

The Impact of the War in Ukraine: Estimating the Economic and Welfare Losses in Africa using a Global CGE Model.



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Abstract

The ongoing Russo-Ukrainian War (RUW) has generated real and artificial scarcity effects globally of food, agricultural inputs such as fertilizer, fossil fuel products such as oil and gas, and other important commodities. Prices of these key commodity items have increased dramatically since 2022, while trade volumes have fallen. The economic effects on the African continent are notable, driven by a surge in consumer prices, particularly prices of agriculture, food and fuel products. A major concern has been the decline in food consumption. This study estimates the effects and impacts of the price and supply shocks on Africa across the following countries and regions: Egypt, Sudan, Morocco, Senegal, Kenya, Ethiopia, Mozambique, South Africa, Nigeria and the Rest of Africa (RoA). To capture the global nature of the RUW impacts, a dynamic global computable general equilibrium (CGE) model was used. The results show that the impacts vary across countries in the African continent. In Egypt, the decline in the consumption of wheat and other cereals (including corn) is relatively higher compared to other food items. In Sudan, the decline in all food items is significant. All food items decline in Ethiopia, similar to Sudan. In Mozambique and South Africa, Nigeria and the rest of Africa the consumption of wheat is relative higher compared to other food. The loss in consumer welfare also varies across countries in the continent. Relative to GDP, significant consumer welfare losses are observed in Sudan, Kenya and Ethiopia. However, in terms of the value of the welfare losses accumulated over the first five years, the impacts in Ethiopia, Kenya, Egypt and South Africa are higher compared to the rest. The economic effects and the welfare losses are higher if the war is protracted and gets resolved longer in five years. Globally, international cooperation among key multinational institutions is required to facilitate and to reduce the artificial supply scarcity in global trade.

Keywords: trade disruption, conflict, developing countries, food security, inflation, computable general equilibrium model

JEL Classification: C68, F11, F51, O11, O55, O57

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I. Introduction

The Russian attack and invasion of Ukraine in 2022 was a major escalation in the ongoing Russo-Ukrainian War (RUW). On top of the many lives lost in the conflict, the RUW has also generated real and artificial scarcity effects globally of food, agricultural inputs such as fertilizer, fossil fuel products such as oil and gas, and other important commodities. Prices of these key commodity items have increased dramatically since 2022, while trade volumes have fallen. The effects of the RUW were further exacerbated by droughts in countries that are major global suppliers of food, in particular those in the Horn of Africa, as well as by global reactions to food security concerns impacting the supply and demand dynamics thereof.

The objective of this paper is to estimate the effects and impacts of these shocks on Africa across the following countries and regions: Egypt, Sudan, Morocco, Senegal, Kenya, Ethiopia, Mozambique, South Africa, Nigeria and the Rest of Africa (RoA). To capture the global nature of the RUW impacts, the paper uses the PEP-w-t model, a dynamic global computable general equilibrium (CGE) model described in Robichaud et al. (2013) that was implemented on the GTAP 10 database¹. We used the model to estimate of the impacts on the following economic variables: real gross domestic product (GDP), inflation, factor prices, household income, consumption (both at an aggregate and commodity level), and consumer welfare.

The reaction of the world economy to the RUW creates artificial scarcity effects on the flow of commodities globally, which places heavy pressure on prices to increase. To capture these effects in a global CGE model, the artificial scarcity effects are modelled as increases in non-tariff measures (NTMs), which reduce the flow of goods globally and increase prices.

The paper is organized in seven sections. After a short introduction in this section, Section II reviews some of the relevant literature on the RUW. To put the discussion in perspective, Section III presents some key economic indicators before and during the war. Section IV discusses the analytical framework adopted in the analysis. Section V

¹ GTAP is the Global Trade Analysis Project

outlines the assumptions used in the simulations conducted. Section VI presents the simulation results over a ten-year period for two scenarios: (a) the conflict and other supply shocks will resolve at the start of the third year after the conflict erupted (Sim1); and (b) the conflict and other supply shocks will resolve at the start of the fifth year (Sim 2). Section VII gives a short summary of the results and some insights. Lastly, the paper includes four appendixes: (a) Appendix A presents the mapping of commodities and countries/regions between the model and the GTAP database; (b) Appendix B presents the trade-weighted estimates of NTM used in the analysis; and (c) Appendix C and Appendix D present the detailed the simulation results for 10 years under Sim1 and Sim2, respectively.

II. Literature review

There are several papers written analyzing the potential impacts of the RUW. Some of these use historical world trade data to analyze the potential disruption of the war on global markets for food, key agricultural inputs, and fossil fuel products, while others apply models (world partial equilibrium models or global computable general equilibrium models) to simulate the possible effects on the global markets for key commodities. This section reviews a few of these papers.

The RUW exacerbated the lingering effects of Covid-19 on the global supply chain of commodities, triggering spikes in commodity prices and shortages in the supply of essential food items. Using historical data and review of literature, Jagtap et al. (2022) investigate the effects of the RUW on six areas of the supply chain: (1) food production, processing and storage; (2) food transport logistics; (3) food market/retail; (4) consumers; (5) food dependent services; and (6) food quality. The key findings of the paper indicate that the conflict will adversely affect almost all countries, but the most affected are the

economies in Europe and Africa. To lessen the adverse effects on the global supply chain, the paper suggests “to explore and find alternative food supply chain partners and solutions in North America, South America, the Middle East, Australia, and some regions of Asia and Africa that have been less affected by this conflict.”

The paper of Bin-Nashwan, Hassan and Muneeza (2022) looks at the implications of the RUW on the 2030 Agenda for Sustainable Development Goals (SDGs). Using qualitative analysis and secondary data, the paper finds that the ongoing war “...is causing immense suffering and a gloomy future for the 2030 Agenda.” The effects of the conflict are found to extend beyond Ukraine, Russia and Europe, with the global economy adversely affected by higher commodity prices (prices of critical food items, as well as fuels and fertilizer). Furthermore, the trade restrictions as a result of the conflict, result in supply disruptions as well as impacts on labour migration and refugee-seekers. The war adversely affects the “environment, health, food and nutrition, education, security and peace.”

Hatab (2022) identifies four key channels through which the RUW could adversely disrupt the food supply chain in Africa: (1) energy markets and shipping routes; (2) availability and prices of agricultural production inputs; (3) domestic food price inflation; and (4) trade sanctions and other financial measures. The paper uses historical secondary data and literature to find that, similar to other papers, the conflict has major disruptive effects on the food supply chain that leads to the African regions, which seriously impacts food security in the continent.

Interestingly, the paper extends the analysis by looking at a slightly different angle; the implications of the conflict, through the food security effects, on social unrest in African regions: ...“the risk of social and political unrest that disruption to food supply chains and spikes in domestic food prices may inflame.” That is, “Evidence shows that disruptions to FSCs and spikes in domestic food prices severely deteriorate the social and economic well-being of the vulnerable population groups and could result in dramatic rioting, often termed ‘food riots’. These have often been associated with an increased probability of social and political unrest (e.g., Bellemare 2015; Hatab and Hess 2021). Thus, the impact of the RUW on food supply and food price inflation could inflame

conflict, destabilize governments, and cause violence to spill over borders.”

Using a global CGE model, Rose, Chen and Wei (2022) simulate the potential disruption impacts of the war on grain exports. During the first year of the conflict, the simulation results indicate substantial impacts not only in Ukraine and Russian, but across the global markets. As a result of the contraction in grain exports, the results indicate that Ukraine will experience a decline in real GDP of \$859 million. On the other hand, Russia, which is less dependent on grains exports compared to Ukraine, the decline in real GDP is considerably lower at \$3.8 million.

These projected effects are relatively lower compared to the estimates of Hassen and Bilali (2022) using a partial equilibrium analysis. This is because the general equilibrium model of Rose, Chen and Wei (2022) captures the supply responses from other regions and countries of the world that offset the effects on grains coming from Ukraine and Russia. Simola (2022) also applies a partial equilibrium analysis and finds that while foodstuffs trade of Russia declines in the first four months of the conflict, Russia’s export revenues improve due to higher prices of the commodities and to the trade shifts to countries not subjected to trade sanctions.

Using a global CGE model, Chepeliev (2023) analyzes the potential effects on world agricultural and food markets due to several factors: the RUW itself, sanctions against Russia, adverse weather events, and domestic policies around the world in pursuit of food security. The paper decomposes these factors and analyzes the impact on food affordability for low-income households in countries within the European Union (EU). The paper finds that while the impact on the overall food availability of the factors listed above is not a major issue in EU, food affordability for EU’s low-income households is a worrying concern largely because of the high inflation on food and energy prices. The paper also finds that sanctions by EU and the U.S. that limit energy imports from Russia could have substantial impacts on the real income of low-income households in EU.

The paper of Chepeliev, Hertel, and Van der Mensbrugge (2022) applies a global CGE to examine the potential effects of the import restrictions on fossil fuel from Russia by OECD countries. The paper finds that the short-term impact on OECD is significant. Real household income declines by 0.7 to 1.7 percent relative to the base (without

restriction) and energy prices increase by 11 percent. However, over the long-term the impact is smaller due to the reduction in CO₂ emissions as “such emission reductions would take the EU more than halfway to its Green Deal mitigation target, reducing the necessary carbon price by around 40 EUR per tCO₂”.

Finally, the paper of Arndt et al. (2023) investigates the role of the RUW in rising commodity and its implications for developing countries using a CGE model. It finds that the RUW did indeed cause severe disruptions to global markets for food, fuel and fertilizer. The macroeconomic and other socio-economic impacts were dependent on each countries’ unique economic structure, consumption and employment patterns. In general, household consumption and poverty were found to be most affected by higher fuel and food prices.

Whilst this is a non-exhaustive overview of literature related to the economy-wide impacts of the RUW, the methods and findings reported on here provide an important base from where to consider the Africa-focused set of impacts and results presented in this paper. These impacts were estimated using a global CGE calibrated using the GTAP database to determine how the world economy reacts to RUW and to identify the channel through which African countries are affected, which is the main contribution of the paper.

III. Some Key Indicators

The RUW has affected world supplies and trade flows of key commodities, particularly food, oil, natural gas, and fertilizers, mainly because Russia, Ukraine, and Belarus have notable shares in the global trade of these essential goods. Table 1 shows that Russia has a sizeable share in the world trade of oil and other fossil products, fertilizer, and essential food items. Ukraine supplies large amount of food commodities

to the world market. Belarus has respectable share in the global trade of fertilizer. A large share of these essential products is exported to African countries, Middle East, Europe and other major economies in East Asia.

Table 1. Commodity Shares of Russia, Ukraine and Belarus in Global Trade (%)

Commodity	Russia	Ukraine	Belarus
Oil and other fossil products:			
Coal	17.9		
Oil products	11.5		
Crude oil	12.8		
Natural gas	19.8		
Fertilizer	14.5		5.6
Food commodities:			
Wheat	17.6	11.1	
Corn	1.5	17.6	
Sunflower oil	23.7	52.2	
Barley	12.7	13.4	

Source: FAO and UN

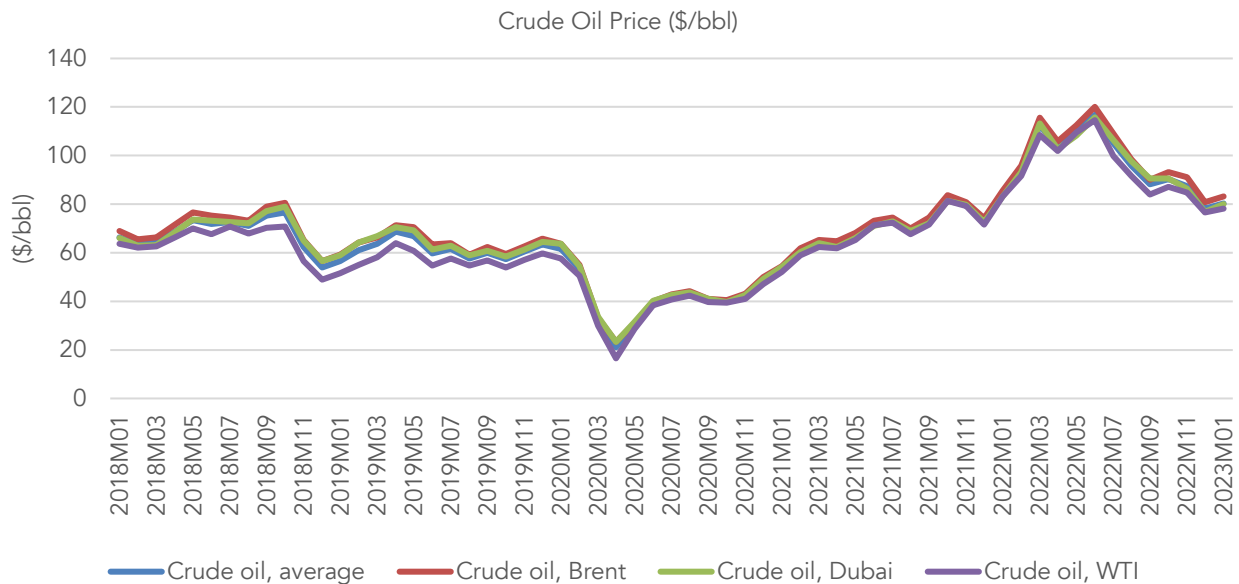
The supply of fertilizer - a key input in agriculture production - was severely affected by the disruption in the supply and trade of natural gas because of the dependence of fertilizer production on natural gas. Since Russia and Ukraine are major global suppliers of key food items, the disruption in the global flow of food trade due to the war generated food security concerns globally. The real and artificial food scarcity effects of the war led to various food security reactions among food exporter countries. For example, India, which is a leading exporter of basmati rice, imposed a 20 percent tariffs on its export of rice (Good, 2022). Laborde and Mamun (2022) have documented export restrictions on a number of food items, including beet exports from Argentina, wheat and sunflower oil exports from Kazakhstan, palm oil exports from Indonesia, and various grains exports from Russia, all with varying degrees of adverse implications for importers of those goods.

Another factor that increased the pressure on global food production was the drought which led to a notable drop in crop yield in the U.S. Canada, Europe, as well as in the Horn of Africa. These countries and regions are major suppliers to the global food market.

Figure 1 shows the trend in crude oil prices. At the start of the Covid-19 pandemic

during the 2nd quarter of 2020, the price of crude oil dipped to its lowest level at about US\$20 per barrel (bbl). This was followed by a gradual recovery throughout 2021. However, when the war erupted, the price of crude oil increased by over 60 percent between the start of 2022 (US\$72.9/bbl) and its peak in mid-2022 (US\$116.8/bbl).

Figure 1. Price of Crude Oil



Source: World Bank

Crude oil, average spot price of Brent, Dubai and West Texas Intermediate, equally weighed

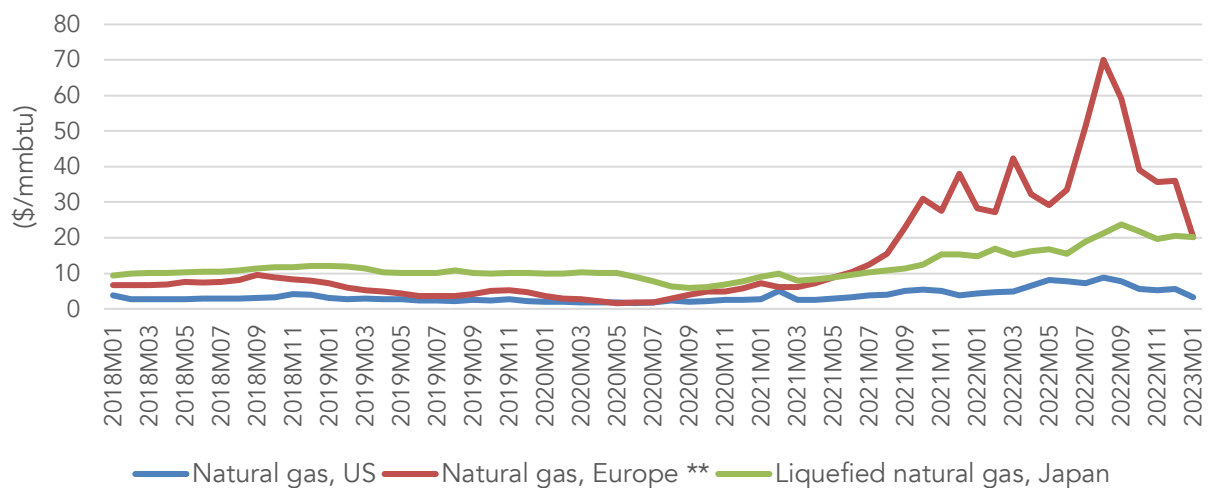
Crude oil, UK Brent 38` API.

Crude oil, Dubai Fateh 32` API for years 1985-present; 1960-84 refer to Saudi Arabian Light, 34` API.

Crude oil, US, West Texas Intermediate (WTI) 40` API.

Figure 2 shows the price of natural gas in Europe. From a generally stable price prior to 2022, the price surged by nearly 150 percent from the start of 2022 (US\$28.26/mmbtu) to its peak in the 3rd quarter of 2022 (US\$70.0/mmbtu). The price surge was largely due to the trade restriction imposed by EU on natural gas imports from Russia.

Figure 2. Price of Natural Gas (\$/mmbtu)



Source: World Bank

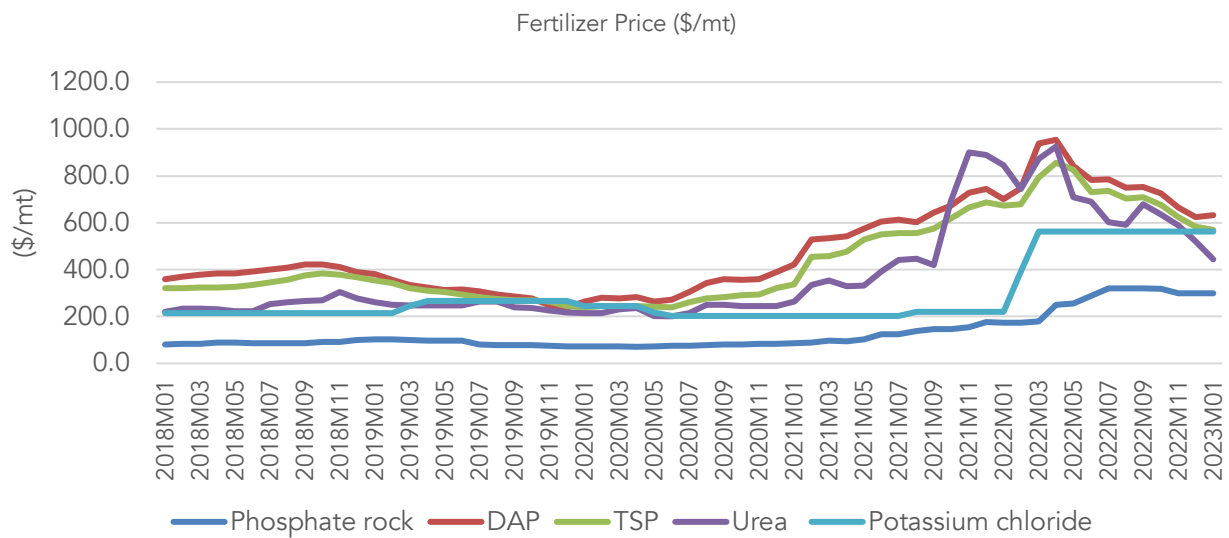
Natural Gas (Europe), from April 2015, Netherlands Title Transfer Facility (TTF); April 2010 to March 2015, average import border price and a spot price component, including UK; during June 2000 - March 2010 prices exclude UK.

Natural Gas (U.S.), spot price at Henry Hub, Louisiana

Liquefied natural gas (Japan), LNG, import price, cif; recent two months' averages are estimates.

Figure 3 shows the price trend of fertilizer. The price of DAP (diammonium phosphate) increased by 36 percent from the start of 2022 to its peak in the 2nd quarter of 2022, with the price of TSP (triple superphosphate) increasing by 26.9 percent over the same period.

