	−40.6	−39.2	−37.4	−30.0	−30.0
Fats and oils	−40.3	−39.1	−39.7	−29.4	−30.0
Maize milling	−37.1	−35.3	−33.3	−30.7	−30.0
Sorghum & millet milling	−37.5	−36.2	−30.0	−31.3	−30.0
Rice milling	−30.9	−30.9	−32.9	−29.4	−30.0
Wheat and barley milling	−75.3	−69.3	−61.7	−30.0	−30.0
Sugar refining	−37.9	−33.8	−33.0	−31.6	−30.0
Coffee processing	−30.0	−30.0	−30.0	−30.0	−30.0
Tea processing	−38.6	−36.2	−35.0	−30.7	−30.0
Other foods	−40.5	−35.9	−34.8	−31.7	−30.0
Animal feed	−34.9	−34.0	−32.7	−30.2	−30.0
Beverages	−39.2	−36.3	−35.1	−30.9	−30.0
Tobacco processing	−30.1	−30.1	−30.0	−30.0	−30.0
Textiles	−41.3	−34.6	−33.7	−32.8	−30.0
Clothing	−38.5	−37.3	−35.9	−30.0	−30.0
Leather and footwear	−37.6	−36.6	−35.3	−30.0	−30.0
Wood products	−56.1	−46.1	−35.6	−35.1	−30.0
Paper products and publishing	−48.0	−36.8	−35.5	−34.7	−30.0
Fertilizers and herbicides	−36.5	−35.3	−34.2	−30.2	−30.0
Other chemicals	−42.2	−37.6	−33.9	−32.1	−30.0
Non-metal minerals	−60.5	−54.4	−34.4	−34.5	−30.0
Metals and metal products	−63.1	−54.1	−32.9	−36.2	−30.0
Machinery and other equipment	−66.4	−60.1	−35.6	−34.9	−30.0
Electrical equipment	−63.4	−57.5	−32.5	−35.2	−30.0
Vehicles and transport equipment	−45.5	−41.6	−33.9	−32.2	−30.0
Other manufacturing	−47.4	−41.6	−34.2	−33.0	−30.0
Electricity, gas and steam	−54.8	−46.6	−35.2	−34.5	−30.0
Water supply and sewage	−38.4	−34.1	−32.5	−31.8	−30.0
Construction	−64.8	−58.4	−31.3	−35.8	−30.0
Wholesale and retail trade	−50.1	−45.1	−34.6	−32.9	−30.0

Endogenous accounts:	Gov, I-S, ROW	I-S, ROW	ROW	Gov, I-S	None
Exogenous accounts:	HH	HH, Gov	HH, Gov, I-S	HH, ROW	HH, Gov, I-S, ROW
Simulation:	S1	S2	S3	S4	S5
Food services trade	−39.2	−37.0	−34.4	−30.8	−30.0
Transportation and storage	−51.1	−46.0	−37.3	−32.4	−30.0
Food services transport	−43.2	−40.0	−36.9	−31.0	−30.0
Accommodation	−72.7	−60.6	−54.7	−33.4	−30.0
Restaurants and food services	−48.3	−43.1	−40.5	−31.5	−30.0
Information and communication	−45.7	−37.5	−33.9	−33.7	−30.0
Finance and insurance	−49.5	−44.2	−36.9	−32.5	−30.0
Real estate activities	−31.1	−30.5	−30.3	−30.2	−30.0
Business services	−50.7	−42.8	−35.5	−33.8	−30.0
Public administration	−63.2	−38.6	−36.9	−40.8	−30.0
Education	−42.1	−30.0	−30.0	−35.6	−30.0
Health and social work	−54.2	−30.0	−30.0	−41.2	−30.0
Other services	−30.0	−30.0	−30.0	−30.0	−30.0

Source: Authors, based on robustness checks using the Rwanda SAM multiplier model
Note: Final demand is made up of demands from households (C), investment (I), government (G), and exports (X).
HH = Household account; I-S = investment/savings; Gov = government; ROW = rest-of-the-world.

