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Climate Change, Loss of Agricultural Output and the Macro-Economy: The Case of Tunisia

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Abstract
Using an empirical, multi-sectoral, open economy, Stock-Flow Consistent model, this paper assesses the long-term consequences of a sustained climate-induced decline in agricultural production for the Tunisian economy. Focus is placed on agricultural and processed food production and the feedback loops of balance sheet and liquidity effects on the real economy. The model is empirically calibrated using a range of national accounts, input-output, balance of payments and balance sheet datasets, agricultural projections from crop models and it is simulated for the period 2018-2050. We show that costs of inaction in the face of declining agricultural production are dire for Tunisia. We find that the economy will face high and rising unemployment and inflation, growing internal and external macroeconomic imbalances and a looming balance of payments crisis, especially if global food inflation remains high in the coming decades. We then simulate two possible adaptation scenarios envisaged by policymakers and show that adaptation investments in water resources, increased water efficiency in production and a public, investment driven big push, can put the economy back on a sustainable path in the long run.

Keywords
Ecological macroeconomics, Climate change, Stock-flow consistent modelling, Open economy macroeconomics

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Résumé

En utilisant un modèle Stock-Flux Cohérent multisectoriel d'une petite économie ouverte, ce document évalue les répercussions à long terme d'une baisse soutenue de la production agricole due au changement climatique sur l'économie tunisienne. L'accentest mis sur la production agricole et agroalimentaire, ainsi que sur les boucles de rétroaction des effets des bilans et de liquidité sur l'économie réelle. Le modèle est calibré empiriquement en utilisant des données provenant de diverses sources telles que la comptabilité nationale, les tableaux entrées-sorties, la balance des paiements et les bilans bancaires. De plus, il intègre des projections agricoles basées sur des modèles de culture et les simulations sont réalisées pour la période allant de 2018 à 2050. Les résultats montrent que les conséquences de l'inaction face au déclin de la production agricole sont désastreuses pour la Tunisie. L'économie sera confrontée à une augmentation croissante du chômage et de l'inflation, ainsi qu'à des déséquilibres macroéconomiques internes et externes de plus en plus importants et une crise imminente de la balance des paiements, en particulier si l'inflation alimentaire mondiale reste élevée dans les décennies à venir. Par la suite, deux scénarios d'adaptation envisagés par les décideurs politiques sont simulés, démontrant que des investissements d'adaptation dans les ressources en eau, une amélioration de l'efficacité de l'utilisation de l'eau dans la production, et une impulsion majeure d'investissement public peuvent remettre l'économie sur une trajectoire de développement durable à long terme.

Mots-clés

Macroéconomie écologique, Changement climatique, Modélisation stock-flux cohérent, Macroéconomie en économie ouverte

1. Introduction

Faced with worsening global warming conditions and limited water resources that are already below the threshold of absolute water scarcity (Ministry of Agriculture, Water Resources and Fisheries of Tunisia, 2020), Tunisia faces major challenges and risks that could exacerbate the country's difficult economic and social situation in the coming decades. Rising temperatures and an increase in the frequency of extreme weather events, coupled with a decrease in rainfall, are expected to affect both the quantity and quality of water resources, and thus the economy, particularly agriculture. While this high level of water stress will require high levels of investment in adaptation and efficiency gains in water use, Tunisia's fragile macroeconomic outlook implies that efficient use of public and private resources is essential to achieve a sustainable water balance alongside the country's development goals (United Nations Climate Change, 2022).

In this context, this paper aims to model the macroeconomic impacts of climate change and the viability of long-term adaptation policies in Tunisia, using a Stock-Flow-Consistent (SFC) economic model and crop yield projections. The model presented below is a multi-sectoral extension of Yilmaz and Godin (2020), who develop a prototype growth model for developing economies. SFC modelling has recently been used to analyse the physical effects of climate change on global macro-financial developments and macrodynamic stability (Dafermos et al., 2017, 2018; Bovari et al., 2018) and the economic consequences of rapid energy transition paths (Jacques et al., 2023), highlighting its suitability for our analysis. Our novel approach synthesises a multi-sector production structure with the SFC framework and the continuous-time dynamic, macrofoundations approach of the Bielefeld school of macroeconomics, developed by P. Flaschel, C. Chiarella and co-authors, in particular with respect to dynamic disequilibrium processes (Chiarella and Flaschel, 2006; Flaschel, 2008; Flaschel et al., 2008; Charpe et al., 2011; Chiarella et al., 2012, 2013). We also pay particular attention to the importance of capital inflows for small open economies (Frankel, 2010; Borio and Disyatat, 2015), such as Tunisia, and the channels through which they affect the domestic economy, including international trade (Blecker, 2016), liquidity (Kaminsky et al., 1997) and balance sheet effects (Bernanke and Gertler, 1995). For agricultural yield projections, we use FAO projections as well as projections from the AdaptAction project (Deandreis et al., 2021).

The paper is structured as follows: the next section presents the macroeconomic developments in Tunisia over the last two decades. Section three discusses the impact of climate change on Tunisia through temperature and precipitation projections. Section four presents the impact of climate change on agriculture and the construction of agricultural production projections. The macroeconomic model and its calibration to the Tunisian economy are presented in the next two sections. Section seven presents the simulation results under the BAU scenario, under the RCP8.5 scenario with a moderate world growth rate and world inflation, and under the RCP8.5 scenario with a low world growth rate and high world inflation for food imports. The eighth section discusses and simulates two long-term adaptation scenarios defined by the Tunisian Ministry of Agriculture and simulates the macroeconomic impact of these policies under two alternative scenarios. The final section presents concluding remarks.

2. Tunisian Economy: Trends and Developments

The Tunisian economy is facing major socioeconomic difficulties. Growing twin deficits, slowing economic growth, depreciation of the Tunisian dinar and persistently high unemployment and inflation rates have characterised the economy over the past decades (Nucifora et al., 2014). These structural weaknesses are likely to limit the country's adaptive capacity and increase its economic vulnerability to climate change in the medium and long term.

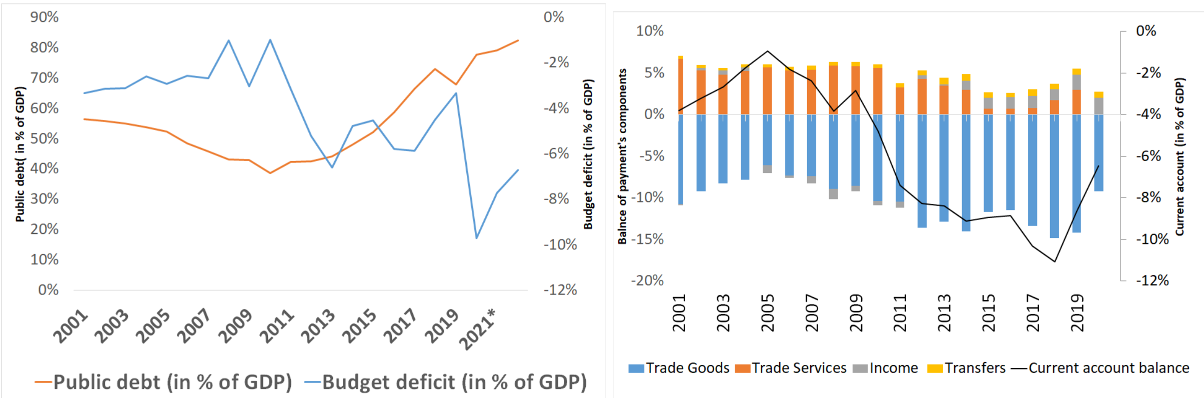
Since the 2011 revolution, Tunisia has experienced particularly fragile economic conditions due to political and social instability, which has led to an unfavourable business climate for investment and hampered economic growth. Real GDP growth has slowed significantly over this period compared with the previous decade, from an average annual rate of 4.6% between 2001 and 2010 to 1.4% between 2011 and 2019, mainly due to the slowdown in domestic and foreign private investment and the decline in export dynamism.

The deterioration in international financial conditions, combined with the structural weaknesses of the economy, has largely contributed to the worsening of the country's internal and external macroeconomic imbalances. The trade and budget deficits have risen to historically high levels, leading to growing imbalances in the current account, public finances, and the foreign exchange market.

Indicator	2001-2010	2011-2019	2020	2021
Average annual growth rate				
GDP	4.6	1.6	−8.6	4.3
Agriculture sector	1.9	4.6	0.2	−2.5
Processed Food sector	2.7	2.4	0.7	−3.5
Sector's contribution to GDP				
Agriculture sector	8.7	8.8	9.4	10.3
Processed Food sector	3.5	3.3	3.4	3.7
Trade Balance(% of GDP)	10.9	15.6	16.9	11.5
Food Balance(% of Trade Balance)	7.5	7.3	12.9	12
Investment (% of GDP)	24.1	21.1	19.4	15.8
Total External Debt (% of GDP)	39.5	46.2	61.9	56.3
FX reserves (months of imports)	6.2	3.7	5.4	4.4
Inflation rate(%)	4.1	5	5.6	5.7
Food inflation(%)	4	5.6	4.3	7.6
Unemployment rate(%)	13	15.1	18	17.9
Budget deficit(% of GDP)	2.5	5.1	9.7	6.6
Public Debt(% of GDP)	49.1	56.2	78.0	79.5
NIIP(% of GDP)	−93.6	−153.2	−163.9	−160.6

Table 1: Macroeconomic indicators, source: National Institute of Statistics, Central Bank of Tunisia, and authors' computations.

While weak economic growth has allowed only marginal growth in general government resources, public expenditure has risen sharply due to increases in the public wage bill and higher subsidies to keep food and energy prices in check in an environment of high global inflation of imported commodities such as oil and cereals. The budget deficit has widened



(a) Budget deficit and public debt, source: Ministry of Finances and authors' computations.

(b) Balance of payment, source: Central Bank of Tunisia and authors' computations.

Figure 1: Fiscal Balances and Balance of Payments; Source: INS

rapidly rising from 3.6% in 2011 to 9.7% in 2020 during the Covid19 pandemic, see figure 1a. As a result, public debt increased significantly, reaching over 80% of GDP in 2020, mainly driven by a sharp rise in public external debt, which exceeded 50% of GDP in 2020.

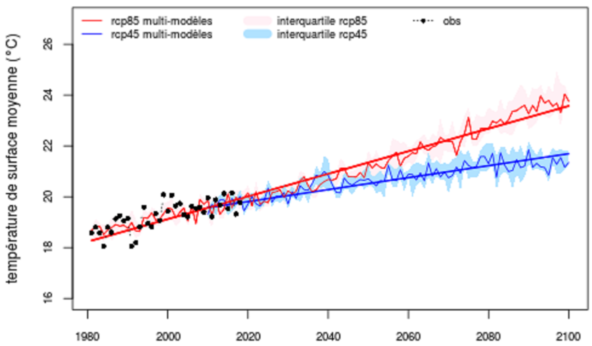
In addition, the sharp rise in the trade deficit, mainly due to the large deficit in energy trade, persistent food deficits, and the decline in the services surplus due to a sharp fall in tourism activity, has led to a widening of the current account deficit, which increased as a percentage of GDP from -4.8% in 2010 to -11% in 2018, see figure 1b. Before 2010, the country relied mainly on FDI inflows to finance its current account deficit. After the revolution, FDI declined from 3.5% of GDP in 2009 to 1.9% of GDP in 2019. Thus, the large and persistent current account deficit was only partially covered by FDI and the government resorted to external borrowing, leading to an accumulation of external debt and a worsening of country risk (IMF, 2019).

Indeed, as the overall financing needs of the economy have steadily increased, and the contribution of the banking system and household savings to this financing has remained limited, external borrowing has enabled the financing of private and public deficits over the last decade. Despite large inflows of remittances, which have averaged 4% of GDP over the last decade, external debt servicing and large dividend payments by the corporate and banking sectors to the rest of the world have absorbed all external financing. As a result, net international reserves have declined significantly, falling to only 84 days of imports in 2018.

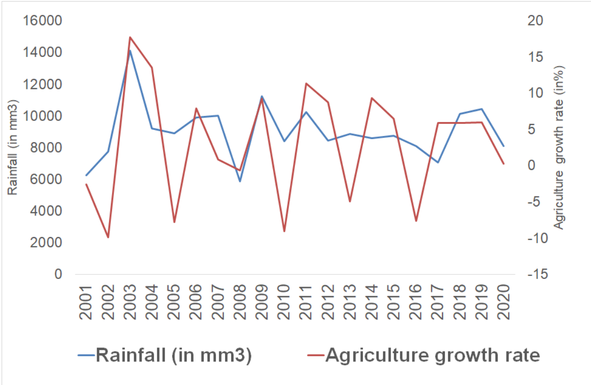
Due to low household income and hence low savings, deposit growth, the main source of bank financing, did not follow loan growth and the banking sector had to resort to large amounts of central bank financing. Liquidity in the sector remained below international standards, with liquid assets not exceeding 20% of total assets. Profitability was also low, with the return on equity averaging 10% between 2008 and 2018, and the non-performing loan ratio was very high, averaging at 13.3% in 2018. (Central Bank of Tunisia, 2019).

3. Climate change in Tunisia

Characterised by an arid to semi-arid climate over 80% of its territory, Tunisia has a permanent water deficit and remains the 30th most water-stressed country in the world (WRI, 2020). Over the past decade, the country has experienced two periods of severe drought in 2013 and 2015-2017, with a significant rise in temperature, followed by periods of recurrent heat waves, as well as fires and floods, which have multiplied in recent years. The agricultural sector is essentially based on rain-fed production, which accounts for more than 90% of the cultivated area and 65% of agricultural value added. It is therefore highly dependent on climatic variations (Chebbi et al., 2019), as shown by the strong correlation between the growth rate of agricultural value added and rainfall in Figure 2b.



(a) Average temperature under RCP4.5 and RCP8.5 scenarios. Source: National Institute of Meteorology (Climat-c, 2020)



(b) Agriculture Value Added and rainfall.