Figure 3. Price of Fertilizer



Source: World Bank

DAP (diammonium phosphate), spot, f.o.b. US Gulf

Phosphate rock, f.o.b. Northern Africa

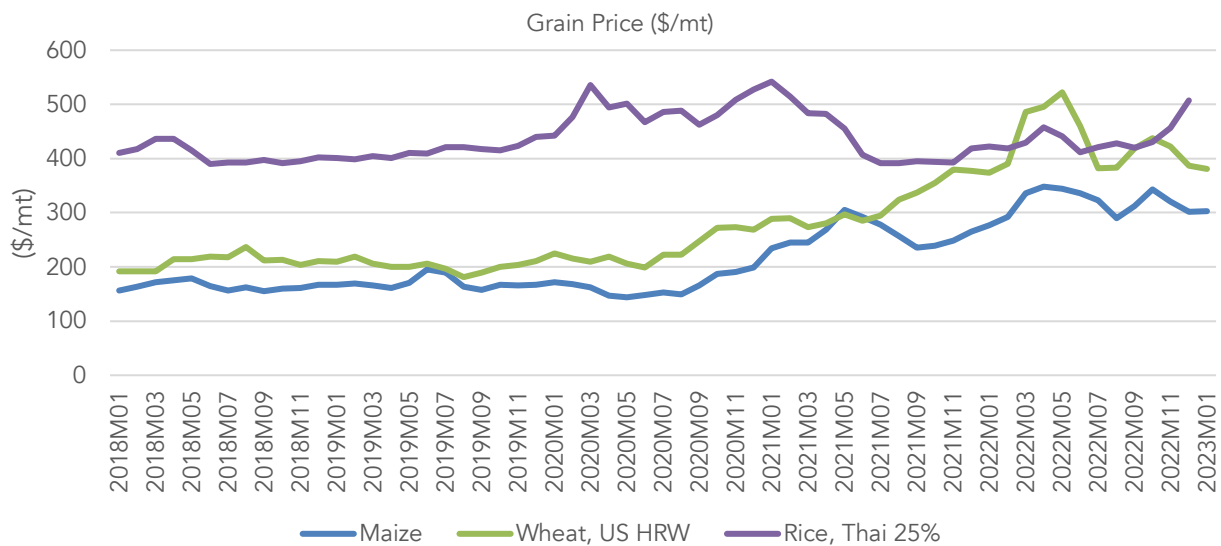
Potassium chloride (muriate of potash), f.o.b. Vancouver

TSP (triple superphosphate), spot, import US Gulf

Urea, (Ukraine), prill spot f.o.b. Middle East, beginning March 2022; previously, f.o.b. Black Sea.

The price trend of grains is presented in Figure 4. From the start of 2022 to its peak in the 2nd quarter of 2022, the price of maize (corn) increased by 24 percent, and wheat by nearly 40 percent.

Figure 4. Price of Grains



Source: World Bank

Maize (U.S.), no. 2, yellow, f.o.b. US Gulf ports

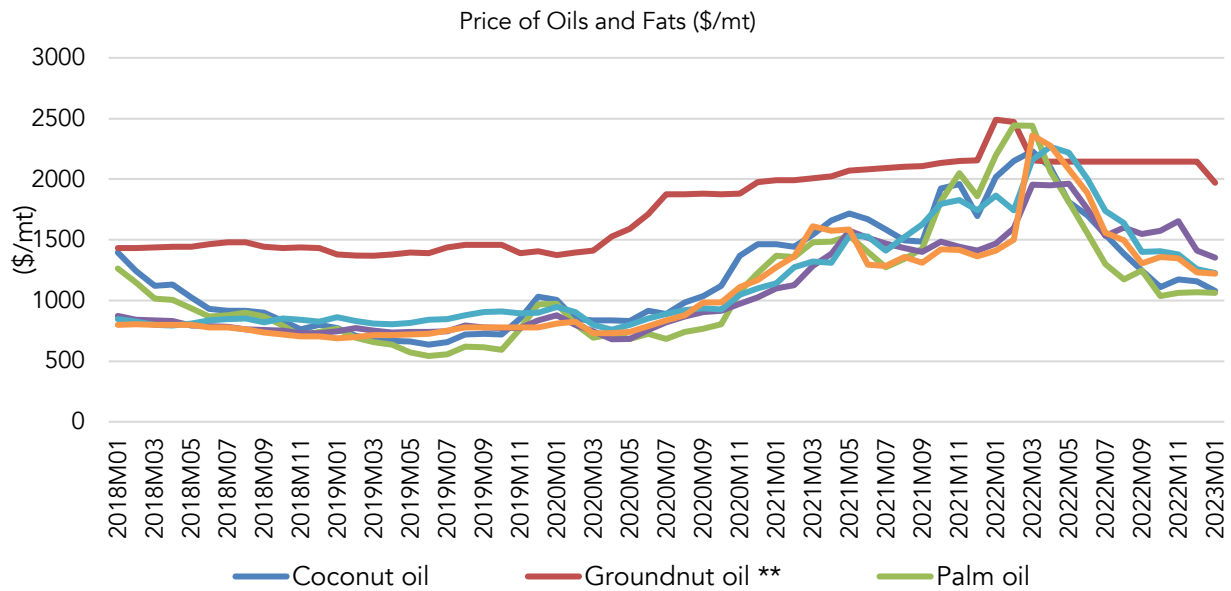
Wheat (U.S.), no. 2 hard red winter Gulf export price; June 2020 backwards, no. 1, hard red winter, ordinary protein, export price delivered at the US Gulf port for prompt or 30 days shipment

Rice (Thailand), 25% broken, WR, milled indicative survey price, government standard, f.o.b. Bangkok

Figure 5 highlights some of the most significant price increases attributable to the RUW. The price of sunflower oil (of which Ukraine supplied more than 50 percent to the world market prior to the RUW) increased by 61 percent from the start of 2022 to its peak in the 2nd quarter of 2022. Over the same months, the price of soybean oil increased by 32 percent and rapeseed oil by 21 percent.

As shown in Figure 6, the price of chicken increased by over 28 percent during the same period, whilst the prices beef remained relatively unchanged.

Figure 5. Price of Oils and Fats



Source: World Bank

Coconut oil (Philippines/Indonesia), from January 2021, crude, CIF Rotterdam; January 1999 to December 2020, crude, CIF NW Europe; previously, bulk, c.i.f. Rotterdam

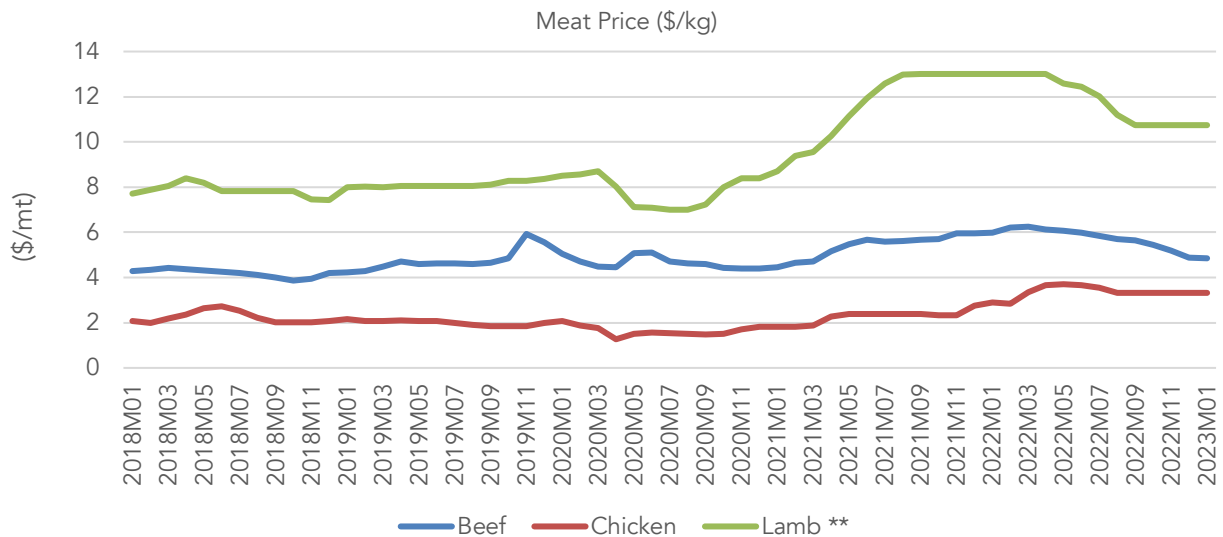
Groundnut oil, Refined, FOR Ports India, beginning January 2023; December 2020-2022, Dutch Refined GroundNut Oil A/O, Ex Tank Rotterdam; January 1999-November 2020, U.S. crude, FOB South-East; previously any origin, c.i.f. Rotterdam.

Palm oil (Malaysia), from January 2021, RBD, FOB Malaysia Ports; December 2001 to December 2020, RBD, CIF Rotterdam; previously Malaysia 5%, c.i.f. N.W. Europe, bulk, nearest forward.

Soybean oil, from January 2021, Dutch Soyoil Crude Degummed, EXW Dutch Mills; January 1999 to December 2020, Dutch crude degummed FOB NW Europe; previously crude, f.o.b. ex-mill Netherlands, nearest forward.

Sunflower oil, from September 2020, Dutch Sunseed Oil, f.o.b. Rotterdam; February 2011 to August 2020, European crude, f.o.b. Rotterdam; previously, EU f.o.b NW Europe ports.

Figure 6. Price of Meat



Source: World Bank

Meat, beef (Australia/New Zealand), mixed trimmings 85%, East Coast, 7-45 day deferred delivery, FOB port of entry, beginning January 1995; previously cow forequarters

Chicken (U.S.), Uner Barry Northern East weighted average for broiler/fryer, whole birds, 2.5 to 3.5 pounds, USDA grade "A" from 2013 onwards; 1980-2012, Georgia Dock weighted average, 2.5 to 3 pounds, wholesale; previously World Bank estimates.

Lamb (U.S.), boxed lamb cuts, leg, double, trotter-on, less than truckload (LTL) pricing, from August 2010; previously, (New Zealand)

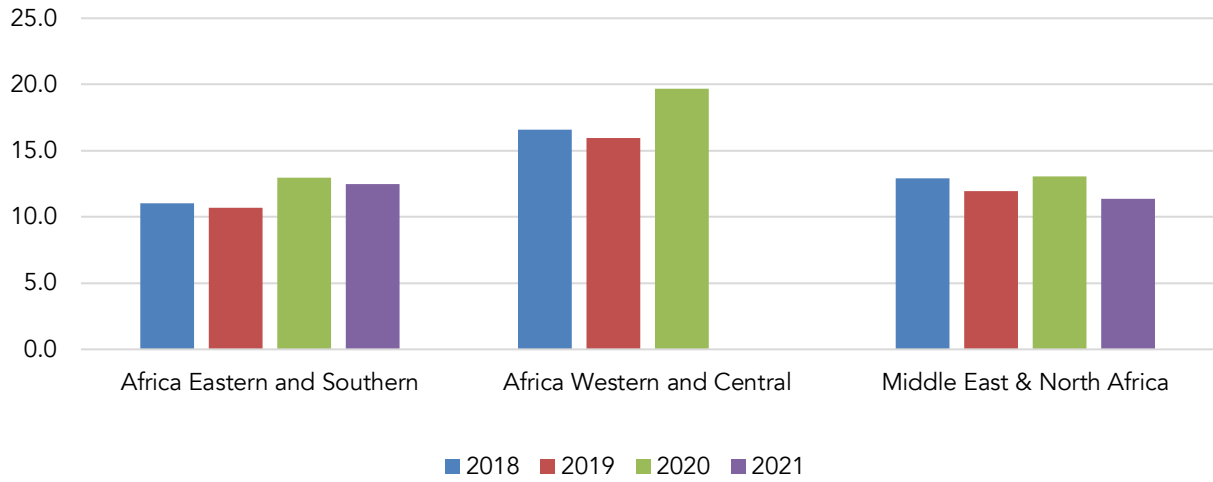
The increase in prices of key commodities (agriculture, food, fuels), supply constraints brought about by the RUW and the reactions from other countries (including sanctions and food security concerns) have significantly impacted African regions in particular due to their dependence on external trade. Table 2 presents the structure of external trade of various regions in Africa. Food and fuel imports have significant shares in external transactions of the regions. In particular, Figure 9 shows that food imports of Africa Western and Central have import shares that range between 15 and 20 percent of the total, while African Eastern and Southern and Middle East and Northern African have imports shares that range between 10 and 15 percent. The dependence of the regions on imported fuel is also notable as shown in Figure 10.

Table 2. External Trade of African Regions

	2018	2019	2020	2021
Africa Eastern and Southern				
Trade (% of GDP)	54.5	51.3	48.1	53.8
External balance on goods and services (% of GDP)	-3.1	-2.8	-1.7	-0.1
Merchandise exports (current US\$ billion)	221.9	201.4	182.5	258.7
Fuel exports (% of merchandise exports)	24.6	24.9	23.3	25.9
Food exports (% of merchandise exports)	14.2	13.7	14.4	12.2
Merchandise imports (current US\$ billion)	257.4	249.1	207.6	267.1
Fuel imports (% of merchandise imports)	17.0	16.7	12.9	15.7
Food imports (% of merchandise imports)	11.0	10.7	13.0	12.5
Africa Western and Central				
Trade (% of GDP)	44.4	45.8	30.0	36.7
External balance on goods and services (% of GDP)	-2.2	-4.3	-1.4	-1.6
Merchandise exports (current US\$ billion)	141.7	139.2	112.0	140.0
Fuel exports (% of merchandise exports)	64.1	61.9	65.5	n.a.
Food exports (% of merchandise exports)	15.2	13.2	12.9	n.a.
Merchandise imports (current US\$ billion)	123.6	134.2	110.9	139.9
Fuel imports (% of merchandise imports)	21.1	14.9	15.6	n.a.
Food imports (% of merchandise imports)	16.6	16.0	19.7	n.a.
Middle East & North Africa				
Trade (% of GDP)	79.1	77.6	69.5	59.1
External balance on goods and services (% of GDP)	7.1	4.7	1.1	n.a.
Merchandise exports (current US\$ billion)	1,322.7	1,219.0	915.3	1,323.0
Fuel exports (% of merchandise exports)	65.0	67.9	65.4	67.6
Food exports (% of merchandise exports)	4.2	3.6	4.1	3.7
Merchandise imports (current US\$ billion)	947.3	1,003.2	865.5	1,097.4
Fuel imports (% of merchandise imports)	8.6	12.9	10.9	9.9
Food imports (% of merchandise imports)	12.9	11.9	13.1	11.3
Sub-Saharan Africa				
Trade (% of GDP)	49.8	48.7	39.7	45.9
External balance on goods and services (% of GDP)	-2.7	-3.5	-1.5	-0.8
Merchandise exports (current US\$ billion)	363.6	340.7	294.5	398.4
Fuel exports (% of merchandise exports)	39.0	37.9	36.9	40.5
Food exports (% of merchandise exports)	14.5	13.5	13.9	10.2
Merchandise imports (current US\$ billion)	381.0	383.4	318.6	407.1
Fuel imports (% of merchandise imports)	18.3	16.2	13.6	18.2
Food imports (% of merchandise imports)	12.8	12.3	14.8	14.0

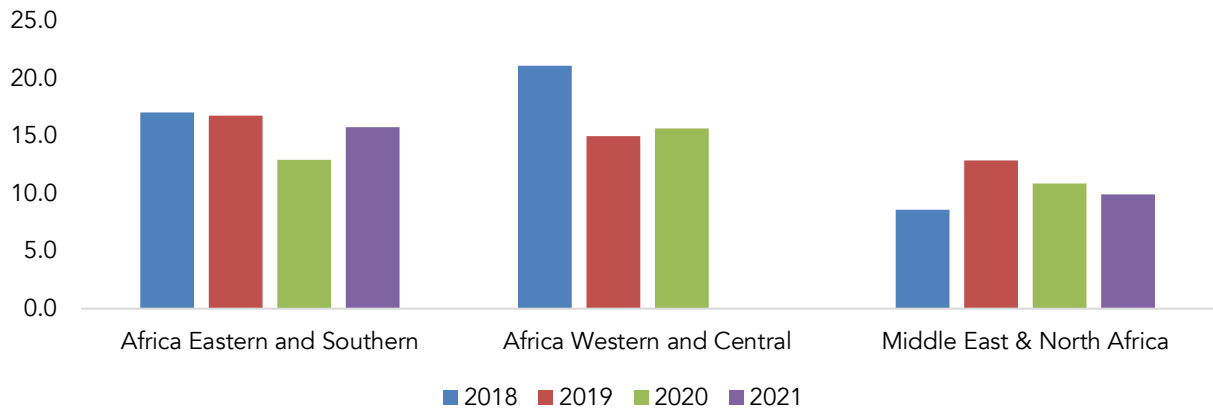
Source: World Bank

Figure 7. Food Imports of African Regions



Source: World Bank

Figure 8. Fuel Imports of African Regions



Source: World Bank

IV. Analytical Framework

The change in trade restrictiveness due to the RUW is modelled as a non-tariff measure (NTMs) which creates artificial scarcity that increases prices. The higher the degree of trade restrictiveness of an NTM, the higher the price wedge between the price of domestically produced goods and imported goods.

Andriamananjara, Ferrantino, Tsigas, (2003) argue that the border effects of NTMs can operate through the import and export sides of trade flows. The tariff equivalents of NTMs can be added to the actual tariffs which increase the price wedge between world prices and domestic prices. This additional tariff due to NTM which increase import prices generate rents which are captured by the importing country.

The NTMs can also be considered as export tax equivalents. As export tax equivalents, NTMs reduce the ability of the exporters to sell their products to international markets. "This approach has been adopted in the study of 'voluntary export restricts (VER)', which are administered by means of exporting economy granting licenses to a particularly firms to sell in the importing country". The firms that are granted with the right to export therefore earns the economic rent.

Furthermore, Andriamananjara, Ferrantino, Tsigas, (2003) argue that NTMs can also be analyzed through the factors that result in losses in import efficiency. The efficiency losses may be due to institutional factors (or "sand in the wheels") that reduce the flow of imports, such as "administrative procedures, technical regulations, sanitary and phytosanitary (SPS) requirements, or other red tapes that tend to produce a harassment effect that discourages imports into the economy". These types of NTMs do not create economic rents. Instead, they create inefficiencies that slow down the flow of imports goods into the country.

In the case of tariff equivalents, NTMs can be incorporated in the local price of imports ($PM_{m,zj,z}$), that is,

$$PM_{m,zj,z} = e_z(1 + ttic_{m,z}) \left(PWM_{m,zj} + \sum_i PWMG_{i,r} tmr g_{i,m,zj,z} \right) (1 + ttim_{m,zj,z} + tim_NTM_{m,zj,z})$$

where (e_z) the exchange rate, $(PWM_{m,zj})$ is the world price of imports, $(PWMG_{i,r})$ world price of trade margins expressed in international prices, $(tmrg_{i,m,zj,z})$ the trade margin, and $(ttim_{m,zj,z})$ the import tariff rate, and $(tim_NTM_{m,zj,z})$ the additional import tariffs due to NTMs. The index m represents imported commodity (of sector i) by country z from country zj .

In the export side, NTMs can be incorporated in the export price $(PE_{x,z,zj})$, that is

$$PE_{x,z,zj}(1 + ttix_{x,z,zj} + tex_NTM_{x,z,zj}) = e_z PWX_{x,z,zj}$$

where $(ttix_{x,z,zj})$ is the export tax rate, $(PWX_{x,z,zj})$ the world price of exports in international currency, and $tex_NTM_{x,z,zj}$ the additional export tax due to NTMs. The index x represents exported commodity (of sector i) by country z to country zj .

The efficiency losses from NTMs can be incorporated by introducing an efficiency parameter in the import demand functions and in the unit price of imports. Following Hertel, Walmsley, and Itakura (2001), the demand-shifting effect of the NTMs is captured in the import-augmenting parameter in the CES import demand function, $\delta_{m,zj,z,t}$, that is,

$$IM_{m,zj,z} = \beta_{m,zj,z}^{\sigma_{2m,z}} (\delta_{m,zj,z} \alpha_{2m,z})^{\sigma_{2m,z}-1} \left(\frac{PMT_{m,z}}{PM_{m,zj,z}} \right)^{\sigma_{2m,z}} IMT_{m,z}$$

where $(\beta_{m,zj,z})$ is the share parameter for imports from the country of origin zj , $(\sigma_{2m,z})$ the elasticity of substitution, $(\alpha_{2m,z})$ the scale parameter in the CES function, $(PM_{m,zj,z})$ the price of imports inclusive of taxes, duties and trade margins. The import efficiency parameter $\delta_{m,zj,z}$ is due to NTMs.