Annex Table A2 displays the relationship between sectors' output used as intermediates and for exports and import demand in total demand and the declines in sector's value-added when government, I-S, and ROW are assumed to be endogenous. Because of the difference in a sector's output consumed as intermediates by other sectors or for exports across sectors, when the endogenous accounts restrain the leakage effects, the uniform and simultaneous shock of negative 30 percent on total final demand results in different changes in sector value-added.

For a sector whose output is disproportionally consumed as intermediates by other sectors or used for exports, the decline in this sector's value-added is generally much more than 30 percent with endogenous government, I-S and ROW accounts. In Annex Table A2, for examples, 89.6 percent of output produced by the sugar sector and 79.2 percent of output produced by the meat sector are used as intermediates by other sectors, while the value-added falls by 37 percent and 54 percent, respectively, in these two sectors with the uniform negative 30 percent demand shock on all sectors. 92.1 percent of tea and 94.9 percent of coffee are exported, while their value-added falls by 79 percent and 82 percent respectively with endogenous government, I-S and ROW.

On the other hand, for sectors whose output is not for exports or less used as intermediates, their value-added falls slightly more than 30 percent. There are 16 such sectors in agriculture, three in manufacturing, and two in services. While sectors of education and health do not have intermediate demand and exports, their value-added falls by 42 and 54 percent, respectively, with endogenous government, I-S and ROW accounts. However, once the government account is treated exogenously, the declines in these sectors' value-added become the same as the shock of negative 30 percent (see Annex Table A1, columns 2 and 3 for the education and health sectors).

Annex Table A2: Multiplier effects due to differing importance of sectoral output consumed as intermediates by other sectors and for export with uniform 30 percent negative shock on total final demand

	Share in total demand			Change in sector's value-added under Scenario 1
	Intermediate demand	Total final demand	Export demand	
Maize	67.6	32.4	0.6	−31.8
Sorghum and millet	64.7	35.3	5.2	−34.0
Rice	31.7	68.3	12.2	−34.6
Wheat and barley	95.0	5.0		−45.3
Pulses	4.1	95.9	0.7	−30.2
Groundnuts	1.7	98.3	0.3	−30.1
Other oilseeds	10.1	89.9		−30.7
Cassava	8.8	91.2		−30.2
Irish potatoes	3.9	96.1	0.5	−30.2
Sweet potatoes	3.8	96.2		−30.0
Other roots	3.5	96.5		−30.0
Leafy vegetables	3.0	97.0	0.8	−30.2
Other vegetables	4.0	96.0		−30.1
Sugarcane	89.6	10.4		−40.2
Tobacco	78.4	21.6		−36.6
Bananas and plantains	4.9	95.1		−30.3
Other fruits	15.1	84.9		−30.8
Leaf tea	7.9	92.1	92.1	−59.1
Coffee	5.1	94.9	94.9	−59.6
Cocoa	23.9	76.1	76.1	−55.9
Cattle	11.5	88.5	7.6	−33.3
Raw milk	9.3	90.7		−30.9
Poultry	24.2	75.8		−33.3
Eggs	30.4	69.6	0.3	−33.9
Small ruminants	14.8	85.2		−31.8
Other livestock	36.3	63.7	8.0	−36.2
Forestry	17.7	82.3		−30.5
Aquaculture	0.0	100.0		−30.0
Capture fisheries	13.8	86.2		−30.7
Other mining	24.3	75.7	61.5	−48.0
Meat processing	79.2	20.8	18.3	−44.0
Fish and seafood processing	0.4	99.6	10.1	−33.0
Dairy	37.5	62.5	16.8	−38.9
Fruit and vegetable processing	1.6	98.4	20.4	−36.2
Fats and oils	0.0	100.0	27.0	−38.1
Maize milling	22.7	77.3	5.7	−32.8
Sorghum and millet milling	2.7	97.3		−30.0
Rice milling	2.4	97.6	7.9	−32.4
Wheat and barley milling	2.3	97.7	86.5	−56.6
Coffee processing	8.9	91.1		−30.0
Tea processing	53.5	46.5		−35.8
Other foods	15.7	84.3	10.3	−33.7
Animal feed	98.8	1.2	1.2	−31.0
Beverages	46.3	53.7	1.0	−35.3
Tobacco processing	0.3	99.7	0.1	−30.0
Textiles	38.9	61.1	3.5	−33.1
Clothing	0.2	99.8	16.5	−35.0
Leather and footwear	1.0	99.0	14.7	−34.5