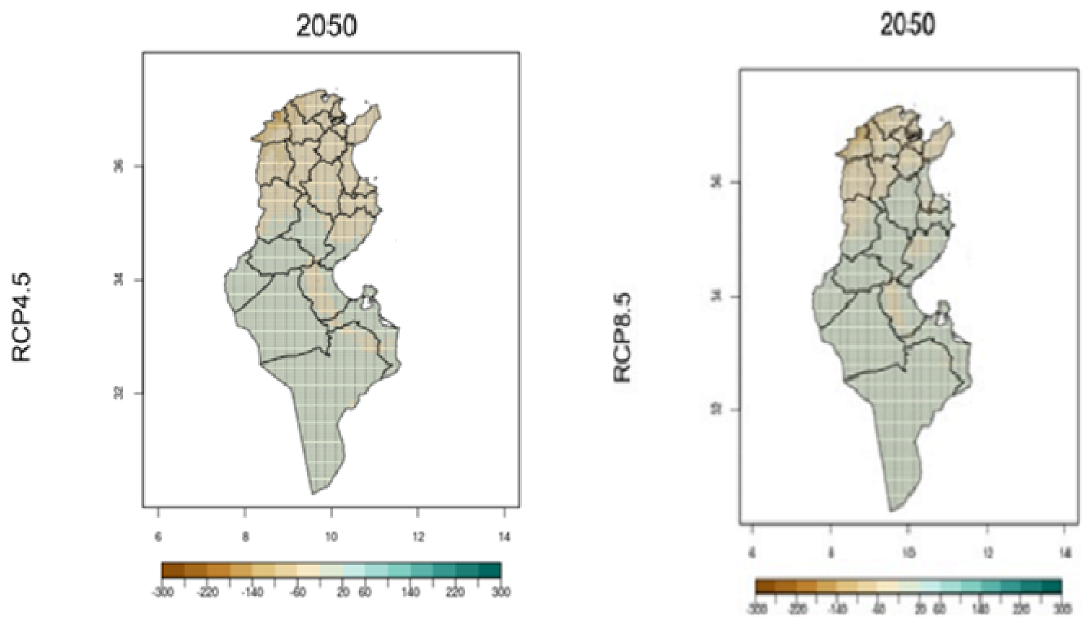
Figure 2: Recent climatic conditions in Tunisia; Source: Tunisia National Institute of Meteorology, National Institute of Statistics and author's computations.

The updated projections of the National Institute of Meteorology in 2020[1] indicate a temperature increase of up to 1.8°C by 2050 for RCP 4.5[2] and up to 3°C by 2100. Tunisia's inland regions will experience a temperature increase compared to the coastal regions. For RCP 8.5, this temperature increase will be even more acute, reaching the values of 2.3°C and 5.2°C for the 2050 and 2100 horizons, respectively. Under thus climate forcing, the arid inland regions will experience major heat waves, threatening already fragile agro-systems.

With regard to precipitation, the climate projections of the National Institute of Meteorology show a significant decrease in precipitation under the two scenarios, with a decrease of between 14 and 22 mm in 2050 under the RCP8.5 and RCP4.5 scenarios respectively, i.e. a loss of -6% and -9% compared to the average precipitation observed over the period 1981-2010.

[1]On the basis of 14 regional climate models with a spatial resolution of up to 12.5 km, the National Institute of Meteorology is assessing the impact of future climate change on temperature and precipitation for two horizons, 2050 and 2100, compared to the 1961-1990 average under RCP 8.5 and RCP 4.5, presented in Figures 3a and 3b.

[2]In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) presented the modelling of greenhouse gases through Representative Concentration Pathway (RCP) scenarios that include a pessimistic scenario RCP 8.5, two intermediate scenarios (RCP 4.5 with a stabilization of emissions before 2100 at a low level and RCP 6.0 with a stabilization of emissions before 2100 at a medium level), and an optimistic scenario RCP 2.6 (IPCC, 2014).



(a) Precipitations under RCP4.5 scenario

(b) Precipitations under RCP8.5 scenario

Figure 3: Precipitation Projections Under RCP4.5 and RCP 8.5; Source: Tunisia National Institute of Meteorology

The climate scenarios also predict a significant increase in climate extremes, indicating a longer duration of heat waves and a high frequency of droughts and floods. Indeed, Tunisia would experience an increase in the number of consecutive maximum dry days on average of 9.3 days per year according to RCP 4.5 and 17.1 days per year according to RCP 8.5 scenario, i.e. an increase of 11% and 19% respectively compared to the average recorded over the period 1981-2010.

4. Agricultural production and climate change

With the predicted increase in temperature and decrease in rainfall, the loss of agricultural production in Tunisia is likely to worsen in the coming decades. Tunisian agriculture has already experienced the severe negative impacts of climate change in certain parts of the country. Rising sea levels due to climate change have increased coastal erosion and salinity contamination of coastal aquifers (Brahmi et al., 2018). These coastal aquifers are used by farmers for irrigation, which has led to the salinisation of several irrigation perimeters in Tunisia and their permanent loss. For example, according to Issam et al. (2022), the aquifer of the coastal town of Dyiar-Al-Hujjej in Capbon has experienced seawater intrusion. The salinisation of the aquifer reached a very high electrical conductivity of 15 dS/m in the 1990s, causing many local farmers to abandon their plots and wells. In addition, salinity has reduced plant growth and water quality, resulting in lower crop yields and reduced water reserves in livestock.

As in coastal areas, the vulnerability of land in the interior of the country, which is classified as semi-arid/arid, is compounded by adverse climatic conditions and unsustainable agricultural practices. In Tozeur, where the largest oasis farming system is located, date crops are at risk, suffering the full impact of climate variability and poor surface irrigation (Dhaouadi et al., 2017). Much of the land occupied by smallholders is on low-fertility land, where inappropriate agricultural practices have led to soil erosion and loss of biodiversity. Irrigation with highly saline water has led to the degradation or even total sterilisation of a significant proportion of Tunisian soils (Khawla and Mohamed, 2020). Indeed, in Tunisia, irrigation water is the main source of salinisation in irrigated areas (Louati et al., 2018).

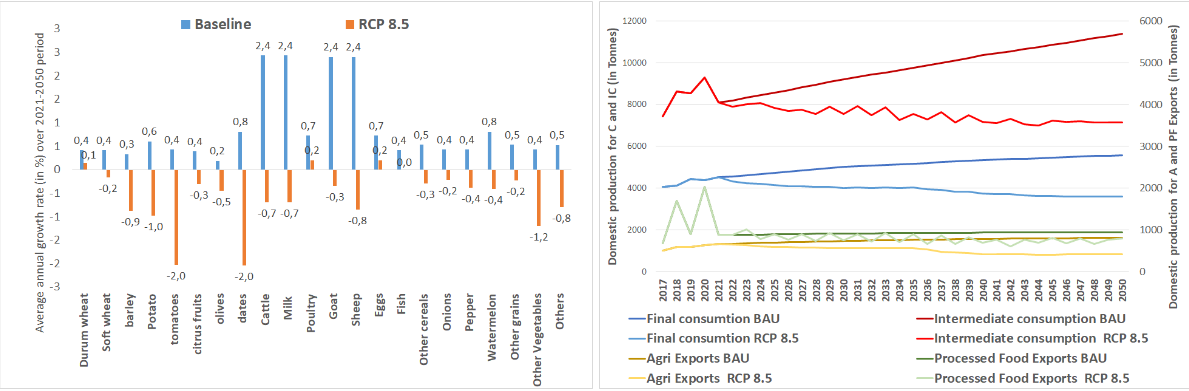
Future climate change is expected to raise sea levels along the Tunisian coastline by 30 to 50 cm, leading to loss of arable land and accelerated salinisation of groundwater in coastal areas. In addition, soil degradation, increased heat waves and droughts, and reduced rainfall will lead to a general decline in yields and cultivated areas, resulting in losses in agricultural production.

In order to analyse the impact of declining agricultural production on the Tunisian economy, we first construct production projections in tonnes for twenty-two different agricultural crops under Business As Usual (BAU) and the RCP 8.5 scenario for the 2022-2050 time horizon. Our crop basket covers all agricultural production. In our BAU scenario, we use projections from the FAO's Global Agro-ecological Zones (GAZ) model (Fischer et al., 2021) to project production levels.[3] For the main cereal crops (durum wheat, soft wheat and barley) and olives, we quantify the impact of climate change on harvested areas and corresponding yields under the RCP 8.5 scenario through projections developed under the Adapt'Action project, with the participation of the Tunisian Ministry of Agriculture and the French Development Agency (Deandreis et al., 2021). For the remaining crops not covered by the Adapt'Action project (dates, citrus fruits, tomatoes, potatoes, onions, peppers, livestock, milk, eggs, watermelon, other cereals and other vegetables & fruits), we use projections by the Food and of the United Nations (2018) under the Stratified Societies Scenario (SSS).

Figure 4a shows the average smoothed growth rates of yields (in tonnes) of our crop basket for the BAU and RCP8.5 scenarios. As expected, projections under the RCP8.5 scenario show significant losses for the main crops grown in Tunisia. Among cereals, barley and soft wheat production in 2050 are projected to decrease by respectively 0.9% and 0.2% per year, while durum wheat is projected to increase by only 0.1% over 2022-2050 period.

The main export commodities, i.e. dates and olives, will also be severely affected by further increases in groundwater salinity in deep aquifers in southern regions, for dates, and by loss of rainfall and increased temperatures for olives. According to projections, dates production will decline by 2% per year until 2050, while olive production will decline by 0.5%. Livestock production (cattle, goat, sheep) will also fall as feed losses increase, leading also to lower milk production by 2050. The growth rate of poultry production will slow down to only 0.2%, which will also be the rate of growth of egg production. According to MedECC (2021), a structural shift in fishery resources is expected, with an increase in thermophilic, exotic species and a

[3] More specifically, for our BAU scenario, we use agricultural production projections reported in the 'Climate Shifter' socio-economic pathway provided by FAO, which corresponds to the RCP 6.0 climate scenario



(a) Crops average annual growth rate over 2021-2050 for BAU and RCP8.5 scenarios. Source: Deandreis et al. (2021); Food and Agriculture Organization of the United Nations (2018) and authors' computations

(b) Demand components of domestic agriculture production (in volume) under BAU and RCP 8.5 scenarios. Source: Deandreis et al. (2021); Food and Agriculture Organization of the United Nations (2018) and authors' computations

Figure 4: Agricultural Production Projections. Source: Author's calculations

simultaneous decrease in current, cold affinity species. So we assume that fish production remains stable and fix to its 2021 value. In summary, the total agricultural production (in added tonnes) sector will decline by an average of 0.5% per year.

In order to use these volume projections in our economic model, we classify crops according to their use, using information from the 2015 product-level supply-use table (SUT) for agricultural commodities. More specifically, we allocate the supply of each crop in tonnes to satisfy three categories of demand: household consumption, intermediate consumption by agro-industry/other sectors, and exports. We then use 2017 prices for each crop to calculate the value of output for consumption, intermediate consumption and exports in constant prices.[4].

Figure 4b shows the evolution of the production of agricultural consumer goods, intermediate consumption goods, and agricultural and processed food exports in constant prices under the BAU and RCP8.5 scenarios.[5] All four production categories show continuous and sustained declines until 2050. With a growing population and increasing demand for food, this decline in production will lead to increased food imports to meet domestic demand, increased rural unemployment and possibly migration to urban areas. Combined with the decline in agricultural and agro-industrial exports, Tunisia faces a significant loss of vital foreign exchange, especially if global food price inflation is high in the coming decades. In the next section, we discuss the main aspects of a large-scale, empirical stock-flow-consistent system dynamics model of the Tunisian economy to capture the implications of these developments for Tunisia's macrodynamic performance.

[4]As discussed in the next section, exports of agro-industrial goods depend solely on projected olive and fish production. From these projections an exogenous export path for the processed food is constructed.

[5]Note that the figure uses actual production data until 2021 and projections from 2022 onwards. The increase in the production of intermediate agricultural goods between 2018 and 2020 is mainly due to high olive production in 2018 and 2020 and high durum wheat production in 2019. However, these trends are not maintained in 2021 and 2022, when drought and heatwaves have a strong negative impact on yields

5. The model

The GEMMES-Tunisia[6] model describes the evolution of the Tunisian macroeconomy under different climate change and climate adaptation scenarios. The technical description of the model with detailed equations, information on the data, calibration and simulation strategies can be found in the Appendix. The structure of the model is captured by the Transaction Flow Matrix (TFM, Table 2) and the Balance Sheet Matrix (Table 3), which show the balance sheet structure of each sector, and the transactions that take place in the economy between the institutional sectors respectively. Note that the TFM also records the net saving positions and the corresponding changes in the financial and real stocks of the model. Assets and inflows are indicated by a (+) and liabilities and outflows by a (-).

The model has six institutional sectors: Firms, Households, Banks, Government, Central Bank and the Rest of the World. The firms sector is further subdivided into the agricultural sector and the non-financial corporations (NFC) sector. There are five types of commodities. Three different agricultural products for household consumption, intermediate consumption and exports respectively, produced by the agricultural sector; a processed food product produced by the NFC sector, which is used for intermediate and final consumption, and a non-food product also produced by the NFC sector, which is used for investment, intermediate and final consumption. In this context, particular attention is paid to the macro-financial conditions affecting production and the development of internal and external imbalances, including food and consumer inflation, unemployment, the accumulation of private and public debt, the deterioration of country risk, external deficits and the accumulation of foreign debt, and the associated financial accelerator effects that feed back into spending decisions in all sectors.

5.1. Firms

5.1.1. Output, Expenses and Resources

Domestic agricultural production for final consumption demand, intermediate consumption and exports is given by the projected climate conditions as described in the previous section, and is exogenous to the model. Aggregate domestic demand for agriculture is composed of final consumption and intermediate consumption. Any excess domestic demand is covered by imports to clear the market. The agricultural sector consumes as intermediate inputs agricultural goods, processed food goods and NFC goods, in fixed proportions of its total production. Similarly, the sector uses labour and capital in fixed proportions. Employment is determined by total production and the constant trend in labour productivity. The agricultural sector is mostly household-owned and therefore it generates mixed income from its production activities, after accounting for all the taxes in production, social contributions and subsidies. Given the exogenous growth of production, it is assumed that the sector operates at a fixed capital to output ratio, and investment is always carried out to ensure that the capital stock is sufficient for the given production path. Net profits are defined by the

[6] GEMMES stands for General Monetary and Multisectorial Macrodynamics for the Ecological Shift.

mixed income of the sector from which interest payments on serviceable loans, insurance and commissions paid to the banking sector and income taxes to the government are deducted. A proportion of net profit is retained to finance investment and remaining financing needs are covered by new borrowing from the banking sector in domestic currency.

The NFC sector produces two goods, processed food and an non-food good, with two distinct production processes. Domestic production of the processed-food good is demanded for final and intermediate consumption, and exports. The non-food good is further demanded for investment by firms and households. As with agricultural production, intermediate consumption functions are given by the technical coefficients and the level of production for both goods. The sector uses labour and capital in fixed proportions, and employment is determined by total output and labour productivity. Due to the dependence of the processed food production to agricultural intermediate inputs, we further assume that processed food exports depend on climatic conditions and are exogenous to the model. Imports of processed food depend on time varying import propensities out of real levels of final and intermediate consumption. The import propensities gradually adjust to their target levels, which depend on relative prices (taking into account import taxes) and relative productivity between Tunisia and the rest of the world, with different elasticities.

Domestic production of the non-food good is sold for final and intermediate consumption, investment and exports. As in the other sectors, fixed proportions of intermediate inputs, labour and capital is assumed. Imports of non-food goods are determined by domestic demand for private final consumption, intermediate consumption and investment, with endogenous import propensities. As with processed food goods, import propensities are slow-moving and depend on relative prices and relative productivity levels. Exports of non-food goods depend on foreign GDP with an endogenous propensity to export that depends on relative prices and relative productivity levels.