The unit cost of imports is

$$PMT_{m,z} = \left(\frac{1}{\alpha_{2m,z}} \right) \left(\sum_{zj} \beta_{m,zj,z} \left(\frac{PM_{m,zj,z}}{\delta_{m,zj,z}} \right)^{1-\sigma_{2m,z}} \right)^{\frac{1}{1-\sigma_{2m,z}}}$$

The import efficiency parameter $\delta_{m,zj,z}$ can generate three distinct effects. The first effect works through the import demand function. An increase in $\delta_{m,zj,z}$ will lower the effective price of imports of good m from exporter zj imported into country z . The lower effective price of imports will induce substitution through the elasticity of

substitution ($\sigma_{m,z}$) to the exporter zj from other exporters. The second effect also works through the same import demand function, but the effect is in the opposite direction. That is, since the effective quantity of the imported commodity has improved, the importer country would need less of the commodity to meet its import requirements. The third effect works through the unit cost of imports. That is, an increase in $\delta_{m,zj,z}$ will lower the price of imports, $PMT_{m,z}$.

The paper adopts the above NTM framework to analyze the trade restrictiveness due to the RUW and incorporates it into the PEP-w-t global CGE model's theoretical framework and database. To calibrate the CGE model, the analysis uses the estimates of the ad valorem tariff equivalent of NTMs of Kee et al. (2009). The estimates were derived through econometric estimation of a gravity equation using world trade flows, tariffs, several geographical variables such as distance between trading centers and links between countries such as colonial past, common languages, contiguity, etc.

V. Definition of Simulations

The paper utilizes the PEP-w-t global CGE model documented in Robichaud et al. (2013). The model is implemented and calibrated to the GTAP 10 database. The model database is aggregated to 17 sectors and commodities, and 21 regions (see Table 3). The model recognizes four factor inputs: skilled labor, unskilled labor, capital and land, as well as one representative household.

In the analysis, nine countries are highlighted and explicitly modelled: Egypt, Sudan, Morocco, Senegal, Kenya, Ethiopia, Mozambique, South Africa, and Nigeria. All other countries in the African continent are lumped into one region: 'Rest of Africa'. Russia, Ukraine and Belarus (where the conflict erupted) are also separately accounted for in the model. The Black Sea region has a separate account in the model because of

the disruption of the trade flows through the Black Sea. The U.S. Canada and EU have separate accounts each because they are also major suppliers of food in the global market. Countries in EU are directly affected because they share borders with Ukraine, Russia and Belarus. They are also severely affected by disruption in the flows of energy materials from Russia. The U.S. Canada, as well as EU imposed various economic sanctions on Russia as a result of the unprovoked invasion.

The standard GTAP 10 database has 65 commodities in 147 countries regions. To simplify the implementation of the CGE model and focus on the specific regions and commodities of interest to this research, the database was aggregated to 17 sectors/commodities and 21 countries/regions. The sectors are disaggregated to capture key agri-food commodities. Oil and gas combined has a separate account to capture the impact of changes in production of fossil-related commodities. Fertilizer, whose production is dependent on natural gas, is included in the chemical sector. The full mapping of the aggregation is presented in the Appendix (Table A1 for the commodity mapping and Table A2 for the country/regional mapping). Table 3 below shows the sectors and countries/regions explicitly modelled in our application.

Table 3. Global PEP CGE Model

Code	Sectors	Code	Countries/Regions
1 ric	Rice	1 egypt	Egypt
2 wht	Wheat	2 sdn	Sudan
3 ocl	All other cereals	3 mar	Morocco
4 v_f	Vegetables fruit nuts	4 sen	Senegal
5 osd	Oil seeds	5 ken	Kenya
6 sug	Sugar	6 eth	Ethiopia
7 oag	Other Agriculture	7 moz	Mozambique
8 mmt	Meat and products	8 zaf	South Africa
9 ofd	All other food products	9 nga	Nigeria
10 p_c	Oil and gas	10 afr	Rest of Africa
11 chm	Chemicals	11 easia	East Asia
12 trq	Transport equipment	12 opec	OPEC
13 omf	Other manufactures nec	13 bsea	Black Sea region
14 indy	Other industry	14 usa	United States
15 trp	Transport	15 can	Canada
16 osr	Other services	16 ukr	Ukraine
17 osg	Public Admin.	17 rus	Russia
		18 blr	Belarus
		19 eu	EU27
		20 ltn	Latin America
		21 row	Rest of the world

The paper conducts two ten-year simulations to analyze the impact of the RUW on Africa: (a) the conflict will resolve at the start of the third year (i.e., start of 2024)²; and (b) the conflict is protracted and gets resolved at the start of the fifth year (i.e., start of 2026). In addition, a baseline simulation (business-as-usual that assumes no RUW effects) is conducted. The effects of the two ten-year war simulations are compared with the baseline to calculate the dynamic effects of the war over time.

Several assumptions are used in the simulations:

(a) Reduction in agricultural productivity in Ukraine, Russia, and Black Sea Region. Based on USDA data, in Ukraine the production yield of corn dropped by 35.9 percent and wheat by 36.4 percent. In the simulation, a 40 percent decline in agricultural productivity in Ukraine is assumed³. Also based on USDA data, the production yield of wheat and rice in Russia declined by 11.9 percent and 5.8 percent, respectively. In the simulation, a 10 percent decline in agricultural productivity in Russia is assumed. Based on the same data source, production yield of wheat in Moldova dropped by 51.6 percent, Turkey by 12.3 percent and Georgia by 19.1 percent. To capture this effect, a 20 percent decline in agricultural productivity in the Black Sea Region is assumed.

In the first simulation, the assumed decline in agriculture-food productivity is retained in the first year and second year. In the third year, the rate of decline in productivity in the first and second year is reduced by half (e.g., for Ukraine from 40 percent down to 20 percent). In the fourth year until the tenth year, BAU is applied.

In the second simulation, the assumed decline in agriculture-food productivity is retained in the first year until the fourth year. In the fifth year, the rate of decline in productivity is reduced by half. In the sixth year until the tenth year, BAU is applied.

(b) Export restrictions on Russian agriculture-food exports. To capture the trade restrictiveness by Russia on exports of agriculture and food, NTMs on these

² Russia invaded Ukraine on February 24, 2022.

³ This is simulated by decreasing the scale parameter of the CES value-added function in agriculture-food sectors. In Table 3, agri-food sectors include: (ric), (wht), (ocl), (v_f), (osd), (sug), (oag), (mmt), and (ofd)

commodities are increased by 30 percent⁴. Similar dynamic assumptions as in (a) above are applied in the first simulation and the second simulations over the ten-year period.

(c) Reduction in oil production in OPEC, Nigeria (as an OPEC country) and Russia. These countries reduced oil production by 10 to support oil prices⁵. Similar dynamic assumptions as in (a) above are applied in the first simulation and the second simulations over the ten-year period.

(d) Reduction in fertilizer production and restriction in fertilizer trade. The reduction in imports of natural gas in EU leads to a reduction in the production of fertilizer. Furthermore, due to food security concerns, countries restrict exports of fertilizers. In the simulation this is implemented by a 30 percent reduction in fertilizer production and a 30 percent increase in NTMs⁶.

Similar dynamic assumptions as in (a) above are applied in the first simulation and the second simulations over the ten-year period.

(e) Food trade restrictions. Because of food security concerns, countries restrict food trade. This trade restriction is implemented using a 30 percent increase in NTMs on agriculture-food trade. Similar dynamic assumptions as in (a) above are applied in the first simulation and the second simulations over the ten-year period.

(f) Drought in the Northern Hemisphere (U.S., Canada and EU), and in the Horn of Africa (Ethiopia, Sudan and Kenya). Based on USDA data, in the U.S. the wheat crop yield declined by 9.9 percent, corn by 8.9 percent and rice by 15.8 percent. Agriculture-food production in the U.S. is reduced by 10 percent. Similar reduction is assumed in EU and Canada. Similar dynamic assumptions as in (a) above are applied in the first simulation and the second simulations over the ten-year period.

Based on USDA data, crop yield in Kenya dropped by 6.7 percent, Ethiopia by 5.7 percent and Sudan by 7.4 percent, which resulted in reduction in agriculture-food

⁴ To implement this shock $tim_NTM_{m,zj,z}$ (additional tariff) and $tex_NTM_{x,z,zj}$ (additional export tax) were increased, while $\delta_{m,zj,z}$ (import efficiency parameter) was reduced. Similar assumption applied by Chepeliev (2023).

⁵ This is lower than the 15 percent reduction in Chepeliev (2023). This is implemented as a downward shift in the scale parameter of oil production (sector p_c Table 3) in OPEC including Nigeria and Russia.

⁶ Fertilizer is in sector chm in Table 3.

production in these countries. In both the first and the second simulations, the drought in these countries is expected to last until the third year. In the fourth year, the reduction in agriculture-food production is reduced by half. Starting in the fifth year, the BAU path is again applied.

VI. Simulation Results

The results of the two simulations are presented in this section. The impacts if the war gets resolved at the start of the third year (Sim1) are discussed in the first, while results if the war is protracted (Sim2) are presented in the appendix. In both simulations, the two simulations are compared with a baseline scenario where BAU assumptions are used. The simulations were conducted for 10 years. In both simulations, the effects on the nine African countries and the rest of Africa are highlighted.

The presentation of results is organized as follows, the effects on: (1) real GDP; (2) inflation; (3) factor prices (skilled wages, unskilled wages, returns to capital and land rent)⁷; (4) household income; (5) consumption: aggregate and agriculture-food; and (6) welfare⁸: as percent of GDP and as accumulated value of welfare losses in the first five years. The effects on household consumption are further disaggregated into specific food items: rice; wheat; all other cereals (including corn); vegetables, fruits and nuts; oil seeds; other agriculture; meat products; and all other food products.

⁷ In a multifactor model, at least one of the factor prices will show an opposite change compared to the rest of the factors. To illustrate in a two-factor case, a change in the relative factor prices along an isoquant will result in one factor price increasing while the other factor price decreasing.

⁸ Welfare is computed as equivalent variation (EV).

6.1. Ukraine-Russian War Resolves at Start of Third Year Under Sim1

Macro Effects. Table 4 shows the real macro effects in African countries: Real GDP and real investment growth⁹. Relative to the baseline, real GDP declines. The decline is higher in the years 1 and 2, and slightly lower starting in year 3. However, because the drought in the Horn of Africa is assumed to last for three years, the reduction is higher in Sudan, Kenya and Ethiopia relative to the rest until year 3. Starting in year 4, the decline in real GDP is slightly lower. In the rest of the ten-year simulation period the real GDP effects are smaller in all countries.

Real investment also declines relative to the baseline. Since investment affects capital, the decline in investment negatively affects production in African countries, which is reflected in real GDP. The decline in production will have negative effects on factor prices as shown below.

Table 4. Real Macro Effects, % change relative to baseline (Sim1)

	Year				
	1	2	3	...	10
	Real GDP Growth				
Egypt	-0.36	-0.37	-0.19		-0.07
Sudan	-3.80	-3.83	-3.77		-0.14
Morocco	-0.53	-0.50	-0.20		-0.02
Senegal	-0.50	-0.64	-0.62		-0.50
Kenya	-3.40	-3.42	-3.35		-0.12
Ethiopia	-3.04	-3.07	-3.10		-0.11
Mozambique	-0.05	-0.10	-0.13		-0.05
South Africa	-0.53	-0.50	-0.18		-0.01
Nigeria	-1.71	-1.71	-0.83		-0.02
Rest of Africa	-0.21	-0.25	-0.17		-0.06
	Real Investment Growth				
Egypt	-2.03	-1.95	-0.86		-0.07
Sudan	-4.96	-5.03	-5.11		-0.30
Morocco	-1.19	-1.09	-0.38		-0.01
Senegal	-4.54	-5.00	-2.93		-0.96
Kenya	-2.94	-2.99	-2.59		-0.05
Ethiopia	-0.71	-0.84	-0.77		-0.13
Mozambique	-0.69	-0.66	-0.27		-0.02
South Africa	-1.02	-0.94	-0.34		-0.04
Nigeria	-0.31	-0.61	-0.67		-0.14
Rest of Africa	0.32	0.06	-0.30		-0.12

Source: Author's calculations

⁹ Changes in real investment are drivers of the dynamic (recursive) effects through capital accumulation over time. The model uses a neoclassical closure where total savings is equal to total investment. Total savings is the sum of private savings (households and firms), government savings, and foreign savings (current account balance).

Table 5 presents the impact on inflation across countries for all commodities and for agriculture and food. Relative to the baseline, the highest increase in prices is in Sudan agriculture-food, 11.39 percent. This is followed by Kenya (7.56 percent) and Ethiopia (6.61 percent).

Except for Mozambique, South Africa and Nigeria, the increase in prices of agriculture-food commodities is higher than non-food.

Table 5. Inflation, % change relative to baseline (Sim 1)

	Year				
	1	2	3	...	10
Egypt					
All commodities	2.64	2.42	0.89		-0.07
Agri-food	4.76	4.30	1.61		-0.17
Sudan					
All commodities	6.54	5.91	2.93		-0.22
Agri-food	11.39	10.65	7.56		-0.34
Morocco					
All commodities	2.61	2.28	0.68		-0.10
Agri-food	3.41	2.93	0.87		-0.17
Senegal					
All commodities	2.66	2.75	1.32		-0.02
Agri-food	3.35	3.33	1.54		-0.05
Kenya					
All commodities	3.67	3.44	2.46		-0.12
Agri-food	7.56	7.06	6.16		-0.28
Ethiopia					
All commodities	2.32	2.04	1.35		-0.06
Agri-food	6.61	5.71	5.08		-0.19
Mozambique					
All commodities	1.68	1.48	0.44		-0.09
Agri-food	1.18	1.18	0.49		-0.07
South Africa					
All commodities	1.86	1.60	0.44		-0.09
Agri-food	1.36	1.18	0.37		-0.06
Nigeria					
All commodities	1.15	0.44	-0.68		-0.26
Agri-food	0.71	0.01	-0.87		-0.26
Rest of Africa					
All commodities	3.43	3.08	1.00		-0.16
Agri-food	4.18	3.71	1.18		-0.22

Source: Author's calculations

Table 6 presents the effects on factor prices less the aggregate inflation presented in Table 5. Factor prices generally decline except for land rent¹⁰. Since labor and returns to capital are major sources of household income, the drop in factor prices leads to lower household income as shown in Table 7.

Table 6. Factor Prices less Inflation, % change from baseline (Sim 1)

	Year			
	1	2	3	10
Egypt				
Skilled wages	-3.86	-3.33	-0.96	0.09
Unskilled wages	-3.52	-2.94	-0.73	0.10
Returns to capital	-2.32	-2.04	-0.60	0.10
Land rent	6.24	5.28	1.52	-0.25
Sudan				
Skilled wages	-5.94	-5.71	-4.90	0.01
Unskilled wages	-5.11	-4.93	-4.22	-0.06
Returns to capital	-3.89	-3.89	-3.69	0.10
Land rent	2.76	2.14	0.68	-0.38
Morocco				
Skilled wages	-2.92	-2.65	-0.88	0.06
Unskilled wages	-2.47	-2.24	-0.73	0.05
Returns to capital	-1.07	-1.10	-0.47	-0.01
Land rent	4.40	4.11	1.60	-0.05
Senegal				
Skilled wages	-4.17	-3.28	-0.69	-0.08
Unskilled wages	-2.93	-2.35	-0.58	-0.18
Returns to capital	-3.12	-2.64	-0.56	0.46
Land rent	2.53	1.73	0.10	-0.36
Kenya				
Skilled wages	-5.88	-5.40	-4.19	0.10
Unskilled wages	-4.22	-3.95	-3.13	-0.02
Returns to capital	-3.64	-3.52	-2.64	0.11
Land rent	4.11	2.85	-0.16	-0.29
Ethiopia				
Skilled wages	-5.18	-4.57	-3.17	0.05
Unskilled wages	-3.86	-3.44	-2.27	-0.03
Returns to capital	-2.61	-3.07	-2.67	0.13
Land rent	2.46	2.02	1.79	-0.26
Mozambique				
Skilled wages	-2.46	-2.03	-0.50	0.08
Unskilled wages	-2.25	-1.89	-0.49	0.06
Returns to capital	-1.64	-1.40	-0.23	0.15
Land rent	6.03	5.10	1.37	-0.20
South Africa				
Skilled wages	-3.01	-2.68	-0.82	0.10
Unskilled wages	-2.79	-2.49	-0.77	0.08
Returns to capital	-2.12	-1.93	-0.62	0.04
Land rent	-2.93	-2.55	-0.70	0.10

¹⁰ See footnote 9

Nigeria				
Skilled wages	-0.99	-0.93	-0.38	-0.01
Unskilled wages	-0.99	-0.94	-0.39	-0.01
Returns to capital	-0.25	-0.43	-0.42	0.00
Land rent	0.00	-0.32	-0.57	-0.22
Rest of Africa				
Skilled wages	-1.79	-1.51	-0.39	0.02
Unskilled wages	-1.48	-1.25	-0.32	0.00
Returns to capital	-0.25	-0.34	-0.21	0.04
Land rent	8.73	7.00	1.48	-0.37

Source: Author's calculations

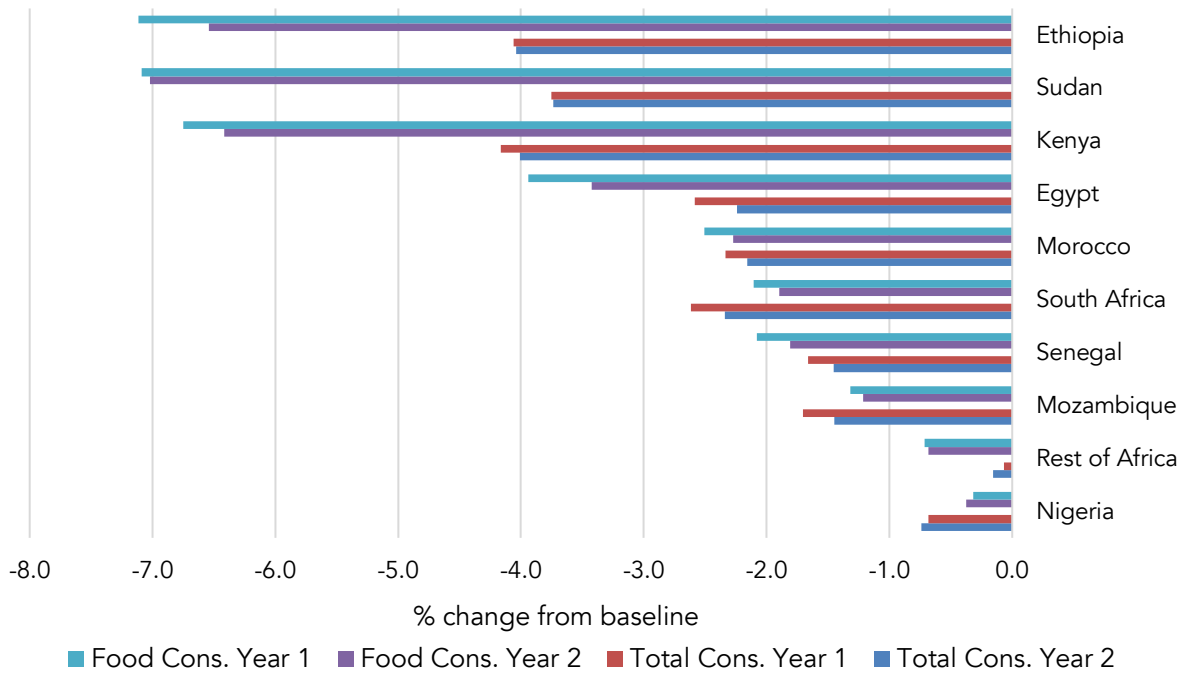
Table 7. Change in real income, % Change Relative to Baseline (Sim 1)

	Year			
	1	2	3	10
Egypt	-2.69	-2.34	-0.72	0.01
Sudan	-4.04	-4.03	-3.76	-0.14
Morocco	-2.02	-1.87	-0.67	0.00
Senegal	-3.35	-2.89	-0.99	-0.20
Kenya	-4.09	-3.94	-3.15	-0.06
Ethiopia	-3.29	-3.29	-2.51	-0.08
Mozambique	-1.60	-1.36	-0.38	0.02
South Africa	-2.80	-2.50	-0.78	0.06
Nigeria	-0.69	-0.75	-0.44	-0.05
Rest of Africa	-0.03	-0.12	-0.20	-0.08

Source: Author's calculations

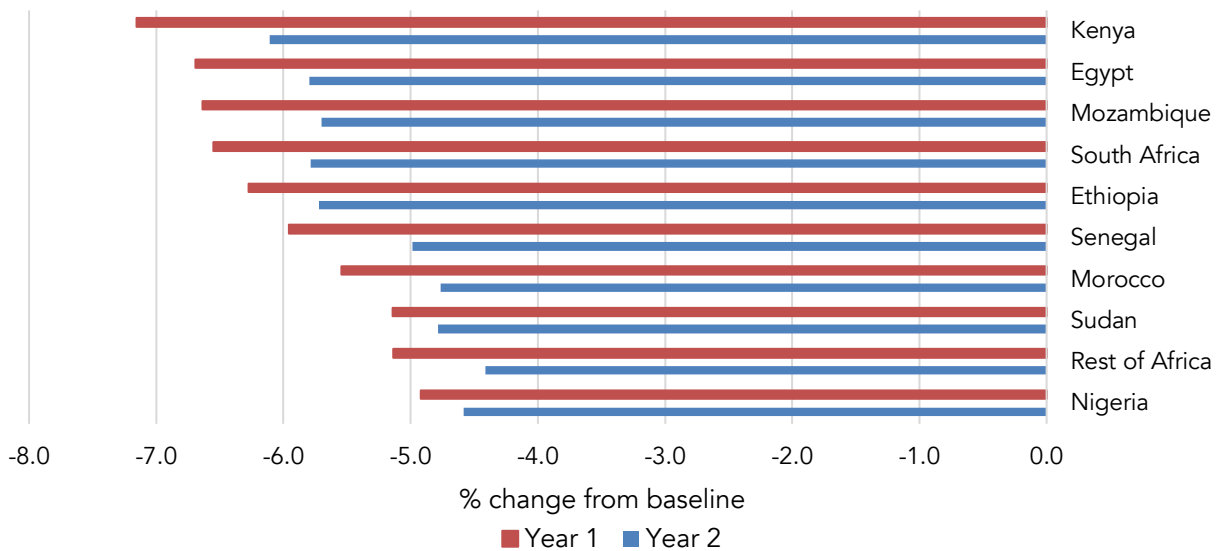
Aggregate Consumption. The increase in prices and the drop in income result in lower consumption, both food and non-food. Across African countries, drop in food consumption generally is larger than non-food particularly in year 1 for Ethiopia, Sudan and Kenya. The decline in consumption is sustained in year 2.