	Share in total demand			Change in sector's value-added under Scenario 1
	Intermediate demand	Total final demand	Export demand	
Wood products	99.6	0.4	0.4	−32.6
Paper products and publishing	48.4	51.6	7.8	−32.9
Fertilizers and herbicides	98.9	1.1	0.4	−37.3
Other chemicals	55.4	44.6	2.0	−35.7
Non-metal minerals	87.0	13.0	7.3	−36.5
Metals and metal products	63.5	36.5	2.5	−31.4
Machinery and other equipment	9.8	90.2	14.0	−34.4
Electrical equipment	17.6	82.4	4.9	−31.7
Vehicles and transport equipment	21.4	78.6	6.9	−32.6
Other manufacturing	84.7	15.3	1.5	−33.9
Electricity, gas and steam	85.4	14.6	0.0	−34.5
Water supply and sewage	41.0	59.0		−32.2
Construction	16.5	83.5	1.9	−31.2
Wholesale and retail trade	92.2	7.8	1.4	−34.5
Transportation and storage	75.7	24.3	11.7	−39.9
Accommodation	35.7	64.3	63.1	−49.2
Restaurants and food services	42.7	57.3		−38.2
Information and communication	71.6	28.4		−31.9
Finance and insurance	89.7	10.3	3.7	−35.4
Real estate activities	5.4	94.6		−30.1
Business services	96.1	3.9	1.3	−35.6
Public administration		100.0	19.3	−35.8
Education		100.0		−30.0
Health and social work		100.0		−30.0
Other services	0.3	99.7		−30.0

Source: Authors, based on robustness checks using the Rwanda SAM multiplier model

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ACKNOWLEGEMENTS

This paper was prepared under the Rwanda Strategy Support Program (Rwanda SSP), which is managed by IFPRI. The analysis here was conducted as part of a collaboration with the Ministry of Finance and Economic Planning (MINECOFIN) and the National Institute of Statistics for Rwanda (NISR) under the project titled “SAM-CGE Modeling Capacity Building for Evidence-based Policy Analysis and Strategy in Rwanda,” which receives financial support from the Deutsche Gesellschaft für Internationale Zusammenarbeit Gmb (GIZ). Additional financial support was provided by the Bill and Melinda Gates Foundation (BMGF); the United States Agency for International Development (USAID); the European Union through the Rwanda SSP; and the CGIAR Research Program on Policies, Institutions, and Markets (PIM).

This paper was prepared with guidance and input from Thierry Kalisa and Didier Tabaro of MINECOFIN and from Arend Kouwenaar, Jan Miksch, and Ksenija Maver of GIZ. We thank our IFPRI colleagues, Karl Pauw and Clemens Breisinger, for their contributions to the underlying analytical framework, and Todd Benson for his technical and editorial assistance in preparing this paper.

We also acknowledge insights on the current situation in Rwanda related to the COVID-19 global pandemic provided by individuals at MINECOFIN, MINAGRI, the Ministry of Trade and Industry (MINICOM), the Rwanda Agriculture Board (RAB), the National Agricultural Export Development Board (NAEB), CGIAR, the research community, the donor community, and the private sector.

Any opinions expressed here belong to the author(s) alone and do not necessarily reflect those of the Government of Rwanda, IFPRI, CGIAR, or the funders listed above.

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The Rwanda Strategy Support Program (Rwanda SSP) is managed by the International Food Policy Research Institute (IFPRI). Funding support for Rwanda SSP is provided by the European Union (EU); the United States Agency for International Development (USAID); and the CGIAR Research Program on Policies, Institutions, and Markets (PIM). This publication has been prepared as an output of Rwanda SSP. It has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and do not necessarily reflect those of IFPRI, EU, USAID, or CGIAR.