The processed food and durable good markets are characterised by disequilibria. At each point in time and for each good, total demand is not necessarily equal to total production. NFC firms form adaptive expectations on real expected demand around the trend growth of processed food and the durable good sales. This trend follows population growth rate for processed food and capital accumulation for non-food good. Excess demand or supply is cleared by inventory adjustments in both markets. NFC firms have a desired inventory to expected sales ratios for processed food and non-food goods, which determine desired inventories. Therefore, total production is based not only on expected demand, but also to attain desired inventory levels.

	Agriculture		Non-Agricultural NFC		Households	Banks	C. Bank	Government	RoW	Σ
	Current	Capital	Current	Capital						
Agricultural Consumption	C^A_{nom}				$-C^A_{nom}$					0
Processed food Cons.			C^{PF}_{nom}		$-C^{PF}_{nom}$					0
NFC Consumption			C^{NF}_{nom}		$-C^{NF}_{nom}$					0
Agricultural Margins	$-MRG^A$		$+MRG^A$							0
Investment		$-I^{NF}_{A,nom}$	$+I^{NF}_{nom}$	$-I^{NF}_{F,nom}$	$-I^{NF}_{H,nom}$			$-I^{NF}_{G,nom}$		0
Imports	$-IM^A_N$		$-IM^{PF}_N - IM^{NF}_N$						$+IM_{nom}$	0
Exports	$+X^A_{nom}$		$+X^{NF}_{nom} + X^{PF}_{nom}$						$-X_{nom}$	0
Agricultural Intermediate Consumption	$+IC^A_{PF,NF,G,nom}$		$-IC^A_{PF,NF,nom}$					$-IC^A_{G,nom}$		0
Processed Food Intermediate Consumption	$-IC^{PF}_{A,nom}$		$+IC^{PF}_{A,G,nom}$					$-IC^{PF}_{G,nom}$		0
NFC Intermediate Consumption	$-IC^{NF}_{A,nom}$		$+IC^{NF}_{A,B,G,nom}$			$-IC^{NF}_{B,nom}$		$-IC^{NF}_{G,nom}$		0
Wages	WB^A		$-WB^F$		$+WB$	$-WB^B$		$-WB^G$		0
Employers' Social Contributions	$-ESC^A$		$-ESC^F$			$-ESC^B$		$+ESC - ESC^G$		0
Value Added Taxes	$-VAT^A$		$-VAT^F$					$+VAT$		0
Other Taxes	$-Otaxes^A$		$-Otaxes^F$					$+Otaxes$		0
Import Taxes	$-TIM^A$		$-TIM^F$					$+TIM$		0
Subsidies	$+sub^A$		$+sub^F$					$-sub$		0
Taxes on production	$-Tpr^A$		$-Tpr^F$			$-Tpr^B$		$+Tpr$		0
Gross Operating Surplus Distribution	$-MI^A$		$-GOS^F_H$		$+MI^A + GOS^F_H$					[0]
Interest on Deposits			$+IntD^F$		$+IntD^H$	$-IntD$				0
Interest on Domestic Loans	$-IntL^A_D$		$-IntL^F_D$		$-IntL^H_D$	$+IntL_D$				0
Interest on NFC FX Loans			$-IntL^F_{B,FX}$			$+IntL^F_{B,FX}$				0
Interest on Direct FX Loans						$-IntL^B_{D,FX}$		$-IntL^G_{D,FX}$	$+IntL_{D,FX}$	0
Interest on Bonds					$+IntB^H$	$+IntB^B$	$+IntB^{CB}$	$-IntB$		0
Comissions	$-Com^A$		$-Com^F$		$-Com^H$	$+Com$				0
Insurance	$-Ins^A$		$-Ins^F$		$-Ins^H$	$+Ins$				0
Interest on Advances						$-IntA$	$+IntA$			0
Remittances					$+Rem$				$-Rem$	0
Central Bank Profits							$-F^{CB}$	$+F^{CB}$		0
Taxes on Income and Profits	$-T^A$		$-T^F$		$-T^H$	$-T^B$		$+T$		0
Social Contributions					$-WSC$			$+WSC$		0
Social Benefits					$+GE$			$-GE$		0
Transfers			$-Transf^F_G$		$+Transf^G_H$	$-Transf^B_G$	$-Transf^{CB}_G$	$+Transf_G$	$-Transf^W_G$	0
Bank Dividends					$+Div^B_H$	$-Div^B$		$+Div^B_G$	$+Div^B_W$	0
NFC Dividends			$-Div^F$		$+Div^F_H$			$+Div^F_G$	$+Div^F_W$	0
Retained Earnings		$+RE^A$		$+RE^F$		$+RE^B$	0			$[RE]$
[Capital]		$[K^A]$		$[\dot{K}^F]$	$[K^H]$			$[\dot{K}^G]$		$[\dot{K}]$
[Inventories]				$[\dot{V}^F]$						$[\dot{V}^F]$
Domestic Currency Deposits			$+\dot{Dep}^F_D$		$+\dot{Dep}^H_D$	$-\dot{Dep}_D$			$+\dot{Dep}^W_D$	0
FX Deposits			$+\dot{Dep}^F_{FX} \cdot e^N$		$+\dot{Dep}^H_{FX} \cdot e^N$	$-\dot{Dep}_{FX} \cdot e^N$			$+\dot{Dep}^W_{FX} \cdot e^N$	0
Gov Deposits at the CB							$-Dep^{\dot{G},cur}$	$+Dep^{\dot{G},Cur}$		0
Domestic Currency Loans	$-\dot{L}^A_D$		$-\dot{L}^F_D$		$-\dot{L}^H$	$+\dot{L}_D$				0
Bonds					$+\dot{B}^G_H$	$+\dot{B}^B_G$	$+\dot{B}^G_{CB}$	$-\dot{B}^G$		0
Advances						$-\dot{Ad}$	$+\dot{Ad}$			0
Foreign Direct Investment			$-FDI^F \cdot e^N$			$-FDI^B \cdot e^N$			$+FDI^W \cdot e^N$	0
Domestic Currency Reserves						$+\dot{R}_D$	$-\dot{R}_D$			0
Banks FX Reserves						$+\dot{R}^B_{FX} \cdot e^N$	$-\dot{R}^B_{FX} \cdot e^N$			0
FX Reserves							$+\dot{R}_{FX} \cdot e^N$		$-\dot{R}_{FX} \cdot e^N$	0
Intermediate FX Loans			$-\dot{L}^F_{FX} \cdot e^N$			$+\dot{L}^F_{FX} \cdot e^N$				0
RoW FX Loans						$-\dot{L}^B_{FX} \cdot e^N$		$-\dot{L}^{G,Tot}_{FX} \cdot e^N$	$+\dot{L}_{FX} \cdot e^N$	0
Σ	0	0	0	0	0	0	0	0	0	0

Table 2: Transaction Flow Matrix

Variable	Agri	NFC	Households	Banks	CB	Government	RoW	$+\sum$
Capital stock	$+K^A$	$+K^F$	$+K^H$			$+K^G$		K
Inventories		$+V^F$						V^F
[Non-Financial Assets]	$+NFA_A$	$+NFA_F$	$+NFA_H$	$+NFA_B$	$+NFA_{CB}$	$+NFA_G$	$+NFA_W$	NFA
Domestic Currency Deposits		$+Dep_D^F$	$+Dep_D^H$	$-Dep_D$			$+Dep_D^W$	0
FX Deposits		$+Dep_{FX}^F \cdot e^N$	$+Dep_{FX}^H \cdot e^N$	$-Dep_{FX} \cdot e^N$			$+Dep_{FX}^W \cdot e^N$	0
Government Deposits at the CB					$-Dep_D^{G,cur}$	$+Dep_D^{G,cur}$		0
Domestic Currency Loans	$-L_D^A$	$-L_D^F$	$-L^H$	$+L_D$				0
Bonds			$+B_H^G$	$+B_G^B$	$+B_{CB}^G$	$-B^G$		0
Advances				$-Ad$	$+Ad$			0
Foreign Equity		$-EQ_F^W$		$-EQ_B^W$			$+EQ^W$	0
Domestic Currency Reserves				R_D	$-R_D$			0
Banks FX Reserves at CB				$+R_{FX}^B \cdot e^N$	$-R_{FX}^B \cdot e^N$			0
FX Reserves					$+R_{FX} \cdot e^N$		$-R_{FX} \cdot e^N$	0
Intermediate FX Loans		$-L_{FX}^F \cdot e^N$		$+L_{FX}^F \cdot e^N$				0
RoW FX Loans				$-L_{FX}^B \cdot e^N$		$-L_{FX}^{G,Tot} \cdot e^N$	$+L_{FX}$	0
Other				$-Other^B$			$+Other^B$	0
[Financial Assets]		$+FA_F$	$+FA_H$	$+FA_B$	$+FA_{CB}$	$+FA_G$	$+FA_W$	0

Table 3: Balance Sheet of the Tunisian Economy.

5.1.2. Price determination

The productive sector charges a range of different prices. The model distinguishes between producer prices and usage prices, i.e. intermediate consumption, final consumption and investment, by the type of good, i.e. agricultural, processed-food and non-food good. It further distinguishes commodity specific international import and export prices. Firms set target producer prices based on a markup over historical unit costs and gradually adjust to these targets, with a relaxation speed inversely proportional to nominal rigidity, capturing price inertia. Then, the different composite usage prices follow producer prices, after considering all the relevant taxes, subsidies and margins, and accounting for the import shares of intermediate and final consumption, and the corresponding effects of world prices and the nominal exchange rate. The agricultural markup is fixed. The markups on processed food and non-food goods depend negatively on the divergence between the actual and a desired inventory to output ratios. Thus, as unwanted inventories accumulate, producers reduce the mark-ups (and vice versa). Note that by separately tracking down the different prices, the model computes food inflation and also household CPI inflation through a CPI index, which depends on the consumer prices of each product and their corresponding, time-varying relative shares in the consumption bundle of households.

5.1.3. Financing Investment

As stated above, the agricultural sector's investment is determined by the constant capital to output ratio and the exogenous, climate dependent, production trajectory. NFC firms' investment decisions depend on sectoral profitability, which is captured by the real rate of profit. The model tracks down explicitly the formation of gross operating surplus from both processed food and non-food good production processes, including the good-specific margins, subsidies and taxes on production[7]. Gross profits are defined after considering the interest received on their deposits, interest paid on their serviceable domestic and foreign currency loans, insurance and commissions that firms pay to the banking sector. Net profits is the residual after firms pay corporate taxes. Net of inflation, net profits form the profitability of the sector. Then, firms distribute part of the profit to domestic and foreign investors as dividends.

[7] In reality, part of production takes place in households and therefore household producers also generate gross operating surplus. The model assumes that all production takes place in firms. In order then to match empirically the national accounts and especially the sectoral saving positions, a proportion of the gross operating surplus that is generated by firms is distributed to households, which is then taxed by the government alongside their other sources of income.

Firms finance investment through retained earnings and external finance. They further require funding to keep deposits in both domestic and foreign currencies for working capital. Firms desire to finance a constant proportion of their total financing needs through FX denominated loans. The model assumes that credit provision in foreign currency is rationed, and only a fraction of the desired credit is provided by the banking sector in FX. The remaining financing needs are satisfied through credit provisioning in the domestic currency.

5.2. Banking Sector

5.2.1. Credit Rationing and Interest Rates

As mentioned above, banks hold saving and current account deposits, provide foreign and domestic currency loans, provide insurance to companies and receive commissions for their services. They also hold government bonds as collateral. A key variable determining the availability of credit and the liquidity of the FX loan market is country risk. Indeed, both the rationing of credit volume and the interest rates charged on FX loans depend on country risk. In turn, the country risk is a convex function of the country's international investment position (ignoring foreign-owned equity of domestic firms), highlighting the sensitivity of small open economies such as Tunisia to the perceived sustainability of the external debt by international investors.

The cost of foreign currency denominated private debt depends on a premium over the world interest rate and is a convex function of the country risk. The target interest rate that banks pay on deposits is determined by a markdown from the policy rate set by the central bank. The markdown, in turn, depends on the liquidity needs of the banking sector, and increases as the banking sector's asset side of the balance sheet expands relative to liquidity needs, captured by the the bank's assets-to-advances ratio. In addition, the domestic target lending rate depends on the domestic premium over the average cost of funding for banks. The domestic premium in turn depends on the ratio of debt to gross operating surplus of the NFC sector. If the private debt burden is high relative to the profitability of the sector's main economic activity, banks will raise the interest rate to compensate for a higher perceived risk of default. For simplicity, it is assumed that the lending interest rate charged to households is a constant markup over the lending rate charged to firms. Actual effective rates gradually adjust to targets with relaxation speeds that depend on the inverse of the average maturity of loans/deposits.

5.2.2. Banks profits, non performing loans and leverage

Banks make profits from the interest they receive on serviceable loans from the private sector, coupon payments on government bonds, commissions and insurance, after deducting their funding costs, i.e. interest paid on saving deposits and advances, wages and salaries of persons employed in the banking sector, employers' social contributions, intermediate consumption and other transfers to the government. We also assume that insurance services to the productive sectors of the economy are constant proportions of the nominal value of the capital stock in each sector. It is also assumed that commissions are proportional to the total debt of the private sector, including households. As in other sectors, gross profits are taxed by the government. Part of net profits is distributed to domestic and foreign shareholders through dividends, and the retained earnings increase banks' own funds to satisfy a risk-weighted target capital ratio (Bank for International Settlements, 2017). Note that a fraction of agricultural loans, mortgages and corporate loans is non-performing (NPLs). The lower the level of economic activity, as measured by unemployment and real GDP growth, the higher is the proportion of NPLs. Inflation tends to reduce the amount of NPLs, as higher nominal incomes make it easier to meet payment obligations. Finally, a higher return on equity allows banks to finance less risky investment projects, thereby reducing the likelihood of non-performing loans (Messai and Jouini, 2013; Abid et al., 2014; Romdhane and Kenzari, 2020). Note that employment in the banking sector is a constant fraction of active population.

In reality, banks receive interest on serviceable loans and pay interest on savings deposits, as recorded in the TFM 2. Note however, that in the national accounts, the output of the financial sector includes financial intermediation services indirectly measured (FISIM). FISIM is an accounting convention that aims to capture financial intermediation and divides interest payments as follows. An amount that corresponds to the interest charged by banks for providing loanable funds to investors, calculated as the interest payments resulting from a rate spread between the lending rate and the reference (policy) rate, plus an amount that corresponds to the interest banks pay to savers, calculated as the interest payments from a rate spread between the deposit rate and the reference rate. Put simply, if credit operated through a loanable funds market and if savings and investment equilibrated through the natural rate, FISIM would correspond to what banks would charge (markup) to investors plus what banks would retain from savers (markdown), over the natural rate of interest. National accounts then proceed by distributing FISIM as final and intermediate consumption of financial services by non-financial corporations and households and treat it as gross value added from financial intermediation. The remaining interest payments not recorded as FISIM, i.e. interest paid on deposits and received on loans, calculated using the reference rate, is then recorded under the primary distribution of income accounts[8].