Figure 9. Impact on Consumption, Total and Food, % change from baseline (Sim 1)



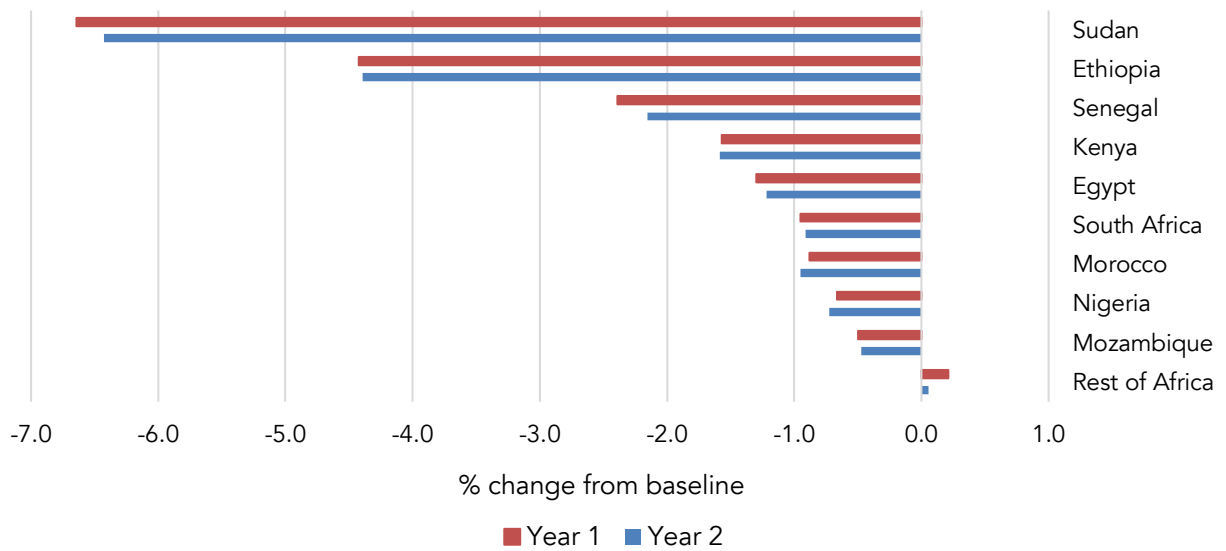
Consumption of Wheat. Across food items, the impacts across African countries vary considerably. Figure 10 shows the drop in wheat consumption. The effects are significant across all countries in Africa. The notable effects in year 1 are sustained in year 2.

Figure 10. Impact on Wheat Consumption, % change from baseline (Sim 1)



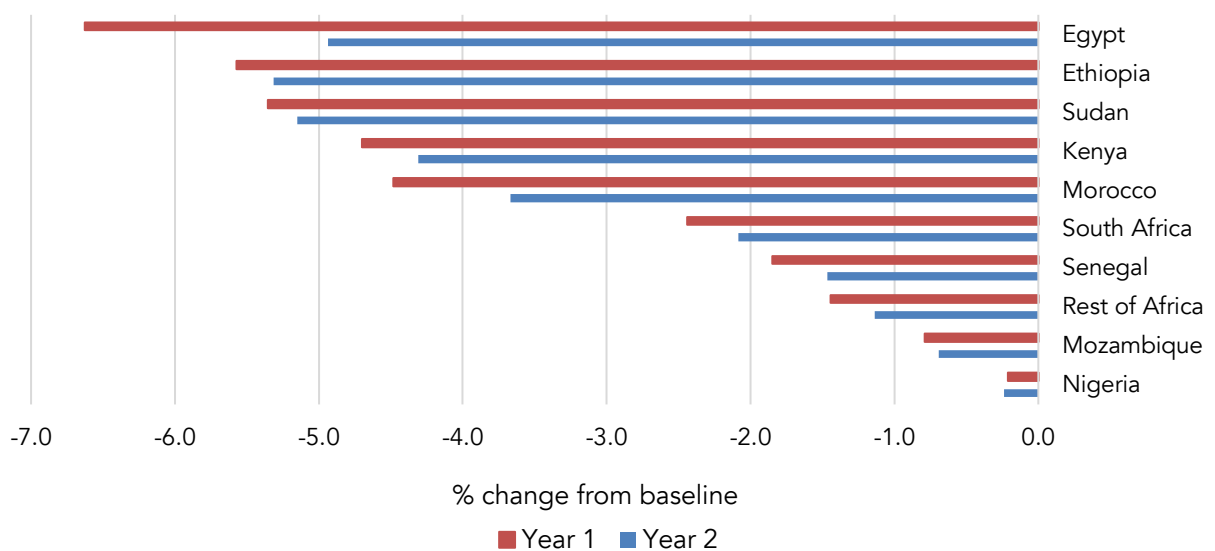
Consumption of Rice. The negative impact on rice consumption differs across countries (Figure 11). The largest drop is in Sudan (-6.6 percent). The effects are sustained in year 2. The negative impact in Ethiopia is also significant.

Figure 11. Impact on Rice Consumption, % change from baseline (Sim 1)



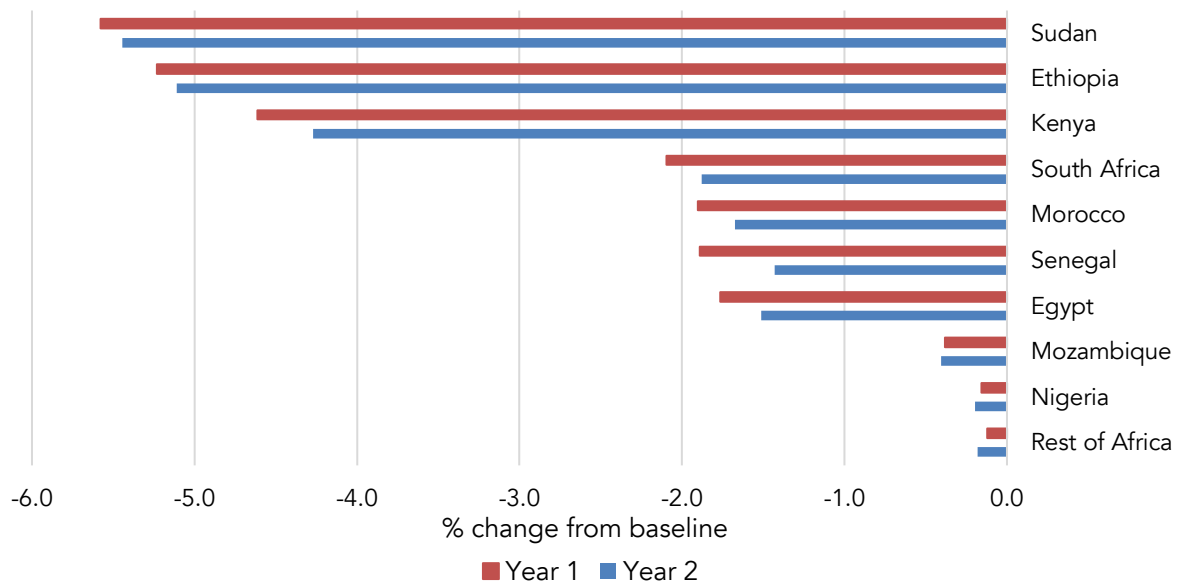
Consumption of Other Cereals (including Corn). The reduction the consumption in other cereals is significant in several countries (Egypt, Ethiopia, Sudan, Kenya and Morocco (Figure 12). In these countries the drop in consumption is sustained in year 2.

Figure 12. Impact on Other Cereals (incl. Corn) Consumption, % change from baseline (Sim1)



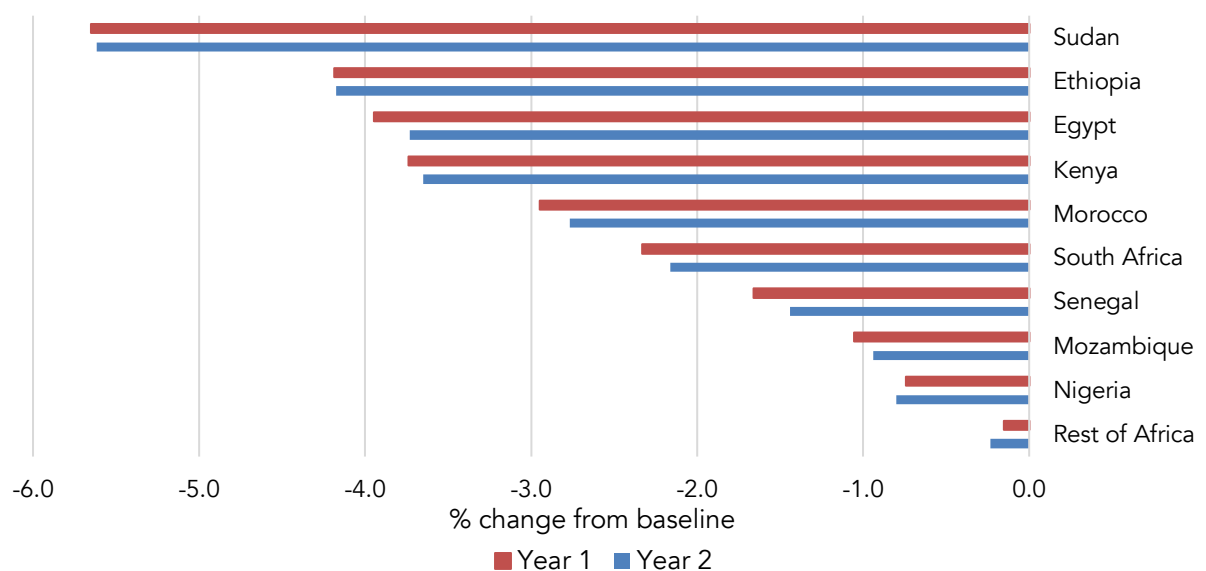
Consumption of Vegetables (including Fruits and Nuts). The drop in these food items is relatively higher in Sudan, Ethiopia and Kenya compared to the rest of the countries in Africa (Figure 13).

Figure 13. Impact on Vegetables (incl. Fruits & Nuts) Consumption, % change from baseline (Sim 1)



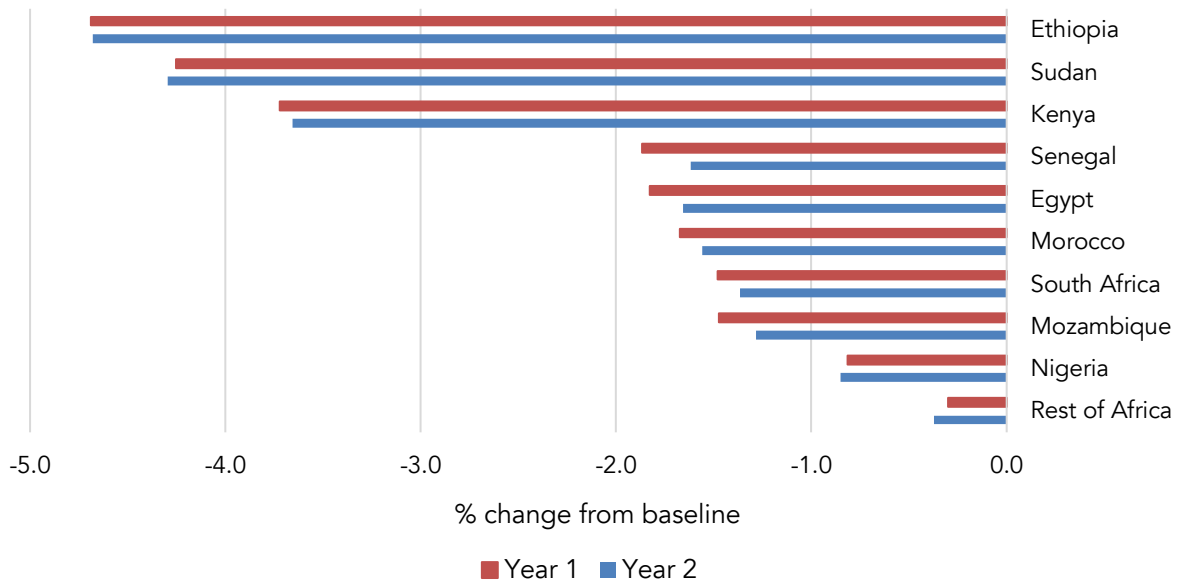
Consumption of Oil Seeds. The impacts on the consumption of oil seeds also vary across countries. The largest drop is in Sudan (Figure 14). The reduction is also notable in Ethiopia, Egypt, and Kenya.

Figure 14. Impact on Oil Seeds Consumption, % change from baseline (Sim 1)



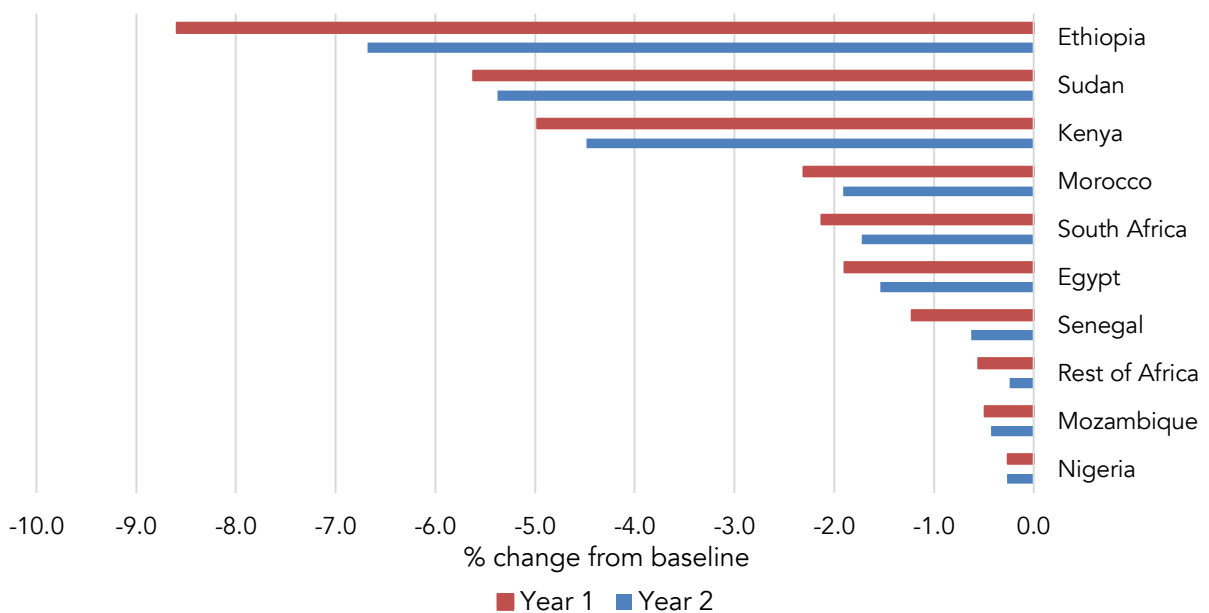
Consumption of Sugar. As shown in Figure 15, the negative effect on sugar consumption is relatively higher in Ethiopia, Sudan and Kenya compared to the rest of the countries in Africa.

Figure 15. Impact on Sugar Consumption, % change from baseline (Sim 1)



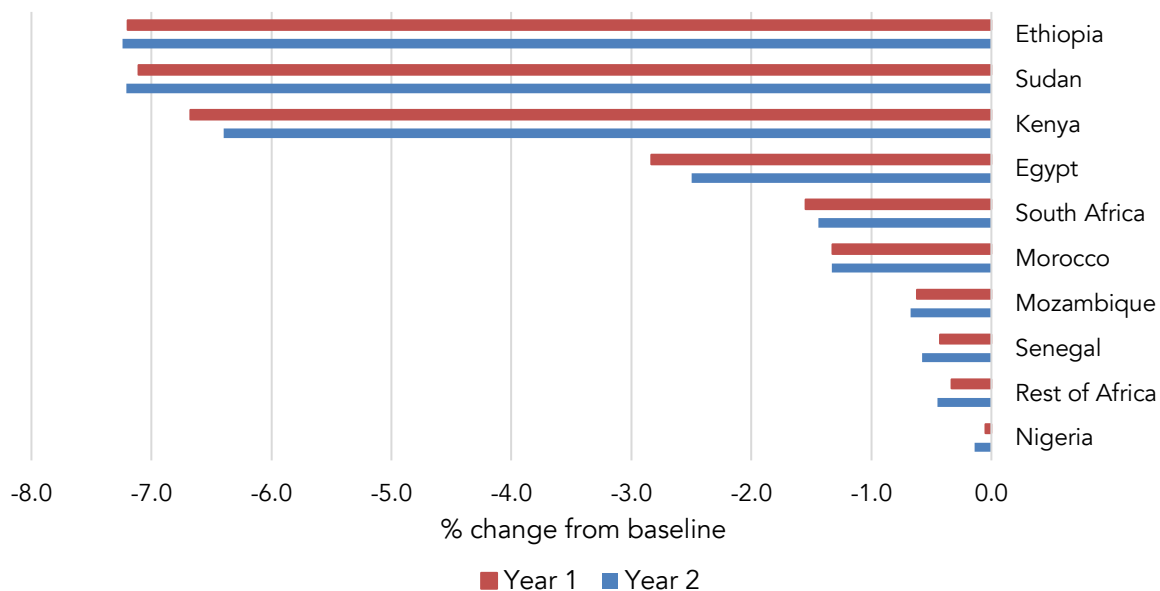
Consumption of All Other Crops. The drop in the consumption of all other crops is significant in Ethiopia (Figure 16). The decline in the demand for these food items is also big large is Sudan and Kenya.

Figure 16. Impact on All Other Crops, % change from baseline (Sim 1)



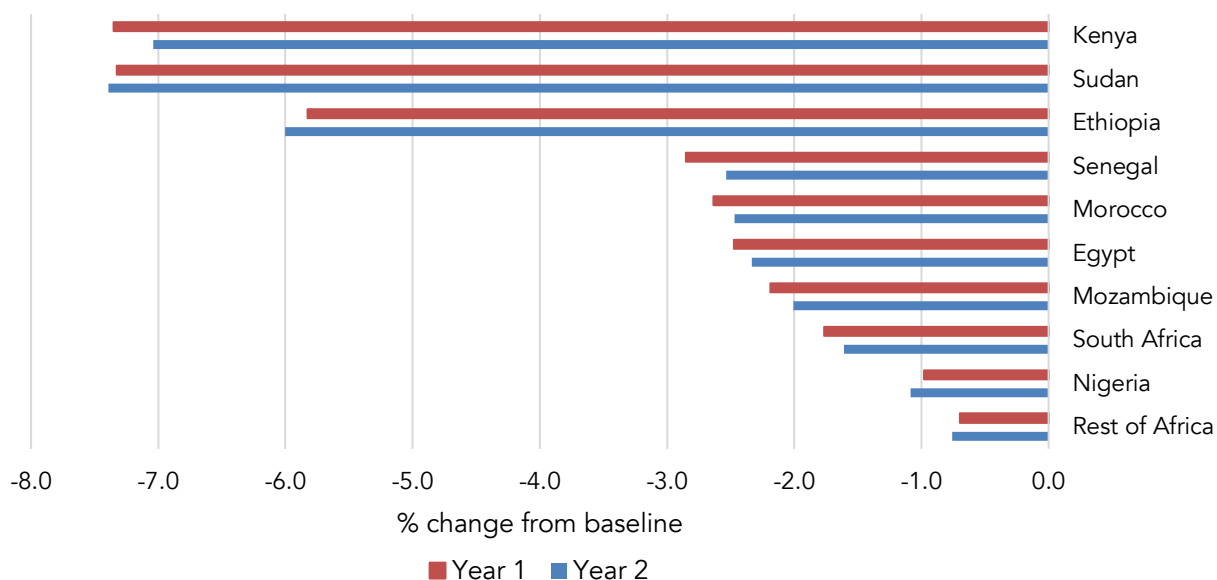
Consumption of Meat Products. The negative impact on the consumption of meat products is relatively higher in Ethiopia, Sudan and Kenya compared to the rest of the countries in Africa (Figure 17).

Figure 17. Impact on Meat Products Consumption, % change from baseline (Sim 1)



Consumption of All Other Food Items. The negative impact on the consumption of all other food commodities is relatively higher in Ethiopia, Sudan and Kenya compared to the rest of the countries in Africa (Figure 18).

Figure 18. Impact on All Other Food Consumption, % change from baseline (Sim 1)



Welfare Effects. The welfare effects on African countries are presented in Figure 19 (US\$ billion) and in Figure 20 (% of GDP). The welfare losses vary across African countries. In terms value, the four countries with the highest welfare losses in year 1 are Egypt (US\$ -5.4 billion), South Africa (US\$ -5.1 billion), Ethiopia (US\$ -4.5 billion) and Kenya (US\$ -4.1 billion). However, relative to GDP, the loss is higher in the Horn of Africa (Kenya, Ethiopia and Sudan) because of the drought in the region. In year 1, the welfare loss in Kenya is 4 percent of GDP, in Ethiopia 3.7 percent of GPP and in Sudan 3.3 percent of GDP. The losses are sustained in year 2.

Figure 19. Welfare Effects, US\$ billion 2021 prices, (Sim 1)

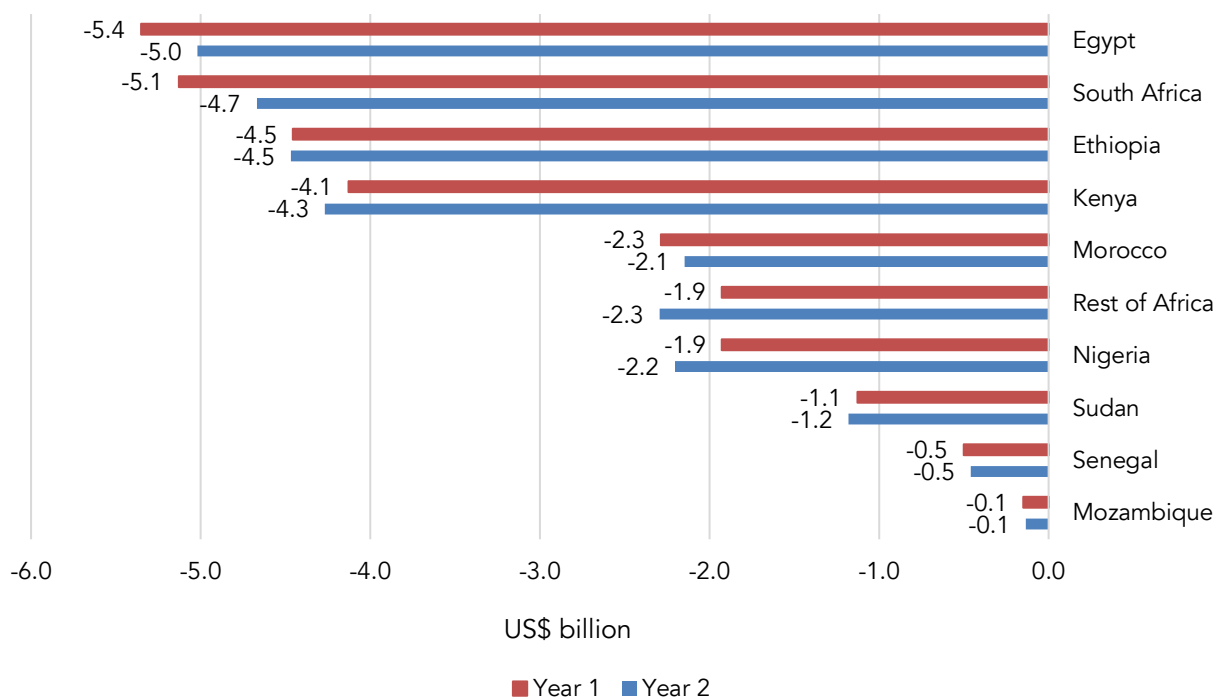


Figure 20. Welfare Effects, % of GDP (Sim 1)

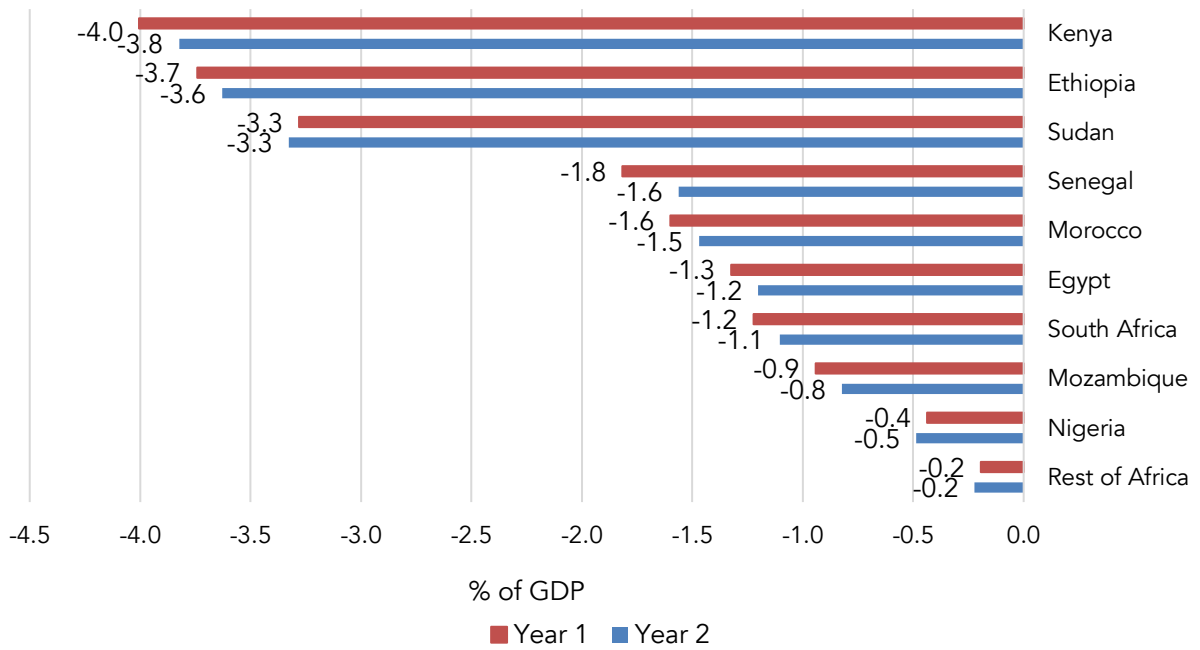
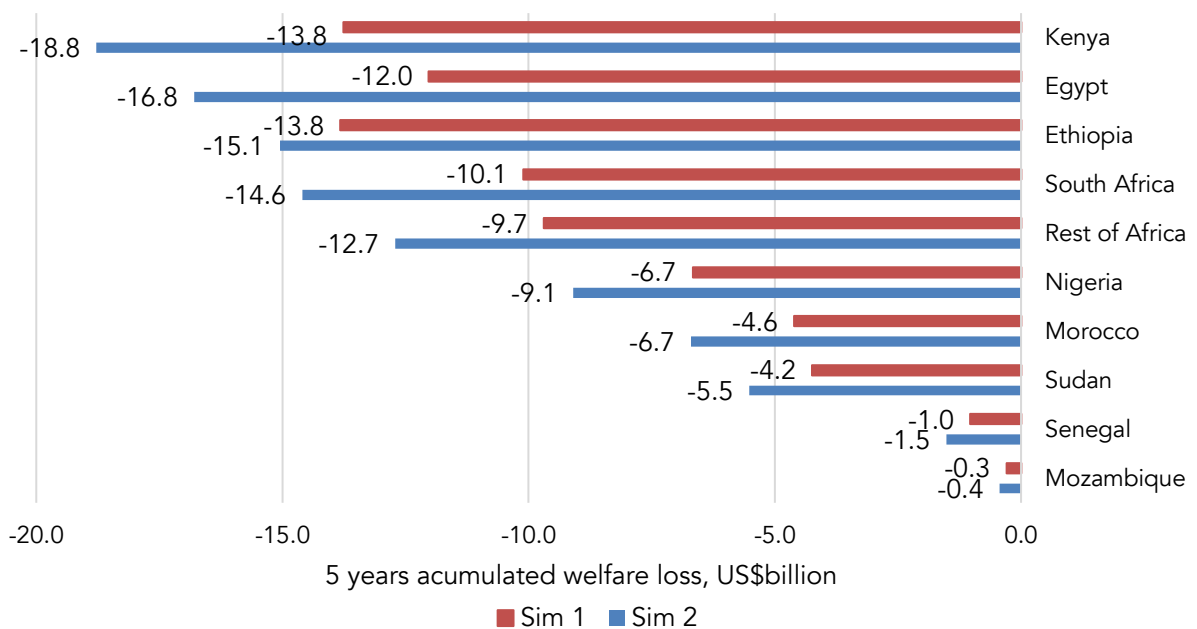


Figure 21 compares the accumulated welfare losses in 5 years under Sim1 and Sim 2. The losses accumulate fast over the years. If the conflict lasts for 3 years, the five-year accumulated loss in Kenya is US\$ 13.8 billion (Sim1), If the war is prolonged 2 more years, the loss in Kenya increases to US\$ -18.8 billion. The incremental welfare loss (Sim 1 vs Sim 2) is notable in Egypt, South Africa, Rest of Africa.

Figure 21. Total Welfare Loss in 5 years, US\$ billion 2021 prices (Sim 1 and Sim 2)



6.2. Ukraine-Russian War Resolves at Start of Third Year Under Sim2

The detailed results under Sim 2 are presented in Appendix D.

VII. Summary and Insights

The RUW has and continues to be extremely costly and disruptive. The disruption has not only been confined to within Ukraine and Russia, but has created both real and artificial scarcity effects on food, agricultural inputs such as fertilizer, and energy products globally, as both countries are major suppliers of these key commodities. Russia is a major global supplier of fossil fuel products, in particular natural gas and oil. The scarcity effects were exacerbated by the drought in major suppliers of food in the world market, including in the Horn of Africa, by the reactions of other food suppliers due to their own food security concerns, and by the series of sanctions imposed by the U.S. and Europe on Russia. Prices of key commodities surged, while the trade flow of food, agricultural inputs, oil and gas were disrupted.

The economic effects on the African continent are notable, driven by a surge in consumer prices, particularly prices of agriculture, food and fuel products. Factor prices has dropped in many countries and real household incomes have decline relative to the baseline. A major concern has been the decline in food consumption, including rice, wheat, cereals, vegetables and nuts, oil seeds, sugar, agriculture, meat products, amongst others.

The impacts vary across countries in the African continent. In Egypt, the decline in the consumption of wheat and other cereals (including corn) is relatively higher compared to other food items. In Sudan, the decline in all food items is significant. The decline in the demand for wheat and other cereals in Morocco is also higher relative to other food items similar to Egypt. In Senegal and Kenya, the drop in wheat demand is

notable. All food items decline in Ethiopia, similar to Sudan. In Mozambique and South Africa, Nigeria and the rest of Africa the consumption of wheat is relative higher compared to other food.

The loss in consumer welfare also varies across countries in the continent. Relative to GDP, significant consumer welfare losses are observed in Sudan, Kenya and Ethiopia. However, in terms of the value of the welfare losses accumulated over the first five years, the impacts in Ethiopia, Kenya, Egypt and South Africa are higher compared to the rest.

The economic effects and the welfare losses are higher if the war is protracted and gets resolved longer in five years.

All of these effects have short, medium and long-term implications. In the long-term, the drop in food consumption may have human health effects through lower calorie intake. In the short to medium-term, as noted in Hatab (2022), disruptions to food supply chains and spikes in domestic food prices are likely to severely deteriorate the social and economic well-being of the vulnerable population groups and that may lead to 'food riots'. These have often been associated with an increased probability of social and political unrest (e.g., Bellemare, 2015; Hatab and Hess, 2021). Thus, the impact of the RUW on food supply and food price inflation could inflame conflict, destabilize governments, and cause violence to spill over borders.

To minimize the negative effect, a well-targeted support to poor households in the regions is critical. Globally, international cooperation among key multinational institutions is required to facilitate and to reduce the artificial supply scarcity in global trade. To lessen the adverse effects on the global supply chain, Jagtap et al. (2022) suggests "to explore and find alternative food supply chain partners and solutions in North America, South America, the Middle East, Australia, and some regions of Asia and Africa that have been less affected by this conflict."

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Appendix

Appendix A: Mapping of Commodities and Countries/Regions

Table A1 . Commodity Mapping: GTAP and Global CGE Model (PEP)

GTAP		Global CGE (PEP Model)	
Code	Description	Code	Description
ric	Rice	pdr	Paddy rice
pcr	Processed rice		
wht	Wheat	wht	Wheat
ocl	All other cereals	gro	Cereal grains nec
v_f	Vegetables fruit nuts	v_f	Vegetables fruit nuts
osd	Oil seeds	osd	Oil seeds
vol	Vegetable oils and fats		
c_b	Sugar cane sugar beet	sug	Sugar
sgr	Sugar		
pfb	Plant-based fibers	oag	Other Agriculture
ocr	Crops nec		
wol	Wool silk worm cocoons		
frs	Forestry		
fsh	Fishing		
cmt	Bovine meat products	mmt	Meat and products
omt	Meat products nec		
ctl	Bovine cattle sheep and goats		
oap	Animal products nec		
ofd	Food products nec	ofd	All other food products
b_t	Beverages and tobacco products		
mil	Dairy products		
rmk	Raw milk		
oil	Oil	p_c	Oil and gas
gas	Gas		
p_c	Petroleum coal products		
chm	Chemical products	chm	Chemicals
mvh	Motor vehicles and parts	trq	Transport equipment
otn	Transport equipment nec		
rpp	Rubber and plastic products	omf	Other manufactures nec
omf	Manufactures nec		
lum	Wood products		
ppp	Paper products publishing		
tex	Textiles		
wap	Wearing apparel		
lea	Leather products		
ome	Machinery and equipment nec		
bph	Basic pharmaceutical products		
ele	Computer electronic and optic		
eeq	Electrical equipment		
i_s	Ferrous metals		
nfm	Metals nec		
fmp	Metal products		
oxt	Other Extraction formerly omn	indy	Other industry
nmm	Mineral products nec		
coa	Coal		
ely	Electricity		
gdt	Gas manufacture distribution		

wtr	Water		
cns	Construction		
otp	Transport nec	trp	Transport
wtp	Water transport		
atp	Air transport		
afs	Accommodation Food and services	osr	Other services
ros	Recreational and other service		
ofi	Financial services nec		
ins	Insurance, formerly isr		
cmn	Communication		
obs	Business services nec		
whs	Warehousing and support activities		
dwe	Dwellings		
rsa	Real estate activities		
edu	Education		
hht	Human health and social work a		
trd	Trade		
osg	Public Administration and defence	osg	Public Admin.

Table A2. Country/Regional Mapping: GTAP and Global CGE Model (PEP)

GTAP		Global CGE (PEP Model)		GTAP		Global CGE (PEP Model)	
Code	Description	Code	Description	Code	Description	Code	Description
egy	Egypt	egy	Egypt	usa	United States	usa	United States
mar	Morocco	mar	Morocco	can	Canada	can	Canada
zaf	South Africa	zaf	South Africa	rus	Russian Federation	rus	Russia
sen	Senegal	sen	Senegal	ukr	Ukraine	ukr	Ukraine
sdn	Sudan	sdn	Sudan	blr	Belarus	blr	Belarus
ken	Kenya	ken	Kenya	ven	Venezuela	opec	OPEC
eth	Ethiopia	eth	Ethiopia	irq	Iraq		
moz	Mozambique	moz	Mozambique	irn	Iran Islamic Rep.		
nga	Nigeria	nga	Nigeria	kwt	Kuwait		
tun	Tunisia	afr	Rest of Africa	sau	Saudi Arabia		
xnf	Rest of North Africa			are	United Arab Emirates		
xcf	Central Africa			mex	Mexico	ltn	Latin America
xac	South Central Africa			arg	Argentina		
bwa	Botswana			bol	Bolivia		
nam	Namibia			bra	Brazil		
xsc	Rest of South Africa			chl	Chile		
ben	Benin			col	Colombia		
bfa	Burkina Faso			ecu	Ecuador		
cmr	Cameroon			pry	Paraguay		
civ	Cote d'Ivoire			per	Peru		

gha	Ghana			ury	Uruguay		
gin	Guinea			xsm	Rest of South Amer.		
tgo	Togo			cri	Costa Rica		
xec	Rest of Eastern Africa			gtm	Guatemala		
mdg	Madagascar			hnd	Honduras		
mwi	Malawi			nic	Nicaragua		
mus	Mauritius			pan	Panama		
rwa	Rwanda			slv	El Salvador		
tza	Tanzania			xca	Rest of Central		
uga	Uganda			dom	Dominican Rep.		
zmb	Zambia			jam	Jamaica		
zwe	Zimbabwe			pri	Puerto Rico		
xwf	Rest of Western Africa			tto	Trinidad and Tobago		
brn	Brunei Darussalam	easia	East Asia	xcb	Caribbean		
khm	Cambodia			ind	India	row	Rest of the world
lao	Lao People's De			srb	Serbia		
phl	Philippines			lbn	Lebanon		
idn	Indonesia			pse	Palestine		
mys	Malaysia			syr	Syria		
sgp	Singapore			hkg	Hong Kong		
tha	Thailand			gbr	United Kingdom		
vnm	Viet Nam			xoc	Rest of Oceania		
nzl	New Zealand			mng	Mongolia		
aus	Australia			twn	Taiwan		
chn	China			xea	Rest of East Asia		
jpn	Japan			xse	Rest of Southeast Asia		
kor	Korea			bgd	Bangladesh		
aut	Austria	eu	EU	npl	Nepal		
bel	Belgium			pak	Pakistan		
cyp	Cyprus			lka	Sri Lanka		
cze	Czech Republic			xsa	Rest of South Amer.		
dnk	Denmark			xna	Rest of North Amer.		
est	Estonia			che	Switzerland		
fin	Finland			nor	Norway		
fra	France			xef	Rest of EFTA		
deu	Germany			alb	Albania		
grc	Greece			xee	Rest of Eastern		
hun	Hungary			xer	Rest of Europe		
irl	Ireland			kaz	Kazakhstan		
ita	Italy			kgz	Kyrgyzstan		
lva	Latvia			tjk	Tajikistan		

ltu	Lithuania			xsu	Rest of Former USSR
lux	Luxembourg			arm	Armenia
mlt	Malta			aze	Azerbaijan
nld	Netherlands			bhr	Bahrain
pol	Poland			isr	Israel
prt	Portugal			jor	Jordan
svk	Slovakia			omn	Oman
svn	Slovenia			qat	Qatar
esp	Spain			xws	Rest of Western
swe	Sweden			xtw	Rest of the World
hrv	Croatia				
bgr	Bulgaria	bsea	Black Sea region		
geo	Georgia				
tur	Turkey				
rou	Romania				