However, it is well established that banks do not act as intermediaries in a loanable funds market when providing domestic currency loans (McLeay et al., 2014). Indeed, because of the model's endogenous money framework, there is no reason to treat banks as intermediaries. We therefore consider all the FISIM recorded in the national accounts as a margin on interest rates and shift it to interest payments. Consequently, the gross operating surplus and the value added generated by the banking sector differ from the national accounts and therefore are not reported, and nominal GDP is measured only through final expenditure. Since we treat the banking sector as a non-productive sector, we underestimate nominal GDP by an amount equal to FISIM paid to households plus commissions and insurance costs of households [9]. In order then to match empirically the nominal GDP, we add to final expenditures the missing financial consumption, i.e. insurance services and commissions paid by households and household FISIM (see equation 267 and 268 in the Appendix).

5.3. Government and the Central Bank

5.3.1. Government expenditure and financing

The government provides public services by employing a constant proportion of the total population as public servants. It also invests in public capital at a constant rate, and in adaptation (irrigation mainly as we will discuss below) depending on the climate change scenario simulated. Total government output is therefore composed of the labour costs of government employees, total public intermediate consumption, employer's social contributions paid by the government and depreciation of public capital, as in System of National Accounts (SNA). Government also provides social benefits and welfare programmes, which are assumed to be pro-cyclical, depending on the unemployment level and the average private wage level. Total public expenditure is given by the sum of public employees' wages and employer's social contributions, intermediate consumption inputs, social benefits, investment in public capital and adaptation, and interest paid on outstanding public debt.

Government revenue is determined by the sum of employers' social contributions, workers'

[8]See (Zezza and Zezza, 2019) for a similar discussion.

[9]The FISIM that accrues to NFCs and the commission and insurance services consumed by NFCs increase the gross value added of banks by the same amount that they reduce the gross value of firms so they do not need to be added to the nominal GDP calculations from the demand side.

social contributions, VAT in the three goods of the economy, import taxes, taxes on production and other taxes on products, dividends from public enterprises, central bank profits, and income taxes. The public deficit is financed by borrowing. First, the government borrows part of its total financing needs as foreign currency (FX) denominated loans at a constant proportion of the trade deficit[10], and the remaining needs are financed by domestic currency bonds. It is assumed that the interest rate on foreign currency public bonds depends on the country risk, while the interest rate on the domestic currency bonds depends on the ratio of public debt to GDP and CPI inflation.

As with the banking sector, we treat the public sector as a non-productive sector. This means that production, and hence final and intermediate consumption of public services as measured by the NSA framework, is not explicitly tracked in the TFM. Therefore, in order to track nominal GDP, we add to final expenditure the nominal depreciation of the public capital stock, the employer's social contributions paid by government, public wages and government's intermediate consumption to account for the production and therefore final consumption of public services.

5.3.2. Central Bank

The central bank follows a pure inflation-ratgeting Taylor rule when setting the policy rate and acts as lender of last resort to the banks, providing liquidity to the banking sector on demand through central bank advances. It also buys a fixed fraction of public bonds at each point in time. Any profits made by the central bank are distributed to the government.

5.4. Households

5.4.1. Labour Market and Wage Bargaining

Employment in the model is demand driven by market conditions, and partly supply constrained, by climate change. As explained above, employment in the agricultural sector is driven by climate change, and a component of demand for processed food, i.e. exports, is also directly affected by climate change. For the rest of the productive activities, expected sales determine production and therefore employment.

The model does not identify distinct social classes within the household sector. However, to capture the different positions in the system of production, we distinguish between two sources of income. First, households earn net disposable wage and production income from the employed persons in the private and public sectors, after considering the income taxes, social benefits and workers' social contributions. Second, households earn net financial income in the form of dividends and profits from the productive and banking sectors, interest income on savings and current deposits and remittances from the rest of the world. Non-wage income is net of interest paid on serviceable household debt, commissions and insurance paid to banks.

In all the sectors, i.e. agriculture, NFCs, banks and government, nominal wages are fully indexed to inflation and productivity growth, keeping real wages constant.

5.4.2. Consumption and Savings

Households have a target level of nominal consumption, which depends on a time-varying marginal propensity to consume out of nominal income; the propensity is a negative function of the real deposit rate as households have an incentive to save more when the deposit

[10] The decision on what proportion of new debt will be in foreign currency depends on a number of factors and considerations, such as arbitrage opportunities, risk management and other policy objectives. We disregard these considerations in this long-run model and use a fixed ratio for public FX borrowing to the trade deficit

rate is higher. Actual consumption adjusts gradually to its target, with a relaxation speed that captures habit formation. Once total consumption is determined, households allocate their income between agriculture, processed food and the non-food good through a linear expenditure system (LES) as in Lluch (1973). However, with fixed marginal budget shares, LES violates Engel's law that marginal income elasticities of food must decrease with growing income (see Ho et al. (2020)). We, therefore, assume that the marginal budget shares of agricultural and processed food are negative functions of real consumption. Households also have a target investment in housing, defined as a fraction of their total net disposable income, and actual household investment gradually adjusts to this target. A constant proportion is financed through banking lending and the rest through the net disposable income.

Households distribute their savings in foreign currency deposits, saving and current account deposits in domestic currency and government bonds. Foreign currency deposits are a share of total remittances received from abroad and current account deposits are a share of consumption for transaction purposes. A constant share of the remaining savings is invested in government bonds and the residual savings are held as saving account deposits in domestic currency.

5.5. Balance of Payments and Exchange Rate Dynamics

The foreign exchange market is characterised by a disequilibrium between the flow of foreign exchange demand and supply, as in Charpe et al. (2011). Therefore, the nominal exchange rate, measured as domestic currency per unit of foreign currency, increases (decreases) with excess demand (supply). Total demand for foreign exchange is given by the sum of imports, the income account, i.e. the interest payments on foreign exchange debt and dividends paid to the rest of the world, and the flow demand of the banking sector, which is determined by the 'no-FX-open position' requirement. Total foreign exchange supply is given by the sum of exports, FDI flows, remittances and other transfers from abroad, cross-border credit and foreign exchange deposit inflows to the private and government sectors and, depending on the simulated scenario, concessional loans to the government that finance public adaptation investment.

The stock-flow consistent structure of the model is particularly suitable for studying external imbalances, the vulnerability of countries to financial crises and the macro-environmental channels that can propagate the environmental damages, since the model tracks not only the evolution of current account imbalances and the first-round negative effects of climate damages on the trade balance, but also the gross exposure to external financial risks, which is usually neglected when assessing external imbalances (Borio and Disyatat, 2011, 2015). The latter is explicitly tracked by the endogenous international investment position, as well as by the dynamics of available foreign exchange reserves. Furthermore, the multisectoral structure allows for a detailed examination of how such financial risks are distributed within the country through the accumulation of external debt in the balance sheets of all institutional sectors, and allows for detailed feedback effects such as price effects, through the evolution of the interest rates, and quantity effects, such as the quantity rationing in the foreign exchange market, the evolution of domestic non-performing loans and the overall indebtedness of the Tunisian economy.

6. Calibration

In order to calibrate the parameters of our model we utilize a wide variety of economic data, listed in Table 4. The Covariance Matrix Adaptation Evolution Strategy (CMA-ES) (Hansen and Auger, 2011) is used to empirically fit the model to Tunisian macroeconomic and financial data for variables for which we have a satisfactorily large dataset. The CMA-ES is a stochastic, evolutionary optimisation algorithm that is appropriate for the calibration of complex, nonlinear systems of differential equations as it allows for an efficient exploration of the parameter space. Using a block approach and taking into account the available data, the calibration of the parameters was carried out for five blocks relating to production and pricing in processed food and non-food good sectors, consumption, imports, exports, and non-performing loans. The iterative procedure that was utilised in the calibration processes is the following. An objective function is defined, which measures the difference between the model's prediction and actual data. Then, the parameter space is defined through a range of plausible parameter values. A vector of parameter values is randomly initialised and the system is simulated through a 4th order Runge-Kutta method. The candidate solutions are evaluated and based on their fit, the mean and covariance matrices of the parameter distribution are updated. Then, a new parameter vector is sampled from the updated distribution. The last two steps are iterated until the algorithm converges to a satisfactory solution. We provide a complete list of parameters in the Appendix, with their values, definitions and how they were obtained. For parameters for which an estimation was not possible due to the lack of a large enough sample, we used the data at the initial point of simulations for calibration to ensure that the model replicates the economic data as precisely as possible.

Source	*Data-set*
National Institute of Statistics (INS)	Integrated Economic Accounts (IEA), Macroeconomic Aggregates, Supply-Use Table, Flow of Funds (FoF), Population and Labour Market Statistics
Central Bank of Tunisia	Balance of Payments (BoP), International Investment Position (IIP), Net Banking Products, Exchange Rates, External Debt, Loans by sector, Bonds and Interest Rates Statistics
Ministry of Agriculture/National Observatory of Agriculture	Domestic production by commodity in Agriculture Sector in quantity (Tonnes) and Value(Tunisian Dinar), Commodity prices
Ministry of Finances	Public Debt, Public financial indicators, Taxes on profits and income
UN COMTRADE, World International Trade Solution (WITS)	Imports/Exports commodity in quantity and value (HS-6 digits, Imports/Exports Commodity prices in Dollar, Imports share for consumption, intermediate consumption and investment by sector(A, PF and F)
Penn World Table(PWT)	Labor productivity in Tunisia and the Rest of the World
International Monetary Fund	Financial Soundness Indicators (FSI), Integrated Monetary Statistics;Banks and Central Bank's Balance sheet

Table 4: Main datasets used to develop the SFC empirical model

7. Simulations

In order to simulate the effects of losses in agricultural output on the Tunisian economy, we make certain assumptions on the future evolution of the exogenous variables in the model. These variables and the different scenarios on their dynamics are listed in Table 5 below.

For our initial analysis, we construct three different scenarios: The business as usual scenario (BAU) defined above with no change in current macroeconomic policies; an optimistic scenario in which we take into account the losses in agricultural production under the RCP 8.5 projections but assume that food prices rise in line with general world inflation (scenario RCPLI); and a pessimistic scenario in which we assume that food price inflation exceeds general world CPI inflation over the next three decades (scenario RCPHI).[11] Table 5 displays the smoothed annual growth rates associated with Figure 4b of agricultural production for consumption (gr_{ypac}), for intermediate consumption (gr_{ypaic}), for exports (gr_{ypaw}) and growth rate of processed food exports (gr_X^{PF}). For all scenarios, we set the world inflation rate of non-food goods ($Inf^{NF,w}$) at three per cent, which is the average of the last two decades. Throughout the simulations, we assume that the terms of trade for all goods remain the same, so that inflation in imports of non-food ($inf^{NF,w}$), processed food (($inf^{PF,w}$)) and agricultural goods for consumption ($Inf_C^{A,w}$) and intermediate consumption ($Inf_{IC}^{A,w}$) are equal to inflation in the prices of exports of these goods (Inf_X^{NF}, Inf_X^{PF} and Inf_X^{A} respectively). We calibrate the labour productivity growth function (see Appendix, equations 248-249) to set its value (gr_a) equal to its average value over the last two decades in Tunisia at 1.5%. We also assume no catching-up or lagging in terms of labour productivity growth between Tunisia and the rest of the world and thus we also set the growth rate of labour productivity in the rest of the world (gr_{aw}) at 1.5%. The growth rate for the world economy (gr_w) is fixed around its average value in the last two decades at three per cent in all the scenarios. For Tunisia's population growth rate (α_{pop}), we use UN's 'high variant' scenario projections with an additional assumption that labour force participation rate increases by 4 % over the next three decades and we smooth the growth rate to 0.7 % per year.

Variable	*BAU*	*RCP8.5 Low Inf (RCPLI)*	*RCP8.5 High Inf (RCPHI)*
gr_{ypac}	0.97%	-0.36%	-0.36%
gr_{ypaic}	1.3%	-0.13%	-0.13%
gr_{ypaw}	1.45%	-0.53%	-0.53%
gr_X^{PF}	1%	-0.37%	-0.37%
$Inf^{NF,w}$	3%	3%	3%
$Inf_C^{A,w}$	3%	3%	5.5%
$Inf_{IC}^{A,w}$	3%	3%	5.5%
$inf^{PF,w}$	3%	3%	5.5%
Inf_X^{NF}	3%	3%	3%
Inf_X^{PF}	3%	3%	5.5%
Inf_X^{A}	3%	3%	5.5%
gr_a	1.5%	1.5%	1.5%
gr_{aw}	1.5%	1.5%	1.5%
gr_w	3%	3%	3%
α_{pop}	0.7%	0.7%	0.7%

Table 5: Exogenous Variables for all scenarios.

The graphs of figure 6 show the results of the simulations for the BAU and the two RCP 8.5 scenarios (RCPLI and RCPHI) described above.[12] Our BAU scenario gradually stabilises just below 13% unemployment rate and general inflation falls below 5%. Both agricultural and processed-food inflation remain close to the general inflation rate. Similarly, economic growth is above 2% in the long run, in line with population and general productivity growth. In the long run, the public deficit is around 5% of GDP and the public debt stabilises at 90% of GDP. Starting from over 13% of GDP in early 2018, the trade deficit settles around 9% in the long

[11] This is essentially the disturbing observation of the last decade, as documented by Bogmans et al. (2021).

[12] We do not bring the economy to a steady state, but simulate the model starting from the actual values of the Tunisian economy at the end of 2017. Therefore, the disequilibrium adjustment processes lead to fluctuations in the model before stabilising. In fact, without lagging productivity growth relative to the rest of the world and due to the large depreciation of the nominal exchange rate relative to domestic inflation, the real exchange rate depreciates at the start of all simulations, leading to an export-led growth spurt that stabilises as the macro-financial feedback loops take effect.

run, leading to a current account deficit of roughly 7% of GDP. As the external deficit settles down to its long-run value, the country slowly accumulates foreign exchange reserves, which reach just over four months of imports in the long run. Finally, food imports as a share of GDP stabilise close to 4% of GDP in the BAU scenario and per capita income, measured in 2017 Euros, rises steadily to 6000 Euros.

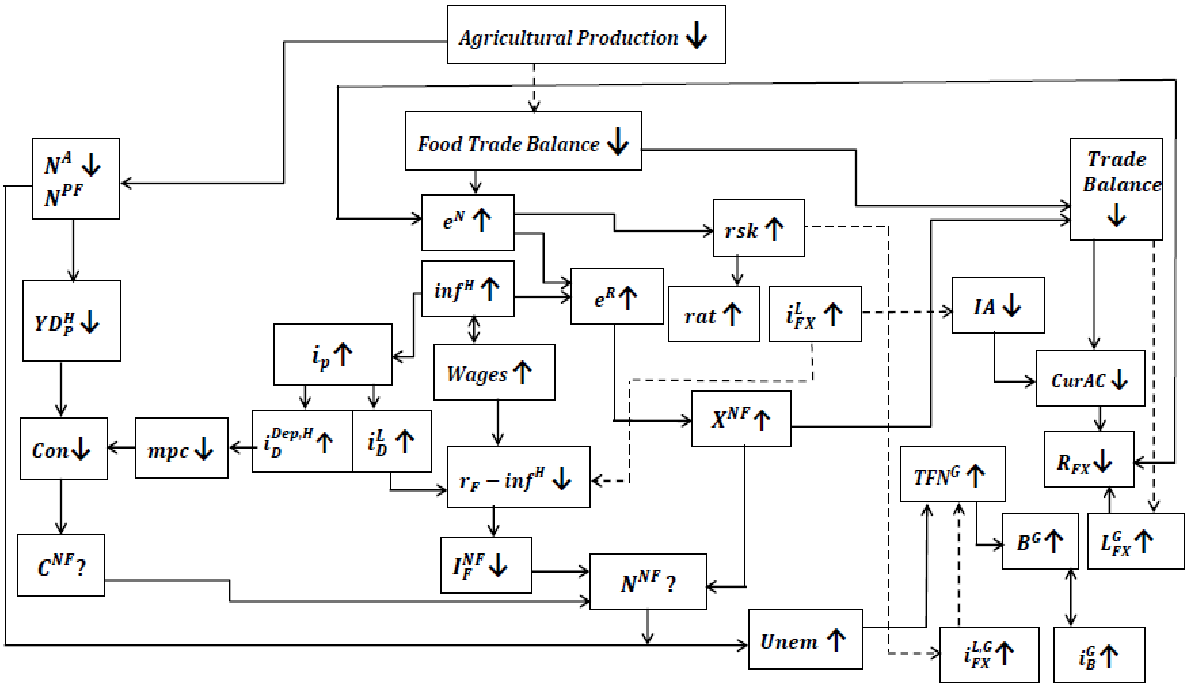


Figure 5: Transmission of Loss of Agricultural Production

Figure 5 summarises the main propagation mechanisms following a continuous decline in agricultural production due to climate change. Because we assume a constant rate of productivity growth in the agricultural sector, in line with the rest of the economy, falling agricultural production leads to an decrease in employment in the agricultural and processed food sector, which reduces household income. This fall in household income leads to a fall in overall real consumption. However, the dynamics of real consumption of food, processed food and non-food goods is ambiguous due to the linear expenditure specification of the consumption allocation decision. On the one hand, lower real consumption levels under RCP 8.5 lead to higher marginal budget shares of food and processed food and a lower marginal share of non-food goods in consumption. On the other hand, real consumption of food and processed food falls because price inflation for these goods is higher than for non-food goods under RCP 8.5 due to the high cost of imported food. As a result, the overall impact on real consumption of non-food goods depends on the magnitude of these effects. In our simulations, this mechanism has an overall positive impact on the real consumption demand for non-food goods under the RCPHI scenario (but not RCPLI), mitigating the negative impact of lower household incomes. However, with higher food prices, the overall share of agro/processed food products in the household consumption basket is higher under both RCPLI and RCPHI scenarios, despite lower real consumption demand for these goods. In other words, households consume less food and spend a higher proportion of their total consumption expenditure due to climate change.

Lower agricultural production and the growing demand for agricultural and processed food commodities also push agricultural imports above BAU levels, which are much higher in

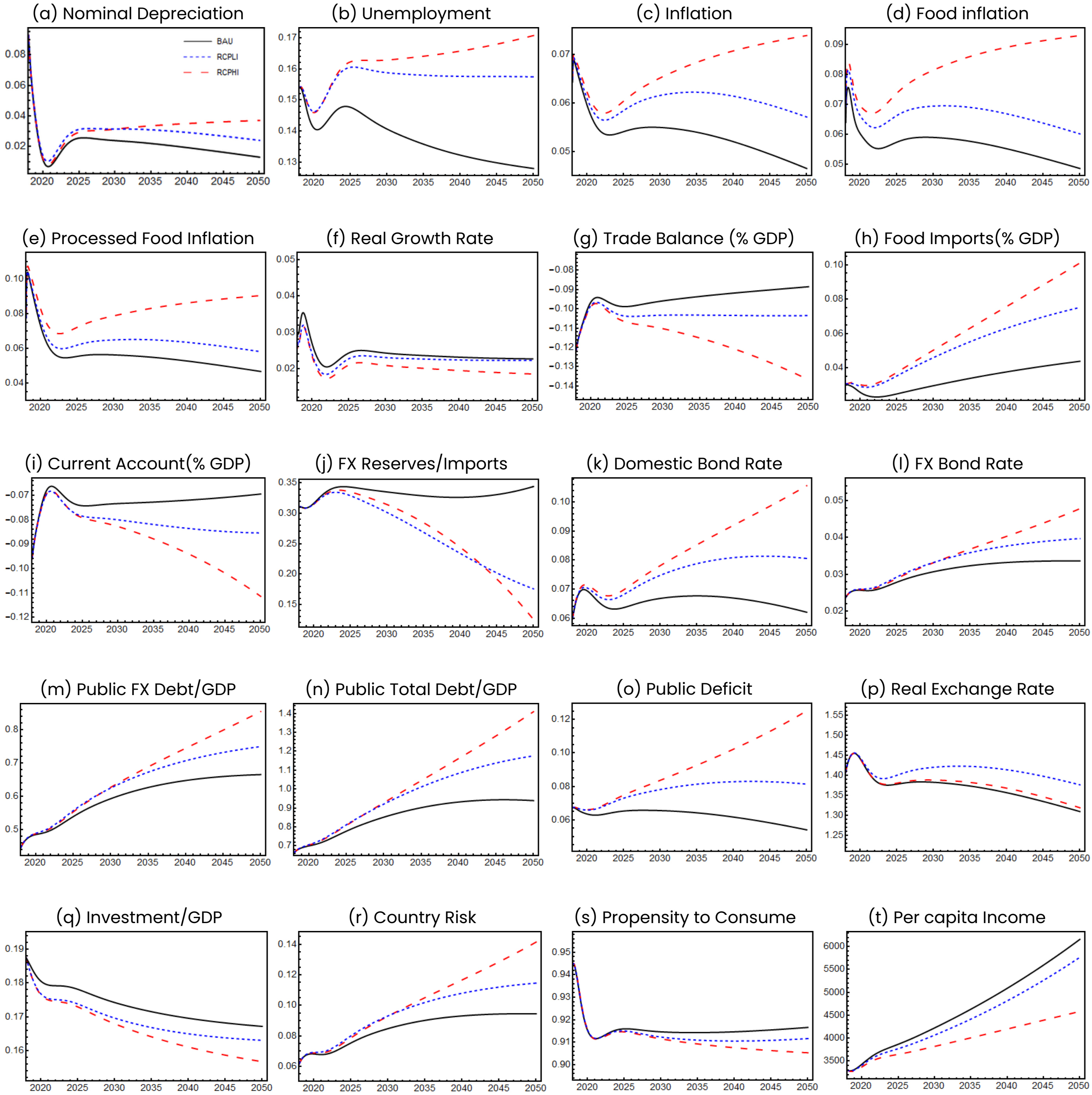


Figure 6: Simulation results for selected variables. Source: authors' computations.

nominal terms in RCPHI with elevated global food price inflation. Demand for foreign exchange is also higher with a higher trade deficit driven by food imports, and given our assumption that the government borrows a fixed proportion of the trade deficit in foreign exchange, part of this additional demand for foreign exchange is met by public sector foreign exchange borrowing. However, the nominal exchange rate still depreciates faster than in the BAU, pushing up inflation.

Rising inflation has several effects on the economy. On the one hand, higher inflation pushes up policy rates, pushing up real deposit rates and lending rates in domestic currency. While higher real deposit rates reduce the marginal propensity to consume, leading to a further decline in consumption demand, higher debt financing costs reduce the rate of profit, leading to lower investment. On the other hand, due to the imperfect pass-through of nominal exchange rates to domestic inflation, the real exchange rate depreciates more relative to BAU, reducing the propensity to import non-food goods and triggering higher export demand for non-food goods. The overall impact on demand for non-food goods is thus determined by the magnitude of these effects on consumption, investment and exports. Although in our simulations the positive effect of higher export demand outweighs the negative effects on consumption and investment under RCPLI and non-food producers employ a slightly higher percentage of the labour force than in the BAU, this additional employment in the non-food sector is far from compensating for the decline in employment in agriculture and processed food, and the overall unemployment rate rises significantly [13].

While real depreciation-induced export growth mitigates higher unemployment as mentioned above, rapid nominal exchange rate depreciation has even more serious consequences for the external position and fiscal balances both by pushing up the already high external debt-to-GDP ratio and by increasing country risk and thus the associated financial accelerator effects. Higher country risk raises foreign exchange borrowing rates for both the government and firms, while at the same time leading to greater rationing of NFCs by international markets and reducing the supply of foreign exchange. The income account deteriorates as a result, putting further pressure on an accelerating current account deficit and eroding foreign exchange reserves.[14] Combined with higher overall unemployment, lower growth, lower tax revenues and higher borrowing rates, the government's overall financing needs soar, pushing up public debt further.

The dynamics of the economy under falling agricultural output are shown in Figure 6, together with the BAU, to illustrate the magnitude of these effects. Clearly, the effects of loss of agricultural output are very severe on the Tunisian economy, whether global food inflation remains low or not. However, as expected, the consequences are much direr if global food prices increase rapidly in the next three decades. Under the RCPHI scenario, unemployment exceeds 17 % in the long run, with both food and processed food imports moving towards two-digit levels in the long-run. Trade deficit explodes above 13 %, driven by high level of food imports. Similarly, current account deficit sets on an unsustainable path, as the country runs the risk of a looming currency crisis with a depletion of FX reserves. Public deficit and public debt levels indicate rising possibility of a default on public debt, as debt to GDP ratio exceeds 140 % in the long-run, with no sign of stabilizing [15]. Per capita income, measured in 2017 Euros, barely grows until 2050. In short, all else equal, no-action against climate change paves the way for an almost certain economic crisis for Tunisia under rapidly rising global food prices.

8. Adaptation Policy

Next, we simulate two different adaptation policy scenarios envisaged by the Tunisian government and outlined in the 'Water 2050 Plan' (Jeff et al., 2020). While this plan includes several different adaptation scenarios, we chose to simulate two of them, namely the Reinforced Tendency Scenario (RTS) and the Water and Development Scenarios (WDS). Table 6 summarises the main assumptions behind these scenarios. In the RTS, economic growth remains around its 2018 value at 2.5%. Similarly, the water elasticities of production in

[13]Under the RCPHI Scenario, employment in the non-food sector also falls below the BAU levels.

[14]Note that we have not imposed any rationing of government FX borrowing, and the higher FX demand caused by higher trade deficits is partly met by government FX borrowing, as the government borrows a fixed proportion of the trade deficit in FX.

[15]Note that we have not assumed any rationing on public FX borrowing to show the implications of climate change on public finances clearly. With such elevated debt levels, the public sector may face high rationing in FX-borrowing, causing a currency crash

manufacturing and services remain at their observed values in 2020, while water elasticity of agricultural production is assumed to fall to 0.2. In such a case, agricultural production can only grow by 1% per year, despite a strong adaptation investment plan to increase water resources, as the available water supply is mainly consumed by the industrial and service sectors and thus cannot support a higher agricultural growth rate. In the WDS scenario, on the other hand, a much more efficient water use strategy in these sectors significantly reduces the water elasticities of production in all sectors, allowing agricultural production to grow by 3.5% per year, alongside an overall economic growth rate of 4.3% per year [16].

Variable	*Reference (2020)*	*Reinforced Tendency*	*Water and Development*
GDP growth (2021-2050)	2.5%	2.5%	4.3%
Agriculture	1.8%	1%	3.5%
Industry	1.1%	2%	4%
Tourism	3.4%	2%	4%
Services	3.2%	3%	4.5%
Water Elasticity of GDP	0.52	0.5	0.1
Agriculture	0.42	0.2	0.15
Industry	0.6	0.6	0.1
Services	0.5	0.5	0.1
Water Resources (Mm3)	4985	4622	4594
Conventional	4929	3745	3968
Non-Conventional	66	877	626
Desalination	39	752	376
Waste Water Management	27	125	250

Table 6: Adaptation Scenarios

In line with the Water 2050 plan, we assume that public and private adaptation investments are both 1.1% of GDP, and that public investment has a very high import propensity of 60%, as it involves the construction of desalination and wastewater management plants, some of which will be solar-powered. It is also assumed that the public adaptation investment will be financed by foreign exchange loans at a fixed rate of 1.7%, which is the interest rate on the loan for the Sfax desalination plant currently under construction (Japan International Cooperation Agency, 2017). In our model, the medium- and long-term growth rate of the economy depends strictly on the growth rate of labour productivity. Thus, to achieve the high growth rate envisaged in the WDS, we assume that public investment grows at a much higher rate than in previous scenarios, at 4.5%, and that efficient investment in areas such as infrastructure, health, R&D and education gradually raises the growth rate of labour productivity to over three per cent per year by 2050. This is in line with the endogenous growth literature, as detailed in Agenor and Yilmaz (2012, 2016), and observed by the IMF (Xiao and Le, 2019).

Figure 7 shows the results of the simulations for BAU, RCPHI, RTS and WDS.[17] The gradual increase in labour productivity, driven by public investment, and the rapid growth in agricultural production have significant positive effects on macroeconomic dynamics, despite the high level of adaptation investment and the high import propensity under the WDS. Unemployment

[16] The adaptation plan does not specify the growth of agricultural goods for consumption, intermediate consumption or exports. Thus, in our simulations, we set the growth rate of these equal to the general growth rate of agricultural production under each adaptation scenario.

[17] In order to ensure that the share of agricultural employment remains within reasonable limits under the WDS scenario, we assume that labour productivity growth in the agricultural sector is equal to the growth rate of agricultural output at 3.5%.