Appendix B: Trade-Weighted Non-Tariff Measures

Table B1: Trade-Weighted Non-Tariff Measures

	egy	sdn	mar	sen	ken	eth	moz	zaf	nga	afr	easia	opec	bsea	usa	can	rus	ukr	blr	eu	ltn	row
Rice	0.891		0.775	0.644					0.694	0.151	0.433	0.110		0.661	0.580	0.593			0.496	0.279	0.145
Wheat	0.001		0.000	0.028					0.002	0.047	0.078	0.000		0.000	0.048	0.000			0.019	0.006	0.003
All other cereals	0.449		0.444	0.338	0.088				0.621	0.084	0.232	0.061		0.217	0.034	0.280			0.205	0.151	0.026
Vegetables fruit nuts	0.436		0.371	0.388	0.005			0.307	0.463	0.088	0.261	0.094	0.078	0.366	0.383	0.383		0.017	0.257	0.171	0.051
Oil seeds	0.406		0.297	0.358	0.008			0.068	0.368	0.060	0.228	0.064	0.026	0.161	0.124	0.239	0.024	0.071	0.229	0.159	0.067
Sugar	0.354		0.191	0.459				0.239	0.504	0.095	0.351	0.071	0.084		0.000	0.184	0.129	0.123	0.286	0.211	0.056
Other Agriculture	0.247		0.095	0.333	0.035			0.167	0.333	0.052	0.129	0.042	0.017	0.126	0.150	0.111	0.004	0.054	0.133	0.118	0.035
Meat and products	0.438		0.347	0.452	0.148	0.286	0.286	0.093	0.498	0.250	0.229	0.270	0.225	0.319	0.232	0.198		0.374	0.306	0.276	0.202
All other food products	0.475	0.001	0.576	0.593	0.005			0.030	0.492	0.097	0.273	0.075	0.092	0.359	0.307	0.525	0.067	0.437	0.353	0.241	0.091
Oil and gas	0.823			0.470				0.422	0.620	0.071	0.226	0.069	0.087	0.320	0.326	0.466	0.344		0.053	0.156	0.093
Chemicals	0.387	0.026	0.214	0.492	0.002	0.005	0.005	0.023	0.498	0.054	0.092	0.062	0.041	0.029	0.009	0.055	0.022	0.029	0.013	0.089	0.026
Transport equipment	0.314		0.052	0.450	0.072				0.386	0.046	0.084	0.021	0.034	0.123	0.113	0.188	0.135	0.087	0.017	0.049	0.036
Other manufactures nec	0.404	0.004	0.093	0.483	0.001	0.001	0.001	0.017	0.458	0.048	0.099	0.017	0.024	0.066	0.021	0.128	0.073	0.089	0.045	0.055	0.037
Other industry	0.156		0.007	0.233				0.003	0.201	0.019	0.039	0.001	0.001	0.000		0.013	0.007	0.001	0.004	0.011	0.006

Source of basic data: Kee, Nicita and Olarreaga (2009)

egy	Egypt	zaf	South Africa	can	Canada
sdn	Sudan	nga	Nigeria	rus	Ukraine
mar	Morocco	afr	Rest of Africa	ukr	Russia
sen	Senegal	easia	East Asia	blr	Belarus
ken	Kenya	opec	OPEC	eu	EU
eth	Ethiopia	bsea	Black Sea region	ltn	Latin America
moz	Mozambique	usa	United States	row	Rest of the world

Appendix C: Detailed Simulation Results (Sim 1)

Table C1. Real Macro Effects, % change relative to baseline

	Year									
	1	2	3	4	5	6	7	8	9	10
Real GDP Change										
Egypt	-0.36	-0.37	-0.19	-0.09	-0.08	-0.08	-0.08	-0.08	-0.07	-0.07
Sudan	-3.80	-3.83	-3.77	-1.90	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14
Morocco	-0.53	-0.50	-0.20	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02
Senegal	-0.50	-0.64	-0.62	-0.59	-0.57	-0.55	-0.54	-0.52	-0.51	-0.50
Kenya	-3.40	-3.42	-3.35	-1.47	-0.15	-0.14	-0.14	-0.13	-0.12	-0.12
Ethiopia	-3.04	-3.07	-3.10	-1.59	-0.18	-0.16	-0.15	-0.13	-0.12	-0.11
Mozambique	-0.05	-0.10	-0.13	-0.12	-0.10	-0.09	-0.07	-0.07	-0.06	-0.05
South Africa	-0.53	-0.50	-0.18	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Nigeria	-1.71	-1.71	-0.83	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02
Rest of Africa	-0.21	-0.25	-0.17	-0.11	-0.09	-0.08	-0.07	-0.07	-0.06	-0.06
Real Investment Change										
Egypt	-2.03	-1.95	-0.86	0.07	0.02	-0.01	-0.04	-0.05	-0.06	-0.07
Sudan	-4.96	-5.03	-5.11	-2.83	-0.44	-0.38	-0.35	-0.32	-0.31	-0.30
Morocco	-1.19	-1.09	-0.38	0.14	0.09	0.05	0.02	0.01	-0.01	-0.01
Senegal	-4.54	-5.00	-2.93	-0.86	-0.80	-0.80	-0.81	-0.85	-0.90	-0.96
Kenya	-2.94	-2.99	-2.59	-0.94	-0.03	-0.04	-0.04	-0.04	-0.05	-0.05
Ethiopia	-0.71	-0.84	-0.77	-0.49	-0.30	-0.24	-0.20	-0.17	-0.15	-0.13
Mozambique	-0.69	-0.66	-0.27	0.01	0.01	0.00	0.00	-0.01	-0.01	-0.02
South Africa	-1.02	-0.94	-0.34	-0.01	-0.02	-0.02	-0.03	-0.03	-0.03	-0.04
Nigeria	-0.31	-0.61	-0.67	-0.66	-0.47	-0.35	-0.26	-0.21	-0.17	-0.14
Rest of Africa	0.32	0.06	-0.30	-0.47	-0.34	-0.26	-0.20	-0.16	-0.14	-0.12

Source: Author's calculations

Table C2. Inflation, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt										
All commodities	2.64	2.42	0.89	-0.41	-0.29	-0.21	-0.15	-0.11	-0.08	-0.07
Agri-food	4.76	4.30	1.61	-0.72	-0.54	-0.39	-0.29	-0.23	-0.19	-0.17
Sudan										
All commodities	6.54	5.91	2.93	-0.61	-1.07	-0.74	-0.52	-0.38	-0.28	-0.22
Agri-food	11.39	10.65	7.56	1.41	-1.32	-0.95	-0.70	-0.53	-0.42	-0.34
Morocco										
All commodities	2.61	2.28	0.68	-0.45	-0.34	-0.26	-0.20	-0.15	-0.12	-0.10
Agri-food	3.41	2.93	0.87	-0.69	-0.52	-0.39	-0.30	-0.24	-0.20	-0.17
Senegal										
All commodities	2.66	2.75	1.32	-0.05	-0.08	-0.08	-0.07	-0.05	-0.04	-0.02
Agri-food	3.35	3.33	1.54	-0.21	-0.14	-0.10	-0.09	-0.07	-0.06	-0.05
Kenya										
All commodities	3.67	3.44	2.46	0.40	-0.43	-0.32	-0.25	-0.19	-0.15	-0.12
Agri-food	7.56	7.06	6.16	1.53	-1.06	-0.79	-0.59	-0.45	-0.35	-0.28
Ethiopia										
All commodities	2.32	2.04	1.35	0.19	-0.31	-0.21	-0.15	-0.11	-0.08	-0.06
Agri-food	6.61	5.71	5.08	1.49	-1.11	-0.71	-0.48	-0.33	-0.24	-0.19
Mozambique										
All commodities	1.68	1.48	0.44	-0.38	-0.28	-0.21	-0.16	-0.13	-0.11	-0.09
Agri-food	1.18	1.18	0.49	-0.27	-0.17	-0.12	-0.09	-0.08	-0.07	-0.07
South Africa										
All commodities	1.86	1.60	0.44	-0.40	-0.31	-0.23	-0.18	-0.14	-0.11	-0.09
Agri-food	1.36	1.18	0.37	-0.34	-0.24	-0.17	-0.13	-0.10	-0.08	-0.06
Nigeria										
All commodities	1.15	0.44	-0.68	-1.46	-1.04	-0.75	-0.55	-0.41	-0.32	-0.26
Agri-food	0.71	0.01	-0.87	-1.51	-1.06	-0.76	-0.55	-0.42	-0.33	-0.26
Rest of Africa										
All commodities	3.43	3.08	1.00	-0.73	-0.54	-0.40	-0.31	-0.24	-0.20	-0.16
Agri-food	4.18	3.71	1.18	-0.97	-0.72	-0.52	-0.39	-0.31	-0.26	-0.22

Source: Author's calculations

Table C3. Real Factor Prices, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt										
Skilled wages	-3.86	-3.33	-0.96	0.67	0.49	0.35	0.25	0.18	0.13	0.09
Unskilled wages	-3.52	-2.94	-0.73	0.74	0.55	0.40	0.29	0.21	0.15	0.10
Returns to capital	-2.32	-2.04	-0.60	0.33	0.27	0.21	0.17	0.14	0.12	0.10
Land rent	6.24	5.28	1.52	-1.68	-1.20	-0.81	-0.57	-0.41	-0.32	-0.25
Sudan										
Skilled wages	-5.94	-5.71	-4.90	-2.01	0.20	0.15	0.11	0.07	0.04	0.01
Unskilled wages	-5.11	-4.93	-4.22	-1.79	0.09	0.05	0.02	-0.01	-0.04	-0.06
Returns to capital	-3.89	-3.89	-3.69	-1.82	-0.06	0.00	0.04	0.07	0.09	0.10
Land rent	2.76	2.14	0.68	-0.91	-1.02	-0.80	-0.64	-0.52	-0.44	-0.38
Morocco										
Skilled wages	-2.92	-2.65	-0.88	0.44	0.32	0.23	0.16	0.12	0.08	0.06
Unskilled wages	-2.47	-2.24	-0.73	0.40	0.29	0.20	0.14	0.10	0.07	0.05
Returns to capital	-1.07	-1.10	-0.47	0.09	0.05	0.02	0.00	-0.01	-0.01	-0.01
Land rent	4.40	4.11	1.60	-0.71	-0.45	-0.26	-0.16	-0.10	-0.07	-0.05
Senegal										
Skilled wages	-4.17	-3.28	-0.69	0.94	0.53	0.28	0.12	0.02	-0.04	-0.08
Unskilled wages	-2.93	-2.35	-0.58	0.53	0.23	0.05	-0.05	-0.12	-0.16	-0.18
Returns to capital	-3.12	-2.64	-0.56	0.92	0.77	0.66	0.58	0.52	0.49	0.46
Land rent	2.53	1.73	0.10	-1.18	-0.70	-0.48	-0.40	-0.37	-0.36	-0.36
Kenya										
Skilled wages	-5.88	-5.40	-4.19	-0.89	0.69	0.48	0.33	0.23	0.15	0.10
Unskilled wages	-4.22	-3.95	-3.13	-0.83	0.26	0.15	0.08	0.03	0.00	-0.02
Returns to capital	-3.64	-3.52	-2.64	-0.70	0.18	0.17	0.15	0.14	0.12	0.11
Land rent	4.11	2.85	-0.16	-2.48	-1.70	-1.05	-0.68	-0.48	-0.36	-0.29
Ethiopia										
Skilled wages	-5.18	-4.57	-3.17	-0.56	0.64	0.39	0.23	0.14	0.08	0.05
Unskilled wages	-3.86	-3.44	-2.27	-0.39	0.36	0.19	0.08	0.02	-0.01	-0.03
Returns to capital	-2.61	-3.07	-2.67	-1.23	-0.21	-0.03	0.06	0.11	0.13	0.13
Land rent	2.46	2.02	1.79	-0.04	-1.12	-0.73	-0.51	-0.39	-0.31	-0.26
Mozambique										
Skilled wages	-2.46	-2.03	-0.50	0.48	0.36	0.27	0.20	0.15	0.11	0.08
Unskilled wages	-2.25	-1.89	-0.49	0.40	0.29	0.22	0.16	0.11	0.08	0.06
Returns to capital	-1.64	-1.40	-0.23	0.43	0.38	0.32	0.26	0.21	0.18	0.15
Land rent	6.03	5.10	1.37	-1.90	-1.21	-0.77	-0.51	-0.35	-0.25	-0.20
South Africa										
Skilled wages	-3.01	-2.68	-0.82	0.47	0.35	0.27	0.20	0.16	0.12	0.10
Unskilled wages	-2.79	-2.49	-0.77	0.44	0.32	0.24	0.18	0.14	0.10	0.08
Returns to capital	-2.12	-1.93	-0.62	0.29	0.21	0.15	0.11	0.08	0.05	0.04
Land rent	-2.93	-2.55	-0.70	0.25	0.24	0.22	0.19	0.16	0.13	0.10
Nigeria										
Skilled wages	-0.99	-0.93	-0.38	0.01	0.01	0.00	0.00	0.00	0.00	-0.01
Unskilled wages	-0.99	-0.94	-0.39	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Returns to capital	-0.25	-0.43	-0.42	-0.34	-0.22	-0.13	-0.08	-0.04	-0.01	0.00
Land rent	0.00	-0.32	-0.57	-0.71	-0.54	-0.43	-0.34	-0.29	-0.25	-0.22
Rest of Africa										
Skilled wages	-1.79	-1.51	-0.39	0.34	0.23	0.15	0.10	0.06	0.04	0.02

Unskilled wages	-1.48	-1.25	-0.32	0.26	0.16	0.10	0.06	0.03	0.01	0.00
Returns to capital	-0.25	-0.34	-0.21	-0.15	-0.06	-0.01	0.02	0.03	0.04	0.04
Land rent	8.73	7.00	1.48	-2.75	-1.85	-1.26	-0.87	-0.63	-0.47	-0.37

Source: Author's calculations

Table C4. Real Income, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt	-2.69	-2.34	-0.72	0.32	0.23	0.16	0.10	0.06	0.03	0.01
Sudan	-4.04	-4.03	-3.76	-1.90	-0.21	-0.18	-0.16	-0.15	-0.14	-0.14
Morocco	-2.02	-1.87	-0.67	0.25	0.17	0.11	0.07	0.04	0.02	0.00
Senegal	-3.35	-2.89	-0.99	0.31	0.12	-0.01	-0.10	-0.15	-0.18	-0.20
Kenya	-4.09	-3.94	-3.15	-1.01	0.04	0.01	-0.01	-0.03	-0.05	-0.06
Ethiopia	-3.29	-3.29	-2.51	-0.96	-0.17	-0.12	-0.10	-0.09	-0.08	-0.08
Mozambique	-1.60	-1.36	-0.38	0.13	0.12	0.10	0.08	0.06	0.04	0.02
South Africa	-2.80	-2.50	-0.78	0.40	0.29	0.21	0.15	0.11	0.08	0.06
Nigeria	-0.69	-0.75	-0.44	-0.19	-0.14	-0.10	-0.08	-0.06	-0.05	-0.05
Rest of Africa	-0.03	-0.12	-0.20	-0.37	-0.26	-0.19	-0.14	-0.11	-0.10	-0.08

Source: Author's calculations

Table C5. Real Consumption, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt										
Total consumption	-2.59	-2.24	-0.68	0.32	0.23	0.16	0.10	0.06	0.03	0.01
Agri-food consumption	-3.94	-3.42	-1.14	0.51	0.38	0.27	0.19	0.14	0.10	0.08
Rice	-1.30	-1.22	-0.53	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
Wheat	-6.69	-5.80	-1.75	1.43	1.07	0.81	0.63	0.49	0.40	0.32
All other cereals	-6.63	-4.94	-0.76	2.16	1.45	0.97	0.66	0.46	0.32	0.23
Vegetables fruit nuts	-1.77	-1.51	-0.44	0.39	0.28	0.19	0.13	0.08	0.05	0.02
Oil seeds	-3.95	-3.73	-1.63	0.26	0.23	0.19	0.16	0.14	0.11	0.09
Sugar	-1.83	-1.66	-0.63	0.13	0.11	0.08	0.06	0.04	0.03	0.02
Other Agriculture	-1.89	-1.54	-0.50	0.40	0.31	0.18	0.11	0.07	0.04	0.03
Meat and products	-2.83	-2.50	-0.92	0.27	0.20	0.15	0.11	0.08	0.05	0.04
All other food products	-2.47	-2.33	-1.02	0.06	0.04	0.03	0.01	0.00	0.00	-0.01
Sudan										
Total consumption	-3.75	-3.73	-3.48	-1.76	-0.20	-0.17	-0.15	-0.14	-0.13	-0.13
Agri-food consumption	-7.09	-7.02	-6.78	-3.23	-0.04	-0.03	-0.03	-0.04	-0.04	-0.05
Rice	-6.64	-6.43	-6.40	-2.93	0.66	0.57	0.49	0.42	0.35	0.29
Wheat	-5.14	-4.78	-2.90	-0.58	0.14	0.05	0.00	-0.03	-0.04	-0.05
All other cereals	-5.36	-5.15	-4.78	-2.08	0.34	0.27	0.20	0.15	0.11	0.08
Vegetables fruit nuts	-5.58	-5.45	-5.01	-2.23	0.28	0.23	0.19	0.14	0.11	0.08
Oil seeds	-5.65	-5.62	-5.18	-2.41	0.06	0.07	0.07	0.06	0.05	0.04
Sugar	-4.25	-4.30	-4.29	-2.35	-0.23	-0.17	-0.13	-0.11	-0.10	-0.09
Other Agriculture	-5.62	-5.38	-5.47	-2.64	0.42	0.34	0.27	0.22	0.17	0.13
Meat and products	-7.11	-7.21	-7.42	-3.97	-0.32	-0.27	-0.24	-0.21	-0.19	-0.18
All other food products	-7.32	-7.39	-7.45	-3.89	-0.22	-0.19	-0.16	-0.14	-0.13	-0.13
Morocco										
Total consumption	-2.33	-2.16	-0.77	0.30	0.20	0.13	0.08	0.05	0.03	0.01
Agri-food consumption	-2.51	-2.27	-0.80	0.39	0.27	0.18	0.12	0.09	0.06	0.04
Rice	-0.88	-0.95	-0.54	-0.03	-0.02	-0.01	-0.01	0.00	0.00	0.00
Wheat	-5.54	-4.76	-1.37	1.33	0.94	0.67	0.49	0.37	0.28	0.23
All other cereals	-4.48	-3.67	-0.94	1.20	0.80	0.53	0.35	0.25	0.18	0.13
Vegetables fruit nuts	-1.90	-1.67	-0.48	0.49	0.38	0.29	0.22	0.17	0.13	0.10
Oil seeds	-2.95	-2.77	-1.13	0.36	0.30	0.24	0.20	0.17	0.15	0.13
Sugar	-1.67	-1.56	-0.60	0.21	0.14	0.10	0.07	0.04	0.03	0.02
Other Agriculture	-2.31	-1.91	-0.47	0.69	0.43	0.26	0.16	0.10	0.07	0.04
Meat and products	-1.32	-1.33	-0.64	0.01	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03
All other food products	-2.64	-2.47	-0.97	0.31	0.22	0.15	0.10	0.07	0.05	0.03
Senegal										
Total consumption	-1.66	-1.45	-0.52	0.12	0.03	-0.04	-0.08	-0.10	-0.12	-0.13
Agri-food consumption	-2.08	-1.81	-0.66	0.21	0.07	-0.01	-0.05	-0.08	-0.09	-0.10
Rice	-2.39	-2.15	-0.88	0.21	0.11	0.05	0.02	0.00	-0.01	-0.02
Wheat	-5.96	-4.99	-1.48	1.24	0.81	0.53	0.34	0.22	0.15	0.10
All other cereals	-1.85	-1.47	-0.37	0.37	0.17	0.07	0.01	-0.01	-0.03	-0.03
Vegetables fruit nuts	-1.89	-1.43	-0.31	0.47	0.24	0.11	0.04	0.01	-0.01	-0.02
Oil seeds	-1.66	-1.44	-0.51	0.22	0.14	0.08	0.04	0.01	-0.01	-0.03