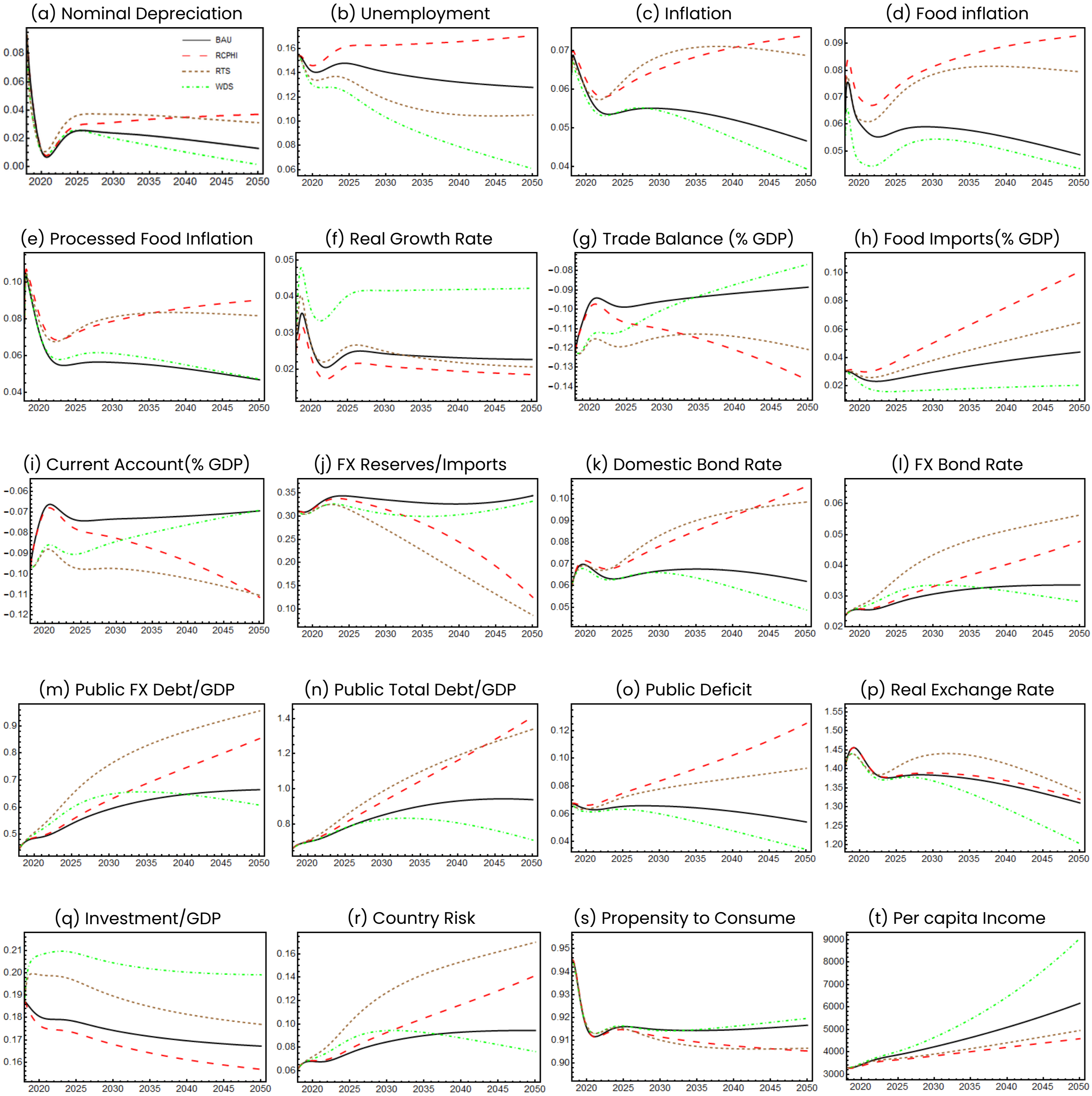


Figure 7: Adaptation Simulations for selected variables. Source: authors' computations.

falls steadily to 6% by 2050 and general consumer price inflation is brought down to below the BAU levels, around 4%[18]. Similarly, processed food price inflation remains just below to BAU scenario, slightly above general inflation while agricultural goods inflation is lower tha baseline throughout the simulation period. Economic growth initially fluctuates (driven by

[18] Borio (2014) proposes a distinction between non-inflationary (potential) output and sustainable output, the latter depending on systemic macro-financial developments and external imbalances. Our model simulations support this modelling feature.

the export-led growth, as discussed above) to settle at 4.2%, in line with the WDS projections. Exports grow strongly due to high productivity growth, and imports of intermediate and capital goods fall steadily, improving the trade balance to around 7% of GDP. The income account also improves slightly, leading to a current account deficit just below 7% in the long term.[19] After a slight decline in the first decade, foreign exchange reserves as a share of imports are set on an increasing path towards sustainable levels in the long term.[20] Despite the increase in foreign currency loans to finance adaptation investment, the total foreign currency debt-to-GDP ratio is set on a declining path after initially rising, falling below BAU levels to just under 60% in the long run, thereby reducing country risk and interest rates on public foreign currency borrowing and eliminating the unsustainable accumulation of foreign debt in RCPHI. High tax revenues and low unemployment lead to a sustained decline in the public sector deficit to 3.5% and in the public debt/GDP ratio to 70% in the long run. Per capita income, measured in 2017 Euros, rises rapidly to 9000 Euros by 2050 as food imports fall below two per cent of GDP, moving Tunisia much closer to near-total food security.

The RTS, on the other hand, paints a very different picture. While the positive multiplier effects of public and private adaptation policies reduce unemployment below the BAU level, the currency depreciates sharply compared to all other scenarios, keeping general, food and processed food inflation close to the high inflation scenario. Despite the positive impact of the real depreciation on non-food trade, low overall productivity growth, high import costs of adaptation policies and increased food import costs due to a depreciated currency lead to a trade deficit of twelve per cent. Coupled with an exploding income account deficit, the current account deficit reaches eleven per cent of GDP and foreign exchange reserves as a share of imports fall below the RCPHI levels in the long run. Country risk also explodes to levels above RCPHI, bringing forth a much higher probablity of rationing on public FX borrowing. Due to the sluggish growth rate of the economy, public adaptation investment puts strong pressure on the budget deficit and public debt, as total debt first exceeds the high inflation scenario level and stabilizes in the long run at around the same level, with excessive external debt driving the increase. Per capita income growth also slows down to RCPHI levels, aggravated by the rapid depreciation of the nominal exchange rate.

9. Conclusion

Climate change will put significant pressure on agricultural production levels in Tunisia, reducing both production for domestic consumption and the two main export commodities, olives and dates. The costs of no action are severe in macroeconomic terms, and the NFC sector cannot compensate for the losses in rural employment and production if productivity growth remains sluggish relative to the rest of the world. The result is excessive fiscal and current account deficits, leading to unsustainable public/external balances and a looming currency crisis, especially if public financing of external deficits through FX borrowing dries up in the face of elevated country risk. The accumulation of such macroeconomic imbalances

[19] We have assumed that FDI remains a fixed percentage of NFC sector production throughout the simulations. We partly underestimate these inflows, as the favourable economic conditions under this high-growth regime may trigger an increase in FDI in the medium and long term, leading to a further improvement in the current account.

[20] Through these simulations, we kept the ratio of public FX borrowing to trade deficit constant, despite a falling trade deficit/GDP ratio. In essence, there is a constant need for coordinated monetary and fiscal policies to prevent currency appreciation and ensure FX reserve accumulation and public solvency. As is the case for all developing economies, real currency depreciation induced by central bank intervention in foreign exchange markets may reduce trade deficits at the cost of reducing per capita income in FX. However, the positive trade effects of real depreciation are limited, take time to materialise and are constrained by productivity growth differentials, the complexity of exports and the size of the tradable sector. On the other hand, depreciation immediately increases the domestic currency value of public and private FX debt, increasing country risk and the likelihood of public/private sector insolvency. While public FX borrowing may provide the economy with much-needed FX reserves, increases in public debt have a destabilising financial accelerator effect through domestic and FX bond interest rates, subsequently worsening the income account and leading to greater rationing of cross-border borrowing by firms or the government. These considerations call for much more sophisticated coordination between monetary and fiscal policy to ensure sustainable development than the simple borrowing rules we used in our model.

will be exacerbated if global food inflation is higher than general global inflation or if Tunisia's export partners grow slowly in the coming decades.

While policymakers have recognised the severity of the problem and have formulated long-term adaptation strategies that include investments in water supply, reducing losses in the distribution process and rehabilitating existing reservoirs, these strategies are costly and require the participation of the private sector in the process alongside the public sector. In addition, increasing water supply requires the construction of desalination and wastewater treatment plants, as well as energy resources to power these units, which in the country's current economic structure require import-intensive investments. Thus, the financing structure and costs of adaptation policies play a central role in determining their overall economic impact and effectiveness in stabilising the economy in the long run.

Even with the planned increases in water supply, the simultaneous achievement of water security and economic development will require significant reductions in the water elasticity of production in agriculture, industry and services through the adoption of water-efficient production techniques. These improvements should also be accompanied by rapid growth in economy-wide productivity levels. Efficient public investment in a large push effort to stimulate this productivity growth is therefore crucial. Our results show that economic development and water security are not orthogonal if such productivity-enhancing public policies are implemented together with water-efficient production methods and adaptation measures.

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A.1. The model

A.1.1. Production

A.1.1.1. Agriculture

Real domestic agricultural production ($Y^{P,A}$, 1) is split in three components: real agricultural production for domestic household consumption ($Y_C^{P,A}$), for intermediate input consumption by other sectors ($Y_{IC}^{P,A}$), and for exports ($Y_W^{P,A}$). All three components of agricultural production are determined by climatic conditions as we mentioned above and are therefore exogenous to the model.[21]

$$Y^{P,A} = Y_C^{P,A} + Y_{IC}^{P,A} + Y_W^{P,A} \tag{1}$$

As explained in the main text, we use Adapt'Action and FAO models in order to project the production levels of these goods in our simulation period. We then smooth the production paths and calculate constant growth rates for each category of agricultural production:

$$\dot{Y}_C^{P,A} = gr_{ypac} \cdot Y_C^{P,A} \tag{2}$$

$$\dot{Y}_{IC}^{P,A} = gr_{ypaic} \cdot Y_{IC}^{P,A} \tag{3}$$

$$\dot{Y}_W^{P,A} = gr_{ypaw} \cdot Y_W^{P,A} \tag{4}$$

Aggregate real domestic demand for agricultural goods ($Y^{D,A}$, 5) is composed of real consumption demand ($Y_C^{D,A}$, 6) from households (C^A) and real intermediate consumption demand ($Y_{IC}^{D,A}$, 7) from processed food (IC_{PF}^A), NFC sectors (IC_{NF}^A), the agricultural sector (IC_A^A) and the government sector (IC_G^A). We assume that the demand for exports always matches supply and thus real exports of agricultural goods (X^A, 8) are given by the exogenous supply ($Y_W^{P,A}$).

$$Y^{D,A} = Y_C^{D,A} + Y_{IC}^{D,A} \tag{5}$$

$$Y_C^{D,A} = C^A \tag{6}$$

$$Y_{IC}^{D,A} = IC_A^A + IC_{PF}^A + IC_{NF}^A + IC_G^A \tag{7}$$

$$X^A = Y_W^{P,A} \tag{8}$$

In order to produce, the agriculture sector uses intermediate inputs from its own production (IC_A^A) , from processed food sector (IC_A^{PF}) and from other non-food sector (IC_A^{NF}). The demand for these goods in real terms are given by fixed input-output coefficients $\alpha_A^A, \alpha_A^{PF}$ and α_A^{NF}.

$$IC_A^i = \alpha_A^i \cdot Y^{P,A}, i \in \{A, PF, NF\} \tag{9}$$

[21] In what follows, the producer sector is denoted with a superscript and the demanding sector with a subscript.

Given the consumption demand by households and intermediate consumption demand from all sectors, the excess demand in agriculture sector is met by imports from the rest of the world. Thus, imports of agricultural consumption (IM_C^A) and intermediate consumption (IM_{IC}^A) are given by:

$$IM_C^A = Y_C^{D,A} - Y_C^{P,A} \tag{10}$$

$$IM_{IC}^A = Y_{IC}^{D,A} - Y_{IC}^{P,A} \tag{11}$$

Due to our market closure by imports to satisfy demand, import shares $\sigma_{M,C}^A$ and $\sigma_{M,IC}^A$ in agriculture are defined as:

$$\sigma_{M,C}^A = IM_C^A / C^A \tag{12}$$

$$\sigma_{M,IC}^A = IM_{IC}^A / IC^A \tag{13}$$

where total intermediate consumption demand for agricultural goods (14) is the sum of demand from all sectors.

$$IC^A = \sum IC_i^A, i \in \{A, PF, NF, G\} \tag{14}$$

A.1.1.2. Non-financial sector

The remaining non-financial sectors are divided into two sectors; a processed food industry, denoted as PF, and a sector that produces all private non-food goods and non-financial services in the economy, denoted as NF. Processed food is sold to households for consumption (C^{PF}), exported to the rest of the world (X^{PF}) and demanded as intermediate consumption by the agricultural (IC_A^{PF}), processed food, (IC_{PF}^{PF}), non-food (IC_{NF}^{PF}) and the government sectors (IC_G^{PF}). Similarly, the homogeneous good produced by the non-food secrtor is demanded for consumption by households (C^{NF}), and intermediate consumption by all sectors including banks $(IC_A^{NF}, IC_{PF}^{NF}, IC_{NF}^{NF}, IC_G^{NF}, IC_B^{NF})$. We further assume that this is the capital good of the economy, purchased for investment by the non-financial sector itself (processed food and non-food NFC sector, I_F^{NF}), households (I_H^{NF}) and the government (I_G^{NF}), and exported to the rest of the world (X^{NF}). Thus the real aggregate demand (net of imports) for the output of the processed food ($Y^{D,PF}$, 15) and the NFC good ($Y^{D,NF}$, 16}) sectors are given by:

$$Y^{D,PF} = (1 - \sigma_{M,C}^{PF}) \cdot C^{PF} + (1 - \sigma_{M,IC}^{PF}) \cdot IC^{PF} + X^{PF} \tag{15}$$

$$Y^{D,NF} = (1 - \sigma_{M,C}^{NF}) \cdot C^{NF} + (1 - \sigma_{M,IC}^{NF}) \cdot IC^{NF} + (1 - \sigma_{M,I}^{NF}) \cdot I^{NF} + X^{NF} \tag{16}$$

where $\sigma_{M,i}^j$, $i \in (C, IC, I)$, $j \in (PF, NF)$ denote the import shares of elements of aggregate demand, to be defined below and IC^{PF} and IC^{NF} are respectively the total intermediate consumption demand for the processed food and non-food sector goods, and I^{NF} (17) is the total capital investment in the economy given by the sum of sectoral investments of agriculture (I_A^{NF}), processed food and non-food NFCs (I_F^{NF}), government (I_G^{NF}), and households (I_H^{NF})[22].

[22] We combine the capital investment of processed food and non-food NFC sectors into a single item I_F^{NF}, as we will discuss below.

$$I^{NF} = I_A^{NF} + I_F^{NF} + I_G^{NF} + I_H^{NF} \tag{17}$$

As in the agricultural sector, processed food and non-food sectors use intermediate inputs from agriculture, processed food and non-food sectors. Intermediate consumption demand functions are given by the technical coefficients and the level of production of these sectors ($Y^{P,PF}$ and $Y^{P,NF}$).

$$IC_{PF}^{i} = \alpha_{PF}^{i} \cdot Y^{P,PF}, i \in \{A, PF, NF\} \tag{18}$$

$$IC_{NF}^{i} = \alpha_{NF}^{i} \cdot Y^{P,NF}, i \in \{A, PF, NF\} \tag{19}$$

For the government, real intermediate consumption demand for food and processed food depends on public employment (N^G), whereas intermediate consumption of non-food sector goods depends on public capîtal stock (K^G):

$$IC_G^{i} = \alpha_G^{i} \cdot N^G, i \in \{A, PF\} \tag{20}$$

$$IC_G^{NF} = \alpha_G^{NF} \cdot K^G \tag{21}$$

while the intermediate consumption of banking sector of non-food NFC goods (IC_B^{NF}) is a function of sector's employment (N^B):

$$IC_B^{NF} = \alpha_B^{NF} \cdot N^B \tag{22}$$

Thus, total intermediate consumption demand for processed food and non-food sector goods are:

$$IC^{PF} = IC_A^{PF} + IC_{PF}^{PF} + IC_{NF}^{PF} + IC_G^{PF} \tag{23}$$

$$IC^{NF} = IC_A^{NF} + IC_{PF}^{NF} + IC_{NF}^{NF} + IC_G^{NF} + IC_B^{NF} \tag{24}$$

The goods markets are characterized by disequilibria such that aggregate demand less of imports ($Y^{D,PF}$ or $Y^{D,NF}$) is not necessarily equal to total production ($Y^{P,PF}$, $Y^{P,NF}$). Firms form adaptive expectations on real expected demand for processed food ($Y^{e,PF}$, 25) and the NFC good ($Y^{e,NF}$, 26):

$$\dot{Y}^{e,PF} = \beta_y^{PF} \cdot (Y^{D,PF} - Y^{e,PF}) + \alpha_{pop} \cdot Y^{e,PF} \tag{25}$$

$$\dot{Y}^{e,NF} = \beta_y^{NF} \cdot (Y^{D,NF} - Y^{e,NF}) + (\frac{\dot{K}^F}{K^F}) \cdot Y^{e,NF} \tag{26}$$

where α_{pop} is the population growth rate, $\frac{\dot{K}^F}{K^F}$ is the growth rate of capital stock in the total NFC sector, and β_y^{PF} and β_y^{NF} are the adjustment speeds of expectations to excess demand, specific to each market. Thus, the trend rate of growth in the processed food sector follows population growth rate and that of the non-food NFC sector follows capital accumulation.

Both processed food and non-food markets are in disequilibrium such that production ($Y^{P,i}$) does not necessarily equal demand ($Y^{D,i}$). The market disequilibrium at each point in time is cleared by inventory (dis)accumulation in both markets ($\dot{V}^i$, 27).

$$\dot{V}^i = Y^{P,i} - Y^{D,i}, i \in \{PF, NF\} \tag{27}$$

We assume that firms have a desired inventory ($V^{des,i}$, 28) to expected sales ratio given by α_V^i.

$$V^{des,i} = \alpha_V^i . Y^{e,i}, i \in \{PF, NF\} \tag{28}$$

The productive sector not only produces to meet expected demand, but also to ensure that it has the desired level of inventories defined in (28). This production for inventory replacement is given by an adjustment equation to the difference between the desired and the actual inventory level for each market (I_V^i, 29):

$$I_V^i = \Omega_V^i \cdot (V^{des,i} - V^i), i \in \{PF, NF\} \tag{29}$$

Total domestic output ($Y^{P,i}$, 30) in each sector is then equal to the sum of expected real demand and production for desired inventory replacement.

$$Y^{P,i} = Y^{e,i} + I_V^i, i \in \{PF, NF\} \tag{30}$$

Employment in the non food (N^{NF}, 31) and processed food (N^{PF}, 32) sectors are determined via a Leontieff production function, with sectoral labour productivity levels given by a^{PF} and a^{NF} respectively.

$$N^{NF} = Yp^{NF} / a^{NF} \tag{31}$$

$$N^{PF} = Yp^{PF} / a^{PF} \tag{32}$$

Real imports of processed food (IM^{PF}, 33) and the non-food good (IM^{NF}, 34) depend on the different time-varying import propensities ($\sigma_{M,j}^i, i \in \{PF, NF\}, j \in \{C, IC, I\}$) out of real levels of consumption, intermediate consumption and investment. In accordance with the data, we assume that the processed food is not used for investment and thus not imported for this purpose.

$$IM^{PF} = \sigma_{M,C}^{PF} \cdot C^{PF} + \sigma_{M,IC}^{PF} \cdot IC^{PF} \tag{33}$$

$$IM^{NF} = \sigma_{M,C}^{NF} \cdot C^{NF} + \sigma_{M,IC}^{NF} \cdot IC^{NF} + \sigma_{M,I}^{NF} \cdot I^{NF} \tag{34}$$

The corresponding nominal imports of processed food (IM_N^{PF}, 35) and the NFC good (IM_N^{NF}, 36) are defined as:

$$IM_N^{PF} = p^{PF,w} \cdot e^N \cdot (\sigma_{M,C}^{PF} \cdot C^{PF} + \sigma_{M,IC}^{PF} \cdot IC^{PF}) \tag{35}$$

$$IM_N^{NF} = p^{NF,w} \cdot e^N \cdot (\sigma_{M,C}^{NF} \cdot C^{NF} + \sigma_{M,IC}^{NF} \cdot IC^{NF} + \sigma_{M,I}^{NF} \cdot I^{NF}) \tag{36}$$

where $p^{PF,w}$ and $p^{NF,w}$ are the world import prices of processed food and non-food good respectively and e^N is the nominal exchange rate. The propensities to import move towards the target import propensities ($\sigma_{M,j}^{i,Tar}$, 37), which are negative functions of sector-specific relative prices, import taxes ($\tau_{M,j}^i$) and the elasticity of substitution between imported and domestic goods ($\epsilon_{1,i}^j$). As well as relative prices, the target propensities also depend on relative labour productivity of Tunisia (taken as the productivity in the non-food sector, a^{NF}) with respect to its trade partners (a^W), which captures non-price determinants of trade competitiveness. The sped of adjustment to the target propensities is given by $\beta_{M,j}^i$ in (38)[23].

$$\sigma_{M,j}^{i,Tar} = \Gamma_{1,j}^i \cdot \left[\frac{p_P^i}{p^{i,w}.e^N.(1+\tau_M^i)}\right]^{\epsilon_{1,j}^i} + \Gamma_{2,j}^i \cdot (\frac{a^W}{a^{NF}})^{\epsilon_{2,j}^i}, i \in \{PF, NF\}, j \in \{C, IC, I\} \tag{37}$$

$$\dot{\sigma}_{M,j}^i = \beta_{M,j}^i \cdot (\sigma_{M,j}^{i,Tar} - \sigma_{M,j}^i) \tag{38}$$

Processed food exports (X^{PF}) depend on the ability of the agricultural sector to provide the necessary intermediate consumption and therefore grow at an exogenous rate given by the climate and adaptation scenarios (39). Exports of the non-food good (X^{NF}, 40) on the other hand are determined by the exogenous world GDP (GDP^W) and a time varying export propensity (σ_X^{NF}), which depends on relative prices and relative labour productivity as above: As with import shares, the export propensity adjusts to its target value slowly, with a relaxation speed of $1/\beta_X^{NF}$.

$$\dot{X}^{PF} = gr_X^{PF} \cdot X^{PF} \tag{39}$$

$$X^{NF} = \sigma_X^{NF} \cdot GDP^W \tag{40}$$

$$\sigma_X^{NF,Tar} = \Gamma_{1,X}^{NF} \cdot \left[\frac{e^N \cdot p_X^{NF}}{p_p^{NF}}\right]^{\epsilon_{1,X}^{NF}} + \Gamma_{2,X}^{NF} \cdot (\frac{a^{NF}}{a^W})^{\epsilon_{2,X}^{NF}} \tag{41}$$

$$\dot{\sigma}_X^{NF} = \beta_X^{NF} \cdot (\sigma_X^{NF,Tar} - \sigma_X^{NF}) \tag{42}$$

A.1.2. Pricing

There are seventeen different prices for goods, these are either denominated in domestic or foreign currency:

- Producer price (p_P^i) for each product in domestic currency, $i \in \{A, PF, NF\}$.
- Consumer price for each product (p_C^i) in domestic currency, $i \in \{A, PF, NF\}$.
- Intermediate consumption price for each product (p_{IC}^i) in domestic currency, $i \in \{A, PF, NF\}$.

[23]As we mentioned above, processed food goods are not used for investment and thus $\sigma_{M,I}^{PF,Tar} = 0$ and $\sigma_{M,I}^{PF} = 0$. We thus exclude this variable from our list of variables and our simulations.

- Capital good price for non-food sector (p_K^{NF}) in domestic currency.
- Import price for processed food and non-food sector goods ($p^{i,w}$) in foreign currency, $i \in \{PF, NF\}$.
- Import price for consumption and intermediate consumption goods of agriculture sector ($p_i^{A,w}$), $i \in \{C, IC\}$.
- Export price for each product (p_X^i) in foreign currency, $i \in \{A, PF, NF\}$.

A.1.2.1. International Prices

We assume that the two international prices for imports and exports for each type of product follow exogenous level of inflation. As we mentioned above, for agricultural goods, we distinguish between international prices of consumption goods ($p_C^{A,w}$) and intermediate consumption goods ($p_C^{A,w}$) , while we assume that there is a single price inflation consumption and intermediate consumption of processed food and non-food goods[24].

$$\dot{p}_i^{A,w} = p_i^{A,w} \cdot Inf_i^{A,w}, i \in \{C, IC\} \tag{43}$$

$$\dot{p}^{i,w} = p^{i,w} \cdot Inf^{i,w}, i \in \{NF, PF\} \tag{44}$$

$$\dot{p}_X^i = p_X^i \cdot Inf_X^i, i \in \{A, NF, PF\} \tag{45}$$

A.1.2.2. Domestic Prices

For all productive sectors, producers set a mark-up on historical unit costs to determine a target producer price. Prices are sticky, and actual producer price slowly moves towards the target producer price. Consumer, intermediate and capital good prices are determined as a weighted average of domestic producer and import prices, taking into account all appropriate taxes and subsidies.

A.1.2.3. Agricultural Prices

Unit costs for the agricultural sector (UC^A, 46) depend on total wages (where w^A is the wage rate in agriculture sector and N^A is the employment) and employer's social contributions (ESC^A, 69) , intermediate consumption costs measured at intermediate consumption prices for agricultural (p_{IC}^A), processed food (p_{IC}^{PF}) and non-food goods (p_{IC}^{NF}) and taxes on production (T_{pr}^A), divided by total agricultural production.

$$UC^A = \frac{(w^A \cdot N^A + IC_A^A \cdot p_{IC}^A + IC_A^{PF} \cdot p_{IC}^{PF} + IC_A^{NF} \cdot p_{IC}^{NF} + ESC^A + T_{pr}^A)}{Y^{P,A}} \tag{46}$$

Agricultural historical unit costs (HUC^A) follow actual unit costs:

$$H\dot{U}C^A = \beta_{HUC}^A \cdot (UC^A - HUC^A) \tag{47}$$

The target agricultural producer price ($p_P^{A,Tar}$, 48) is a constant mark-up (μ^A) over historical unit costs.

[24] And for capital goods produced by the non-food sector.

$$p_P^{A,Tar} = (1 + \mu^A) \cdot HUC^A \tag{48}$$

As discussed above, the actual agricultural producer price (p_P^A) moves slowly towards this target.

$$\dot{p}_P^A = \beta_P^A \cdot (p_P^{A,Tar,} - p_P^A) \tag{49}$$

Consumer price (p_C^A, 50) and and intermediate consumption price (p_{IC}^A, 51) for agricultural goods is a combination of domestic production and import prices with taxes and subsidies:

$$\begin{aligned} p_C^A \quad = \quad & (1 - \sigma_{M,C}^A) \cdot p_P^A \cdot (1 + \tau_{VA}^A + otax^A - subr^A + mrg_C^A) \\ & + \sigma_{M,C}^A \cdot p_C^{A,w} \cdot e^N \cdot (1 + \tau_{VA}^A + otax^A - subr^A + mrg_C^A + \tau_M^A) \end{aligned} \tag{50}$$

$$\begin{aligned} p_{IC}^A \quad = \quad & (1 - \sigma_{M,IC}^A) \cdot p_P^A \cdot (1 + otax^A - subr^A + mrg_{IC}^A) \\ & + \sigma_{M,IC}^A \cdot p_{IC}^{A,w} \cdot e^N \cdot (1 + otax^A - subr^A + mrg_{IC}^A + \tau_M^A) \end{aligned} \tag{51}$$

where τ_{VA}^A is the value-added tax, $subr^A$ is the subsidy rate, $otax^A$ is the rate on other taxes, τ_M^A is the import tax rate and mrg_C^A, mrg_{IC}^A are respectively the transport and commerce margins on agricultural consumption and intermediate consumption goods.

A.1.2.4. Processed Food Prices

The determination of domestic processed food prices is similar to agricultural products. The unit costs in the sector are:

$$UC^{PF} = \frac{(w^{PF} \cdot N^{PF} + p_{IC}^A \cdot IC_{PF}^A + IC_{PF}^{PF} \cdot p_{IC}^{PF} + IC_{PF}^{NF} \cdot p_{IC}^{NF} + ESC^{PF} + T_{pr}^{PF})}{Y^{P,PF}} \tag{52}$$

Historical unit costs (HUC^{PF}) follow actual unit costs:

$$H\dot{U}C^{PF} = \beta_{HUC}^{PF} \cdot (UC^{PF} - HUC^{PF}) \tag{53}$$

The target processed food producer price ($p_P^{PF,Tar,}$, 54) is a time-varying mark-up (μ^{PF}) over historical unit costs.

$$p_P^{PF,Tar} = (1 + \mu^{PF}) \cdot HUC^{PF} \tag{54}$$

In the processed food sector, mark-up over historical unit costs (μ^{PF}, 55) changes over time to reflect demand pressures. As in Yilmaz and Godin (2020), we measure this demand pressure as the deviation of actual inventories from their desired level:

$$\mu^{PF} = \mu_0^{PF} - \mu_1^{PF} \cdot (V^{PF}/Y^{e,PF} - \alpha_V^{PF}) \tag{55}$$

As above, the actual producer price (p_P^{PF}) moves slowly towards this target.

$$\dot{p}_P^{PF} = \beta_P^{PF} \cdot (p_P^{PF,Tar} - p_P^{PF}) \tag{56}$$

Once again, consumer price (p_C^{PF}, 57) and intermediate consumption price (p_{IC}^{PF}, 58) for processed food goods is a combination of domestic production and import prices with taxes and subsidies:

$$\begin{aligned} p_C^{PF} &= (1-\sigma_{M,C}^{PF}) \cdot p_P^{PF} \cdot (1+\tau_{VA}^{PF} + otax^{PF} - subr^{PF} + mrg_C^{PF}) \\ &+\sigma_{M,C}^{PF} \cdot p^{PF,w} \cdot e^N \cdot (1+\tau_{VA}^{PF} + otax^{PF} - subr^{PF} + mrg_C^{PF} + \tau_M^{PF}) \end{aligned} \tag{57}$$

$$\begin{aligned} p_{IC}^{PF} &= (1-\sigma_{M,IC}^{PF}) \cdot p_P^{PF} \cdot (1 + otax^{PF} - subr^{PF} + mrg_{IC}^{PF}) \\ &+\sigma_{M,IC}^{PF} \cdot p^{PF,w} \cdot e^N \cdot (1 + otax^{PF} - subr^{PF} + mrg_{IC}^{PF} + \tau_M^{PF}) \end{aligned} \tag{58}$$

where τ_{VA}^{PF} is the value-added tax, $subr^{PF}$ is the subsidy rate, $otax^{PF}$ is the rate on other taxes, τ_M^{PF} is the import tax rate and mrg_C^{PF}, mrg_{IC}^{PF} are respectively the transport and commerce margins on processed food consumption and intermediate consumption goods.