Sugar	-1.87	-1.62	-0.55	0.19	0.12	0.07	0.02	-0.01	-0.03	-0.04
Other Agriculture	-1.23	-0.63	0.11	0.39	0.05	-0.05	-0.07	-0.06	-0.05	-0.04
Meat and products	-0.43	-0.58	-0.46	-0.28	-0.25	-0.22	-0.21	-0.20	-0.19	-0.18
All other food products	-2.85	-2.53	-0.97	0.32	0.12	0.00	-0.07	-0.12	-0.14	-0.16
Kenya										
Total consumption	-4.17	-4.01	-3.20	-1.02	0.05	0.02	-0.01	-0.03	-0.05	-0.06
Agri-food consumption	-6.75	-6.41	-5.69	-1.78	0.48	0.35	0.24	0.16	0.10	0.06
Rice	-1.57	-1.58	-1.33	-0.62	-0.28	-0.25	-0.22	-0.20	-0.18	-0.16
Wheat	-7.16	-6.11	-2.52	0.74	0.58	0.32	0.17	0.08	0.04	0.01
All other cereals	-4.70	-4.31	-3.63	-1.02	0.41	0.22	0.11	0.05	0.01	0.00
Vegetables fruit nuts	-4.61	-4.27	-3.66	-1.07	0.41	0.23	0.12	0.05	0.01	-0.01
Oil seeds	-3.74	-3.65	-3.15	-1.15	0.04	0.03	0.01	0.00	-0.01	-0.02
Sugar	-3.72	-3.66	-3.20	-1.25	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03
Other Agriculture	-4.98	-4.48	-3.44	-0.96	0.14	0.02	-0.03	-0.05	-0.05	-0.05
Meat and products	-6.68	-6.40	-5.89	-1.97	0.57	0.40	0.27	0.18	0.11	0.06
All other food products	-7.35	-7.04	-6.41	-2.13	0.64	0.47	0.33	0.22	0.14	0.09
Ethiopia										
Total consumption	-4.06	-4.04	-3.14	-1.21	-0.15	-0.11	-0.10	-0.09	-0.09	-0.08
Agri-food consumption	-7.11	-6.54	-5.71	-2.06	0.49	0.29	0.17	0.09	0.05	0.02
Rice	-4.42	-4.39	-3.78	-1.67	-0.08	0.01	0.04	0.04	0.03	0.03
Wheat	-6.28	-5.72	-4.44	-1.34	0.48	0.28	0.17	0.10	0.06	0.04
All other cereals	-5.57	-5.32	-4.78	-1.87	0.41	0.25	0.15	0.10	0.06	0.04
Vegetables fruit nuts	-5.23	-5.11	-4.79	-2.08	0.18	0.11	0.06	0.04	0.02	0.01
Oil seeds	-4.19	-4.17	-3.36	-1.32	-0.13	-0.09	-0.07	-0.06	-0.05	-0.05
Sugar	-4.69	-4.68	-4.38	-1.93	0.13	0.12	0.09	0.07	0.05	0.03
Other Agriculture	-8.59	-6.68	-4.90	-0.57	1.82	1.00	0.54	0.29	0.16	0.08
Meat and products	-7.20	-7.24	-6.95	-3.21	0.04	0.03	0.01	0.00	-0.01	-0.02
All other food products	-5.83	-6.00	-5.62	-2.65	-0.22	-0.14	-0.10	-0.08	-0.07	-0.07
Mozambique										
Total consumption	-1.70	-1.45	-0.40	0.14	0.13	0.11	0.08	0.06	0.04	0.02
Agri-food consumption	-1.32	-1.21	-0.44	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Rice	-0.50	-0.47	-0.18	-0.07	-0.03	-0.01	0.00	0.00	0.00	0.00
Wheat	-6.64	-5.70	-1.85	1.18	0.78	0.52	0.35	0.24	0.18	0.13
All other cereals	-0.79	-0.69	-0.22	0.08	0.06	0.04	0.02	0.01	0.01	0.00
Vegetables fruit nuts	-0.38	-0.40	-0.21	-0.08	-0.04	-0.03	-0.02	-0.01	-0.01	-0.01
Oil seeds	-1.06	-0.94	-0.30	0.12	0.13	0.12	0.11	0.09	0.07	0.06
Sugar	-1.47	-1.28	-0.38	0.21	0.22	0.20	0.18	0.15	0.13	0.11
Other Agriculture	-0.49	-0.43	-0.12	0.06	-0.03	-0.05	-0.04	-0.03	-0.02	-0.01
Meat and products	-0.62	-0.68	-0.38	-0.15	-0.10	-0.06	-0.04	-0.03	-0.03	-0.02
All other food products	-2.19	-2.01	-0.71	0.18	0.14	0.11	0.07	0.05	0.03	0.02
South Africa										
Total consumption	-2.62	-2.34	-0.73	0.37	0.27	0.20	0.15	0.11	0.08	0.06
Agri-food consumption	-2.10	-1.90	-0.64	0.30	0.20	0.14	0.09	0.06	0.04	0.03
Rice	-0.95	-0.91	-0.34	0.08	0.06	0.05	0.04	0.04	0.03	0.03
Wheat	-6.55	-5.78	-1.84	1.38	1.01	0.75	0.58	0.46	0.38	0.32
All other cereals	-2.44	-2.09	-0.58	0.54	0.34	0.21	0.13	0.09	0.06	0.05
Vegetables fruit nuts	-2.10	-1.88	-0.62	0.36	0.29	0.22	0.16	0.12	0.10	0.08

Oil seeds	-2.33	-2.16	-0.81	0.27	0.22	0.17	0.14	0.11	0.09	0.07
Sugar	-1.48	-1.36	-0.49	0.18	0.14	0.10	0.08	0.06	0.04	0.03
Other Agriculture	-2.13	-1.72	-0.41	0.62	0.33	0.16	0.08	0.04	0.02	0.01
Meat and products	-1.55	-1.44	-0.54	0.15	0.09	0.06	0.03	0.01	0.00	-0.01
All other food products	-1.76	-1.61	-0.56	0.21	0.15	0.10	0.06	0.04	0.03	0.01
Nigeria										
Total consumption	-0.68	-0.74	-0.43	-0.19	-0.14	-0.10	-0.08	-0.06	-0.05	-0.05
Agri-food consumption	-0.32	-0.37	-0.26	-0.15	-0.11	-0.08	-0.07	-0.05	-0.04	-0.04
Rice	-0.66	-0.72	-0.43	-0.13	-0.07	-0.04	-0.02	0.00	0.01	0.01
Wheat	-4.92	-4.58	-1.84	0.42	0.21	0.09	0.02	-0.01	-0.02	-0.02
All other cereals	-0.21	-0.24	-0.16	-0.09	-0.07	-0.06	-0.05	-0.04	-0.04	-0.03
Vegetables fruit nuts	-0.16	-0.20	-0.15	-0.11	-0.08	-0.07	-0.05	-0.04	-0.04	-0.03
Oil seeds	-0.74	-0.80	-0.45	-0.10	-0.04	-0.01	0.01	0.02	0.03	0.03
Sugar	-0.82	-0.85	-0.47	-0.15	-0.10	-0.06	-0.04	-0.03	-0.02	-0.01
Other Agriculture	-0.26	-0.27	-0.15	-0.06	-0.06	-0.05	-0.04	-0.04	-0.03	-0.03
Meat and products	-0.05	-0.14	-0.19	-0.20	-0.15	-0.12	-0.09	-0.08	-0.07	-0.06
All other food products	-0.98	-1.09	-0.67	-0.23	-0.15	-0.10	-0.07	-0.05	-0.03	-0.02
Rest of Africa										
Total consumption	-0.07	-0.16	-0.22	-0.40	-0.28	-0.20	-0.15	-0.12	-0.10	-0.09
Agri-food consumption	-0.72	-0.68	-0.35	-0.17	-0.12	-0.09	-0.07	-0.06	-0.05	-0.04
Rice	0.21	0.06	-0.19	-0.41	-0.28	-0.19	-0.14	-0.10	-0.07	-0.06
Wheat	-5.14	-4.41	-1.35	0.92	0.63	0.43	0.30	0.21	0.15	0.11
All other cereals	-1.44	-1.14	-0.27	0.25	0.13	0.06	0.02	0.00	-0.01	-0.02
Vegetables fruit nuts	-0.12	-0.18	-0.20	-0.20	-0.11	-0.07	-0.05	-0.04	-0.03	-0.03
Oil seeds	-0.15	-0.23	-0.25	-0.28	-0.17	-0.11	-0.08	-0.05	-0.04	-0.03
Sugar	-0.30	-0.37	-0.31	-0.31	-0.19	-0.11	-0.07	-0.05	-0.03	-0.03
Other Agriculture	-0.56	-0.24	0.13	0.21	0.04	-0.04	-0.05	-0.05	-0.04	-0.03
Meat and products	-0.33	-0.45	-0.42	-0.37	-0.24	-0.17	-0.12	-0.09	-0.07	-0.06
All other food products	-0.70	-0.76	-0.49	-0.32	-0.22	-0.16	-0.11	-0.09	-0.07	-0.06

Source: Author's calculations

Table C6. Welfare Effects, % of GDP

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt	-1.32	-1.20	-0.46	0.05	0.02	0.01	-0.01	-0.02	-0.03	-0.03
Sudan	-3.28	-3.33	-3.41	-1.83	-0.15	-0.13	-0.12	-0.11	-0.10	-0.10
Morocco	-1.60	-1.47	-0.53	0.24	0.16	0.11	0.08	0.05	0.03	0.02
Senegal	-1.82	-1.56	-0.54	0.20	0.08	0.01	-0.04	-0.07	-0.09	-0.10
Kenya	-4.00	-3.82	-3.12	-0.99	0.13	0.07	0.03	0.00	-0.02	-0.04
Ethiopia	-3.74	-3.63	-3.07	-1.21	0.07	0.03	0.01	0.00	-0.01	-0.02
Mozambique	-0.94	-0.82	-0.25	0.09	0.08	0.06	0.05	0.04	0.03	0.02
South Africa	-1.22	-1.10	-0.36	0.17	0.12	0.08	0.06	0.04	0.03	0.02
Nigeria	-0.44	-0.49	-0.30	-0.14	-0.10	-0.07	-0.05	-0.04	-0.03	-0.03
Rest of Africa	-0.19	-0.22	-0.17	-0.20	-0.13	-0.10	-0.07	-0.06	-0.05	-0.04

Source: Author's calculations

Table C7. Accumulated Loss in Welfare, US\$ million

	Year					Accumulated: 5 years
	1	2	3	4	5	
Egypt	-5,352	-5,019	-1,976	201	114	-12,033
Sudan	-1,126	-1,180	-1,218	-661	-58	-4,243
Morocco	-2,285	-2,146	-788	356	253	-4,608
Senegal	-502	-459	-168	66	29	-1,035
Ethiopia	-4,455	-4,469	-3,806	-1,268	173	-13,826
Kenya	-4,130	-4,266	-3,844	-1,615	93	-13,762
Mozambique	-149	-135	-43	15	14	-298
South Africa	-5,128	-4,668	-1,555	724	519	-10,109
Nigeria	-1,926	-2,204	-1,383	-668	-488	-6,668
Rest of Africa	-1,928	-2,295	-1,811	-2,139	-1,517	-9,690

Source: Author's calculations

Appendix D: Detailed Simulation Results (Sim 2)

Table D1. Real Macro Effects, % change relative to baseline

	Year									
	1	2	3	4	5	6	7	8	9	10
Real GDP Effects										
Egypt	-0.36	-0.37	-0.39	-0.23	-0.12	-0.11	-0.11	-0.10	-0.10	-0.10
Sudan	-3.80	-3.82	-3.86	-3.81	-1.94	-0.18	-0.18	-0.18	-0.18	-0.19
Morocco	-0.53	-0.50	-0.49	-0.20	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03
Senegal	-0.50	-0.64	-0.84	-0.84	-0.81	-0.78	-0.76	-0.74	-0.72	-0.71
Kenya	-3.40	-3.42	-3.46	-1.56	-0.18	-0.17	-0.16	-0.16	-0.15	-0.14
Ethiopia	-3.04	-3.07	-3.13	-3.17	-1.65	-0.24	-0.22	-0.20	-0.18	-0.17
Mozambique	-0.05	-0.10	-0.16	-0.18	-0.16	-0.13	-0.11	-0.10	-0.09	-0.08
South Africa	-0.53	-0.50	-0.48	-0.18	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Nigeria	-1.71	-1.71	-1.71	-0.84	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03
Rest of Africa	-0.21	-0.24	-0.29	-0.21	-0.15	-0.13	-0.11	-0.10	-0.09	-0.08
Real Investment Effects										
Egypt	-2.03	-1.82	-1.78	-0.73	0.06	0.01	-0.03	-0.06	-0.08	-0.09
Sudan	-4.96	-5.01	-5.17	-5.26	-2.99	-0.58	-0.50	-0.45	-0.42	-0.40
Morocco	-1.19	-1.10	-1.01	-0.33	0.17	0.10	0.06	0.02	0.00	-0.01
Senegal	-4.54	-4.85	-5.25	-3.20	-1.26	-1.20	-1.20	-1.23	-1.29	-1.38
Kenya	-2.94	-2.90	-2.91	-1.29	-0.14	-0.12	-0.10	-0.09	-0.08	-0.08
Ethiopia	-0.71	-0.82	-0.89	-0.81	-0.56	-0.38	-0.31	-0.27	-0.23	-0.20
Mozambique	-0.69	-0.66	-0.64	-0.26	0.01	0.01	0.00	-0.01	-0.02	-0.02
South Africa	-1.02	-0.95	-0.91	-0.35	-0.02	-0.03	-0.04	-0.04	-0.05	-0.05
Nigeria	-0.31	-0.58	-0.89	-0.89	-0.83	-0.60	-0.44	-0.34	-0.27	-0.22
Rest of Africa	0.32	0.08	-0.13	-0.43	-0.58	-0.43	-0.33	-0.26	-0.21	-0.18

Source: Author's calculations

Table D2. Inflation, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt										
All commodities	2.64	2.37	2.18	0.71	-0.50	-0.35	-0.25	-0.18	-0.14	-0.11
Agri-food	4.76	3.93	3.72	1.19	-0.75	-0.56	-0.42	-0.33	-0.27	-0.23
Sudan										
All commodities	6.54	5.87	5.18	2.37	-0.94	-1.29	-0.89	-0.63	-0.45	-0.34
Agri-food	11.39	10.56	9.79	6.90	1.05	-1.57	-1.13	-0.83	-0.63	-0.50
Morocco										
All commodities	2.61	2.23	2.01	0.51	-0.53	-0.40	-0.31	-0.24	-0.19	-0.15
Agri-food	3.41	2.70	2.46	0.56	-0.72	-0.56	-0.43	-0.35	-0.28	-0.24
Senegal										
All commodities	2.66	2.68	2.64	1.22	-0.06	-0.08	-0.07	-0.06	-0.04	-0.02
Agri-food	3.35	3.13	3.13	1.39	-0.14	-0.10	-0.08	-0.07	-0.06	-0.04
Kenya										
All commodities	3.67	3.33	3.15	1.00	-0.44	-0.34	-0.26	-0.20	-0.16	-0.13
Agri-food	7.56	6.88	6.54	1.98	-0.93	-0.70	-0.54	-0.41	-0.33	-0.26
Ethiopia										
All commodities	2.32	1.88	1.71	1.16	0.21	-0.32	-0.22	-0.16	-0.12	-0.09
Agri-food	6.61	5.41	5.00	4.74	1.54	-1.15	-0.76	-0.53	-0.38	-0.29
Mozambique										
All commodities	1.68	1.45	1.27	0.28	-0.45	-0.33	-0.25	-0.20	-0.16	-0.14
Agri-food	1.18	1.03	0.96	0.32	-0.26	-0.17	-0.12	-0.10	-0.09	-0.09
South Africa										
All commodities	1.86	1.59	1.41	0.31	-0.49	-0.38	-0.29	-0.23	-0.18	-0.14
Agri-food	1.36	1.04	0.95	0.21	-0.33	-0.24	-0.18	-0.13	-0.11	-0.09
Nigeria										
All commodities	1.15	0.49	-0.22	-1.16	-1.82	-1.29	-0.93	-0.68	-0.52	-0.41
Agri-food	0.71	0.04	-0.68	-1.38	-1.87	-1.32	-0.95	-0.69	-0.53	-0.42
Rest of Africa										
All commodities	3.43	3.04	2.69	0.71	-0.90	-0.67	-0.50	-0.38	-0.30	-0.25
Agri-food	4.18	3.53	3.14	0.77	-1.11	-0.82	-0.61	-0.47	-0.38	-0.32

Source: Author's calculations

Table D3. Real Factor Prices, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt										
Skilled wages	-3.86	-3.23	-2.92	-0.72	0.76	0.56	0.40	0.29	0.21	0.15
Unskilled wages	-3.52	-2.87	-2.54	-0.49	0.85	0.63	0.46	0.34	0.24	0.17
Returns to capital	-2.32	-1.98	-1.83	-0.46	0.39	0.32	0.26	0.21	0.18	0.15
Land rent	6.24	4.99	4.26	0.72	-1.99	-1.36	-0.94	-0.67	-0.50	-0.39
Sudan										
Skilled wages	-5.94	-5.70	-5.56	-4.83	-1.99	0.22	0.17	0.11	0.07	0.03
Unskilled wages	-5.11	-4.94	-4.85	-4.20	-1.79	0.08	0.04	0.00	-0.03	-0.06
Returns to capital	-3.89	-3.86	-3.90	-3.70	-1.83	-0.06	0.01	0.06	0.10	0.12
Land rent	2.76	2.15	1.58	0.28	-1.15	-1.22	-0.95	-0.77	-0.63	-0.54
Morocco										
Skilled wages	-2.92	-2.62	-2.43	-0.74	0.52	0.37	0.27	0.19	0.14	0.10
Unskilled wages	-2.47	-2.23	-2.06	-0.61	0.48	0.34	0.24	0.17	0.12	0.08
Returns to capital	-1.07	-1.16	-1.11	-0.46	0.15	0.09	0.04	0.02	0.00	-0.01
Land rent	4.40	3.35	3.42	1.09	-0.51	-0.31	-0.18	-0.10	-0.06	-0.04
Senegal										
Skilled wages	-4.17	-3.34	-2.89	-0.52	1.07	0.61	0.32	0.13	0.01	-0.06
Unskilled wages	-2.93	-2.43	-2.17	-0.53	0.59	0.25	0.04	-0.09	-0.17	-0.22
Returns to capital	-3.12	-2.69	-2.24	-0.23	1.24	1.03	0.89	0.79	0.72	0.68
Land rent	2.53	1.20	1.04	-0.32	-1.08	-0.71	-0.56	-0.51	-0.50	-0.50
Kenya										
Skilled wages	-5.88	-5.39	-5.07	-1.50	0.87	0.61	0.43	0.29	0.20	0.13
Unskilled wages	-4.22	-3.97	-3.81	-1.31	0.42	0.26	0.15	0.07	0.02	-0.01
Returns to capital	-3.64	-3.56	-3.42	-1.21	0.38	0.33	0.28	0.23	0.20	0.17
Land rent	4.11	1.89	1.41	-0.95	-1.98	-1.27	-0.83	-0.59	-0.45	-0.37
Ethiopia										
Skilled wages	-5.18	-4.51	-4.32	-3.08	-0.52	0.70	0.44	0.27	0.17	0.11
Unskilled wages	-3.86	-3.45	-3.35	-2.29	-0.38	0.39	0.21	0.10	0.03	-0.01
Returns to capital	-2.61	-3.15	-3.25	-2.68	-1.09	-0.10	0.06	0.14	0.17	0.19
Land rent	2.46	1.60	1.37	1.42	0.03	-1.16	-0.80	-0.59	-0.47	-0.39
Mozambique										
Skilled wages	-2.46	-2.02	-1.80	-0.37	0.55	0.41	0.31	0.23	0.17	0.13
Unskilled wages	-2.25	-1.89	-1.71	-0.40	0.45	0.34	0.25	0.18	0.13	0.09
Returns to capital	-1.64	-1.45	-1.22	-0.07	0.62	0.51	0.42	0.34	0.28	0.23
Land rent	6.03	4.99	3.97	0.59	-2.16	-1.38	-0.89	-0.59	-0.42	-0.31
South Africa										
Skilled wages	-3.01	-2.68	-2.43	-0.66	0.58	0.43	0.33	0.25	0.19	0.15
Unskilled wages	-2.79	-2.49	-2.26	-0.62	0.53	0.39	0.29	0.22	0.17	0.13
Returns to capital	-2.12	-1.96	-1.79	-0.54	0.37	0.27	0.19	0.13	0.10	0.07
Land rent	-2.93	-2.83	-2.51	-0.74	0.43	0.38	0.32	0.27	0.22	0.17
Nigeria										
Skilled wages	-0.99	-0.93	-0.91	-0.38	0.00	0.00	0.00	0.00	0.00	-0.01
Unskilled wages	-0.99	-0.93	-0.92	-0.40	-0.03	-0.02	-0.01	-0.01	-0.01	-0.01
Returns to capital	-0.25	-0.41	-0.57	-0.51	-0.41	-0.26	-0.15	-0.08	-0.04	-0.01
Land rent	0.00	-0.31	-0.64	-0.82	-0.91	-0.70	-0.55	-0.45	-0.38	-0.33
Rest of Africa										
Skilled wages	-1.79	-1.48	-1.34	-0.30	0.37	0.25	0.17	0.11	0.07	0.04

Unskilled wages	-1.48	-1.25	-1.14	-0.29	0.27	0.18	0.11	0.07	0.04	0.01
Returns to capital	-0.25	-0.34	-0.41	-0.23	-0.13	-0.05	0.01	0.04	0.05	0.06
Land rent	8.73	6.99	5.46	0.51	-3.25	-2.20	-1.51	-1.06	-0.77	-0.59

Source: Author's calculations

Table D4. Real Income, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt	-2.69	-2.28	-2.10	-0.60	0.35	0.25	0.17	0.11	0.07	0.03
Sudan	-4.04	-4.02	-4.07	-3.82	-1.97	-0.27	-0.23	-0.21	-0.19	-0.18
Morocco	-2.02	-1.90	-1.77	-0.61	0.31	0.21	0.13	0.08	0.04	0.02
Senegal	-3.35	-3.00	-2.74	-0.95	0.38	0.13	-0.03	-0.14	-0.21	-0.25
Kenya	-4.09	-4.00	-3.88	-1.51	0.20	0.12	0.06	0.01	-0.02	-0.04
Ethiopia	-3.29	-3.36	-3.39	-2.57	-0.93	-0.16	-0.13	-0.12	-0.11	-0.11
Mozambique	-1.60	-1.39	-1.30	-0.37	0.17	0.15	0.12	0.09	0.06	0.04
South Africa	-2.80	-2.53	-2.30	-0.66	0.49	0.36	0.26	0.19	0.14	0.10
Nigeria	-0.69	-0.73	-0.82	-0.50	-0.25	-0.18	-0.13	-0.10	-0.08	-0.07
Rest of Africa	-0.03	-0.12	-0.27	-0.33	-0.46	-0.33	-0.24	-0.18	-0.15	-0.13

Source: Author's calculations

Table D5. Real Consumption, % change

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt										
Total consumption	-2.59	-2.19	-2.01	-0.57	0.35	0.25	0.17	0.11	0.07	0.03
Agri-food consumption	-3.94	-3.13	-2.96	-0.86	0.48	0.36	0.27	0.20	0.15	0.11
Rice	-1.30	-1.14	-1.14	-0.50	-0.06	-0.04	-0.03	-0.03	-0.02	-0.02
Wheat	-6.69	-5.64	-5.07	-1.27	1.63	1.25	0.96	0.76	0.61	0.49
All other cereals	-6.63	-4.05	-3.65	-0.06	1.82	1.27	0.89	0.63	0.45	0.33
Vegetables fruit nuts	-1.77	-1.45	-1.28	-0.28	0.42	0.30	0.21	0.13	0.08	0.05
Oil seeds	-3.95	-3.48	-3.35	-1.31	0.28	0.25	0.21	0.18	0.15	0.12
Sugar	-1.83	-1.59	-1.52	-0.55	0.13	0.11	0.08	0.06	0.05	0.03
Other Agriculture	-1.89	-1.38	-1.25	-0.19	0.46	0.28	0.17	0.11	0.07	0.04
Meat and products	-2.83	-2.25	-2.19	-0.75	0.20	0.16	0.12	0.09	0.07	0.05
All other food products	-2.47	-2.16	-2.15	-0.90	0.01	0.01	0.00	-0.01	-0.01	-0.02
Sudan										
Total consumption	-3.75	-3.73	-3.77	-3.53	-1.82	-0.25	-0.22	-0.19	-0.18	-0.17
Agri-food consumption	-7.09	-6.98	-6.98	-6.76	-3.27	-0.08	-0.07	-0.06	-0.06	-0.07
Rice	-6.64	-6.42	-6.26	-6.26	-2.81	0.77	0.66	0.57	0.48	0.40
Wheat	-5.14	-4.57	-4.56	-2.82	-0.74	0.03	-0.03	-0.06	-0.07	-0.07
All other cereals	-5.36	-5.02	-4.96	-4.66	-2.11	0.34	0.27	0.21	0.16	0.11
Vegetables fruit nuts	-5.58	-5.43	-5.37	-4.97	-2.21	0.31	0.26	0.20	0.16	0.12
Oil seeds	-5.65	-5.59	-5.59	-5.16	-2.42	0.06	0.08	0.08	0.07	0.06
Sugar	-4.25	-4.29	-4.38	-4.38	-2.42	-0.29	-0.22	-0.17	-0.15	-0.13
Other Agriculture	-5.62	-5.34	-5.27	-5.42	-2.64	0.43	0.36	0.29	0.24	0.19
Meat and products	-7.11	-7.18	-7.31	-7.51	-4.08	-0.41	-0.35	-0.31	-0.28	-0.26
All other food products	-7.32	-7.36	-7.45	-7.51	-3.96	-0.29	-0.24	-0.21	-0.19	-0.18
Morocco										
Total consumption	-2.33	-2.19	-2.03	-0.69	0.37	0.24	0.16	0.10	0.06	0.03
Agri-food consumption	-2.51	-2.18	-2.03	-0.65	0.41	0.28	0.19	0.13	0.09	0.07
Rice	-0.88	-0.93	-0.94	-0.51	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01
Wheat	-5.54	-4.63	-4.15	-0.99	1.47	1.05	0.76	0.57	0.44	0.35
All other cereals	-4.48	-3.11	-2.86	-0.45	1.02	0.70	0.48	0.34	0.25	0.18
Vegetables fruit nuts	-1.90	-1.59	-1.41	-0.29	0.56	0.43	0.33	0.25	0.19	0.15
Oil seeds	-2.95	-2.64	-2.48	-0.89	0.43	0.35	0.29	0.24	0.20	0.17
Sugar	-1.67	-1.51	-1.43	-0.51	0.23	0.16	0.10	0.07	0.05	0.03
Other Agriculture	-2.31	-1.74	-1.55	-0.25	0.68	0.43	0.27	0.17	0.11	0.07
Meat and products	-1.32	-1.31	-1.30	-0.62	0.01	-0.02	-0.03	-0.04	-0.05	-0.05
All other food products	-2.64	-2.41	-2.29	-0.85	0.34	0.24	0.16	0.11	0.07	0.05
Senegal										
Total consumption	-1.66	-1.54	-1.39	-0.51	0.16	0.04	-0.05	-0.11	-0.14	-0.16
Agri-food consumption	-2.08	-1.79	-1.68	-0.62	0.20	0.05	-0.04	-0.09	-0.11	-0.13
Rice	-2.39	-2.15	-2.02	-0.81	0.24	0.13	0.06	0.02	-0.01	-0.02
Wheat	-5.96	-4.86	-4.40	-1.13	1.36	0.89	0.58	0.38	0.25	0.17
All other cereals	-1.85	-1.34	-1.25	-0.29	0.29	0.13	0.04	0.00	-0.03	-0.04
Vegetables fruit nuts	-1.89	-1.41	-1.25	-0.23	0.49	0.25	0.11	0.04	0.00	-0.02
Oil seeds	-1.66	-1.43	-1.30	-0.43	0.24	0.15	0.08	0.03	0.00	-0.03

Sugar	-1.87	-1.64	-1.50	-0.51	0.22	0.13	0.06	0.01	-0.02	-0.05
Other Agriculture	-1.23	-0.55	-0.47	0.09	0.28	0.01	-0.07	-0.08	-0.07	-0.06
Meat and products	-0.43	-0.59	-0.66	-0.54	-0.35	-0.32	-0.30	-0.28	-0.27	-0.26
All other food products	-2.85	-2.53	-2.37	-0.90	0.33	0.10	-0.04	-0.12	-0.17	-0.20
Kenya										
Total consumption	-4.17	-4.07	-3.95	-1.53	0.20	0.12	0.06	0.01	-0.02	-0.04
Agri-food consumption	-6.75	-6.43	-6.19	-2.17	0.53	0.37	0.26	0.17	0.10	0.05
Rice	-1.57	-1.63	-1.64	-0.81	-0.16	-0.17	-0.17	-0.17	-0.16	-0.15
Wheat	-7.16	-6.00	-5.62	-1.81	1.21	0.74	0.44	0.25	0.15	0.08
All other cereals	-4.70	-4.26	-4.10	-1.36	0.49	0.28	0.15	0.08	0.03	0.01
Vegetables fruit nuts	-4.61	-4.27	-4.10	-1.38	0.46	0.27	0.15	0.07	0.03	0.00
Oil seeds	-3.74	-3.65	-3.58	-1.46	0.12	0.08	0.05	0.02	0.00	-0.01
Sugar	-3.72	-3.68	-3.65	-1.54	0.05	0.04	0.02	0.00	-0.01	-0.02
Other Agriculture	-4.98	-4.37	-4.21	-1.43	0.45	0.21	0.08	0.01	-0.02	-0.03
Meat and products	-6.68	-6.43	-6.22	-2.25	0.56	0.40	0.27	0.17	0.10	0.05
All other food products	-7.35	-7.06	-6.83	-2.47	0.66	0.48	0.33	0.22	0.14	0.08
Ethiopia										
Total consumption	-4.06	-4.12	-4.14	-3.21	-1.18	-0.14	-0.12	-0.12	-0.11	-0.11
Agri-food consumption	-7.11	-6.51	-6.31	-5.63	-2.04	0.52	0.31	0.18	0.10	0.05
Rice	-4.42	-4.45	-4.44	-3.80	-1.62	-0.05	0.03	0.05	0.05	0.04
Wheat	-6.28	-5.62	-5.41	-4.27	-1.34	0.49	0.30	0.19	0.12	0.07
All other cereals	-5.57	-5.32	-5.18	-4.71	-1.84	0.44	0.28	0.17	0.11	0.07
Vegetables fruit nuts	-5.23	-5.12	-5.03	-4.74	-2.04	0.19	0.12	0.07	0.04	0.02
Oil seeds	-4.19	-4.10	-4.10	-3.27	-1.31	-0.14	-0.11	-0.09	-0.08	-0.07
Sugar	-4.69	-4.72	-4.67	-4.37	-1.89	0.15	0.13	0.09	0.07	0.04
Other Agriculture	-8.59	-6.54	-5.89	-4.61	-0.58	1.84	1.03	0.58	0.32	0.17
Meat and products	-7.20	-7.29	-7.31	-7.00	-3.20	0.05	0.03	0.01	0.00	-0.02
All other food products	-5.83	-6.06	-6.16	-5.72	-2.66	-0.24	-0.17	-0.13	-0.11	-0.10
Mozambique										
Total consumption	-1.70	-1.48	-1.38	-0.39	0.18	0.16	0.13	0.10	0.07	0.04
Agri-food consumption	-1.32	-1.16	-1.13	-0.40	0.06	0.05	0.04	0.03	0.02	0.02
Rice	-0.50	-0.46	-0.46	-0.19	-0.08	-0.03	-0.01	0.00	0.00	0.00
Wheat	-6.64	-5.45	-5.07	-1.49	1.16	0.76	0.50	0.34	0.24	0.17
All other cereals	-0.79	-0.64	-0.63	-0.18	0.05	0.04	0.03	0.02	0.01	0.00
Vegetables fruit nuts	-0.38	-0.38	-0.41	-0.22	-0.11	-0.07	-0.04	-0.03	-0.02	-0.02
Oil seeds	-1.06	-0.86	-0.80	-0.20	0.12	0.13	0.12	0.11	0.09	0.07
Sugar	-1.47	-1.27	-1.15	-0.28	0.29	0.28	0.25	0.22	0.19	0.16
Other Agriculture	-0.49	-0.33	-0.38	-0.13	-0.06	-0.09	-0.07	-0.05	-0.03	-0.02
Meat and products	-0.62	-0.66	-0.71	-0.41	-0.18	-0.12	-0.08	-0.06	-0.05	-0.04
All other food products	-2.19	-1.93	-1.86	-0.63	0.18	0.14	0.10	0.07	0.04	0.02
South Africa										
Total consumption	-2.62	-2.37	-2.14	-0.62	0.46	0.34	0.24	0.18	0.13	0.10
Agri-food consumption	-2.10	-1.83	-1.70	-0.51	0.32	0.22	0.14	0.10	0.07	0.04
Rice	-0.95	-0.88	-0.81	-0.27	0.10	0.08	0.06	0.05	0.04	0.04
Wheat	-6.55	-5.60	-5.11	-1.37	1.57	1.17	0.89	0.70	0.57	0.48
All other cereals	-2.44	-1.89	-1.75	-0.37	0.47	0.31	0.20	0.14	0.10	0.08
Vegetables fruit nuts	-2.10	-1.75	-1.58	-0.41	0.38	0.29	0.22	0.17	0.13	0.10

Oil seeds	-2.33	-2.11	-1.97	-0.68	0.31	0.25	0.19	0.15	0.12	0.10
Sugar	-1.48	-1.36	-1.26	-0.42	0.22	0.16	0.12	0.09	0.06	0.04
Other Agriculture	-2.13	-1.51	-1.36	-0.21	0.51	0.27	0.14	0.07	0.04	0.02
Meat and products	-1.55	-1.43	-1.34	-0.48	0.17	0.10	0.06	0.03	0.01	-0.01
All other food products	-1.76	-1.58	-1.47	-0.47	0.24	0.16	0.11	0.07	0.04	0.02
Nigeria										
Total consumption	-0.68	-0.73	-0.81	-0.49	-0.24	-0.18	-0.13	-0.10	-0.08	-0.07
Agri-food consumption	-0.32	-0.35	-0.42	-0.30	-0.20	-0.15	-0.11	-0.09	-0.07	-0.06
Rice	-0.66	-0.71	-0.77	-0.46	-0.16	-0.09	-0.05	-0.02	0.00	0.01
Wheat	-4.92	-3.70	-3.68	-1.08	0.29	0.13	0.03	-0.01	-0.03	-0.03
All other cereals	-0.21	-0.22	-0.27	-0.19	-0.13	-0.10	-0.08	-0.07	-0.06	-0.05
Vegetables fruit nuts	-0.16	-0.19	-0.23	-0.18	-0.14	-0.11	-0.09	-0.07	-0.06	-0.05
Oil seeds	-0.74	-0.75	-0.82	-0.45	-0.14	-0.06	-0.02	0.01	0.02	0.03
Sugar	-0.82	-0.83	-0.89	-0.50	-0.19	-0.12	-0.08	-0.05	-0.04	-0.03
Other Agriculture	-0.26	-0.24	-0.28	-0.17	-0.10	-0.09	-0.07	-0.06	-0.05	-0.04
Meat and products	-0.05	-0.13	-0.22	-0.25	-0.26	-0.20	-0.15	-0.12	-0.10	-0.09
All other food products	-0.98	-1.04	-1.16	-0.73	-0.30	-0.20	-0.13	-0.09	-0.06	-0.04
Rest of Africa										
Total consumption	-0.07	-0.15	-0.32	-0.37	-0.50	-0.36	-0.26	-0.20	-0.16	-0.14
Agri-food consumption	-0.72	-0.58	-0.69	-0.40	-0.29	-0.20	-0.15	-0.11	-0.08	-0.07
Rice	0.21	0.09	-0.09	-0.31	-0.52	-0.36	-0.25	-0.17	-0.13	-0.10
Wheat	-5.14	-4.19	-3.90	-1.09	0.90	0.63	0.44	0.31	0.22	0.16
All other cereals	-1.44	-0.96	-0.97	-0.21	0.12	0.05	0.02	0.00	-0.01	-0.02
Vegetables fruit nuts	-0.12	-0.14	-0.23	-0.25	-0.27	-0.15	-0.11	-0.08	-0.06	-0.05
Oil seeds	-0.15	-0.17	-0.29	-0.30	-0.37	-0.24	-0.16	-0.11	-0.08	-0.06
Sugar	-0.30	-0.34	-0.46	-0.38	-0.39	-0.24	-0.15	-0.10	-0.06	-0.05
Other Agriculture	-0.56	-0.02	-0.09	0.13	-0.02	-0.08	-0.09	-0.08	-0.06	-0.05
Meat and products	-0.33	-0.36	-0.54	-0.50	-0.50	-0.33	-0.23	-0.17	-0.13	-0.11
All other food products	-0.70	-0.67	-0.84	-0.58	-0.45	-0.31	-0.22	-0.16	-0.13	-0.10

Source: Author's calculations

Table D6. Welfare Effects (% of GDP)

	Year									
	1	2	3	4	5	6	7	8	9	10
Egypt	-1.32	-1.16	-1.12	-0.43	0.03	0.01	-0.01	-0.02	-0.03	-0.04
Sudan	-3.28	-3.31	-3.40	-3.49	-1.90	-0.21	-0.17	-0.15	-0.14	-0.13
Morocco	-1.60	-1.46	-1.36	-0.45	0.27	0.19	0.13	0.09	0.06	0.04
Senegal	-1.82	-1.59	-1.47	-0.52	0.22	0.08	-0.01	-0.06	-0.10	-0.12
Kenya	-4.00	-3.86	-3.75	-1.43	0.24	0.15	0.09	0.04	0.00	-0.02
Ethiopia	-3.74	-3.67	-3.64	-3.09	-1.19	0.08	0.04	0.01	-0.01	-0.02
Mozambique	-0.94	-0.82	-0.77	-0.23	0.10	0.09	0.07	0.05	0.04	0.03
South Africa	-1.22	-1.11	-1.02	-0.31	0.20	0.14	0.10	0.07	0.05	0.03
Nigeria	-0.44	-0.47	-0.54	-0.34	-0.18	-0.13	-0.09	-0.07	-0.05	-0.04
Rest of Africa	-0.19	-0.20	-0.29	-0.24	-0.27	-0.18	-0.13	-0.10	-0.08	-0.06

Source: Author's calculations

Table D7. Accumulated Loss in Welfare (US\$ million) (Sim2)

	Year					Accumulated:
	1	2	3	4	5	5 years
Egypt	-5,352	-4,844	-4,829	-1,891	120	-16,796
Sudan	-1,126	-1,173	-1,238	-1,277	-706	-5,520
Morocco	-2,285	-2,128	-2,022	-689	424	-6,700
Senegal	-502	-468	-457	-169	76	-1,520
Ethiopia	-4,455	-4,505	-4,588	-1,833	328	-15,053
Kenya	-4,130	-4,304	-4,542	-4,110	-1,694	-18,779
Mozambique	-149	-134	-131	-41	18	-437
South Africa	-5,128	-4,695	-4,328	-1,338	887	-14,601
Nigeria	-1,926	-2,141	-2,510	-1,632	-891	-9,100
Rest of Africa	-1,928	-2,100	-3,087	-2,626	-2,969	-12,710

Source: Author's calculations