A.1.2.5. Non-Food Prices

The determination of non-food prices is symmetric to processed food sector.

$$UC^{NF} = \frac{(w^{NF}.N^{NF} + p_{IC}^{A} \cdot IC_{NF}^{A} + IC_{NF}^{PF} \cdot p_{IC}^{PF} + IC_{NF}^{NF} \cdot p_{IC}^{NF} + ESC^{NF} + T_{pr}^{NF})}{Y^{P,F}} \tag{59}$$

Historical unit costs (HUC^{NF}) follow actual unit costs:

$$H\dot{U}C^{NF} = \beta_{HUC}^{NF} \cdot (UC^{NF} - HUC^{NF}) \tag{60}$$

The target non-food producer price ($p_P^{NF,Tar,}$, 61) is a time-varying mark-up (μ^{NF}) over historical unit costs.

$$p_P^{NF,Tar} = (1+\mu^{NF}) \cdot HUC^{NF} \tag{61}$$

As in the processed food sector, mark-up over historical unit costs in the non-food sector (μ^{NF}, 62) also changes over time to reflect demand pressures.

$$\mu^{NF} = \mu_0^{NF} - \mu_1^{NF} \cdot (V^{NF}/Y^{e,NF} - \alpha_V^{NF}) \tag{62}$$

As above, the actual producer price (p_P^{NF}) moves slowly towards this target.

$$\dot{p}_P^{NF} = \beta_P^{NF} \cdot (p_P^{NF,Tar} - p_P^{NF}); \tag{63}$$

Consumer prices for non-food goods is a combination of domestic production and import prices with taxes and subsidies:

$$\begin{aligned} p_C^{NF} &= (1-\sigma_{M,C}^{NF}) \cdot p_P^{NF} \cdot (1+\tau_{VA}^{NF} + otax^{NF} - subr^{NF}) \\ &+\sigma_{M,C}^{NF} \cdot p^{NF,w} \cdot e^N \cdot (1+\tau_{VA}^{NF} + otax^{NF} - subr^{NF} + \tau_M^{NF}) \end{aligned} \tag{64}$$

$$\begin{aligned} p_{IC}^{NF} &= (1-\sigma_{M,IC}^{NF}) \cdot p_P^{NF} \cdot (1 + otax^{NF} - subr^{NF}) \\ &+\sigma_{M,IC}^{NF} \cdot p^{NF,w} \cdot e^N \cdot (1 + otax^{NF} - subr^{NF} + \tau_M^{NF}) \end{aligned} \tag{65}$$

where τ_{VA}^{NF} is the value-added tax, $subr^{NF}$ is the subsidy rate, $otax^{NF}$ is the rate on other taxes, τ_M^{NF} is the import tax rate. Transportation and commerce margins do not affect domestic prices in this sector as the sector both pays and receives these costs.

The non-food sector's good is also used for capital accumulation. The price of capital goods (p_K^{NF}, 66) is given by:

$$\begin{aligned} p_K^{NF} &= (1-\sigma_{M,I}^{NF}) \cdot p_P^{NF} \cdot (1 + otax^{NF}) \\ &+\sigma_{M,I}^{NF} \cdot p^{NF,w} \cdot e^N \cdot (1 + otax^{NF} + \tau_M^{NF}) \end{aligned} \tag{66}$$

A.1.3. Financing

A.1.3.1. Agriculture

Agricultural sector employs labour force (N^A, 68) at the ongoing wage (w^A), paying a total wage bill WB^A (67). Employment depends on total real agricultural production and labour productivity (a^A) in the sector through a Leontieff production function (68).

$$WB^A = w^A \cdot N^A \tag{67}$$

$$N^A = Y^{P,A}/a^A \tag{68}$$

Employer's social contributions (ESC^A, 69) is a fixed fraction of the wage bill.

$$ESC^A = \tau_{ESC}^A \cdot w^A \cdot N^A \tag{69}$$

The sector also pays taxes on production (T_{pr}^A, 70), which we assume to be a constant share of production.

$$T_{pr}^A = \tau_{pr}^A \cdot \left[(Y_C^{P,A} + Y_{IC}^{P,A}) \cdot p_P^A + X^A \cdot p_X^A \cdot e^N \right] \tag{70}$$

where e^N denotes the nominal exchange rate.

The mixed income of the agricultural sector (MI^A, 71) is given by the value of production for domestic markets at producer prices and exports less of wage bill, employer's social contributions and taxes on production:

$$MI^A = (Y_C^{P,A} + Y_{IC}^{P,A}) \cdot p_P^A + X^A \cdot p_X^A \cdot e^N - IC_A^A \cdot p_{IC}^A \\ -IC_A^{PF} \cdot p_{IC}^{PF} - IC_A^{NF} \cdot p_{IC}^{NF} - WB^A - ESC^A - T_{pr}^A \quad (71)$$

Out of this mixed income, the sector pays income taxes at the rate (τ^A), spends on interest payments on its domestic currency loans and on insurance (Ins^A) and comissions (Com^A) paid to the financial sector. Thus, its net income (NI^A, 72) becomes

$$NI^A = (1 - \tau^A) \cdot MI^A - (1 - \beta_{npl}^A) \cdot i_D^L \cdot L_D^A - Ins^A - Com^A \quad (72)$$

where i_D^L is the interest on domestic currency loans, L_D^A is the total stock of loans from the financial sector to the agricultural sector and β_{npl}^A is the non-performing loans rate in the agriculture sector. We set this rate equal to the general non-performing loans rate in the economy, β_{npl}^F, to be defined below.

$$\beta_{npl}^A = \beta_{npl}^F \quad (73)$$

We assume that a fixed capital-output ratio prevails in the sector and the desired capital stock ($K^{A,Tar}$, 74) is thus defined as:

$$K^{A,Tar} = \kappa^A \cdot Y^{P,A} \quad (74)$$

Investment at each point in time (I_A^{NF}, 75) depends on the difference between the target and actual capital stock

$$I_A^{NF} = (K^{A,Tar} - K^A) \quad (75)$$

A fixed fraction of the costs of investment is financed by retained earnings (RE^A, 76) from the net income in (72). The rest is borrowed from the banking sector in domestic currency loans (L_D^A). We assume that there is no rationing on agricultural loan demand.

$$RE^A = \lambda \cdot I_A^{NF} \cdot p_K^{NF} \quad (76)$$

$$\dot{L}_D^A = I_A^{NF} \cdot p_K^{NF} - RE^A \quad (77)$$

Finally, capital stock in the agricultural sector (K^A) evolves according to

$$\dot{K}^A = I_A^{NF} - \delta^A \cdot K^A \quad (78)$$

with δ^A denoting the depreciation rate of capital stock.

A.1.3.2. Processed Food and Non-Food NFCs

In order to determine the financing need of non-financial corporations, we combine the balance sheets of processed food and non-food sectors. The consolidated gross operating surplus for processed food and non-food enterprises (GOS_T^F, 79) is given by the difference between sales income and total costs. Sales income is composed of sales of processed food and the non-food good for final consumption and intermediate consumption, sales of the NFC good as the capital good for investment, exports of the two sectors, margins and subsidies. We use consumer prices to calculate sales revenues and subtract import taxes (TIM), value-added taxes (VAT), and other taxes ($Otaxes$), Costs include wage costs calculated as sectoral wage level ($w^{i\cdot}$) times employment (N^i), employer's social contributions (ESC^i) and taxes on production (T^i_{pr}) for $i \in \{PF, NF\}$.

$$\begin{aligned} GOS_T^F \;=\; & C^{PF} \cdot p_C^{PF} + C^{NF} \cdot p_C^{NF} + p_K^{NF} \cdot I^{NF} - IM^{NF} - IM^{NPF} - w^{PF} \cdot N^{PF} \\ & - w^{NF} \cdot N^{NF} - ESC^{NF} - ESC^{PF} - T_{pr}^{NF} - T_{pr}^{PF} - VAT^{NF} - VAT^{PF} \\ & - TIM^{NF} - TIM^{PF} + sub^{NF} + sub^{PF} - Otaxes^{PF} - Otaxes^{NF} - IC_{PF}^{A} . p_{IC}^{A} \\ & - IC_F^A \cdot p_{IC}^A + (IC_A^{PF} + IC_G^{PF}) \cdot p_{IC}^{PF} + (IC_A^{NF} + IC_G^{NF} + IC_B^{NF}) \cdot p_{IC}^{NF} \\ & + X^{PF.} \cdot p_X^{PF} \cdot e^N + X^{NF} \cdot p_X^{NF} \cdot e^N + mrg_X^{PF} \cdot X^{PF} \cdot p_X^{PF} \cdot e^N + mrg_X^A \cdot X^A \cdot p_X^A \cdot e^N \\ & + mrg_C^A \cdot (Y_C^{P,A} \cdot p_P^A + IM_C^A \cdot p_C^{A,w} \cdot e^N) + mrg_{IC}^A \cdot (Y_{IC}^{P,A} \cdot p_P^A + IM_{IC}^A \cdot p_{IC}^{A,w} \cdot e^N) \end{aligned} \tag{79}$$

A part of GOS_T^F is distributed to households a income (GOS_H^F, 80) and the rest is retained as business profits (GOS^F, 81).

$$GOS_H^F = gosh.GOS_T^F \tag{80}$$

$$GOS^F = GOS_T^F - GOS_H^F \tag{81}$$

Gross sectoral profits (GF^F, 82) is the difference between total income, which includes GOS^F and interest received on domestic deposits saved ($i_D^{Dep} \cdot Dep_D^{F,sav}$), and total payments, which includes interest paid on domestic ($i_D^L \cdot L_D^F.$) and FX debt ($i_{FX}^L \cdot L_{FX}^F \cdot e^N$), insurance ($Ins^F$), commissions ($Com^F$) and transfers ($Transf_G^F$) paid to the government:

$$GF^F = GOS^F + i_D^{Dep} \cdot Dep_D^{F,sav} - i_D^L \cdot L_D^F \cdot (1 - \beta_{npl}^F) - i_{FX}^L \cdot L_{FX}^F \cdot e^N - Ins^F - Com^F - Transf_G^F \tag{82}$$

As in the agricultural sector, the interest paid to the banking sector takes into account the non-performing loans rate for NFCs (β_{npl}^F). The net profits of the sector (F^F) after paying taxes on profits

$$F^F = (1 - \tau^F) \cdot GF^F \tag{83}$$

Target capital investment ($I_{F,D}^{Tar}$, 84) for domestic NFCs depends positively on the return on capital r^F net of producer price inflation ($\dot{p}_P^{NF}/p_P^{NF}$) in the non-food sector and real private sector investment in adaptation ($I_{F,irrig}$, 85):

$$I_{F,D}^{Tar} = K^F \cdot \left[\kappa_0^F + \kappa_1^F \cdot (r^F - \dot{p}_P^{NF}/p_P^{NF})\right] + I_{F,irrig} \tag{84}$$

Nominal value of private sector adaptation investment is set to a percentage of nominal GDP as in the adaptation plans of Tunisia.Thus, $I_{F,irrig}$ becomes:

$$I_{F,irrig} = \gamma^F_{ir}.(NomGDP/p^{NF}_K) \tag{85}$$

Carrying out investment projects takes time and thus actual domestic investment moves slowly towards this target:

$$\dot{I}_{F,D} = \beta^F_{id} \cdot (I^{Tar}_{F,D} - I_{F,D}) \tag{86}$$

The country also receives FDI^F to its non-financial corporation sector, which is a constant fraction of expected production in the processed food and non-food NFC sector, measured in producer prices.

$$FDI^{F,Tar} = fdi.(Y^{e,NF} \cdot p^{NF}_P + Y^{e,PF} \cdot p^{PF}_P) \tag{87}$$

$$F\dot{D}I^F = \beta_{fdi}.(FDI^{F,Tar} - FDI^F) \tag{88}$$

Thus, total capital investment by the NFC sector (I^{NF}_F, 89) is the sum of domestic real private investment and real foreign direct investment (FDI^F/p^{NF}_K).

$$I^{NF}_F = I_{F,D} + FDI^F/p^{NF}_K \tag{89}$$

Capital stock in the NFC sector (K^F) then evolves according to:

$$\dot{K}^F = I^{NF}_F - \delta^F \cdot K^F \tag{90}$$

with δ^F denoting the depreciation rate.

In order to calculate the profit rate (r^F) in (84) , we define the pre-tax profits of the sector (GF^F_T, 91), taking into account the gross operating surplus distributed to the households.

$$GF^F_T = GOS^F_T + i^{Dep}_D \cdot Dep^{F,sav}_D - i^L_D \cdot L^F_D \cdot (1 - \beta^F_{npl}) - i^L_{FX} \cdot L^F_{FX} \cdot e^N - Ins^F - Com^F - Transf^F_G \tag{91}$$

This is because we treat our households as pure households and hence use only housing investment, which we will define below, to be decided by households in the model. We add the rest of the household investment in the SNA data to the NFC sector. This means that the investment by producer-households is also treated as being carried out by the NFCs so the appropriate profit rate must take into account the after-tax gross operating surplus distributed to households.

$$F^F_T = GF^F_T - \tau^F \cdot GF^F - \tau^H \cdot GOS^F_H \tag{92}$$

$$r^F = F^F_T/(p^{NF}_K.K^F) \tag{93}$$

Part of firms' after-tax profits (F^F, 82) are kept as domestic currency deposits ($Dep^{F,cur}_D$) for liquidity & working capital needs. This, we assume is a fraction of the wage bill and employees social contributions paid by the sector.

$$Dep^{F,cur,Tar}_D = \eta_D \cdot (w^{NF} \cdot N^{NF} + w^F \cdot N^{PF} + ESC^{NF} + ESC^{PF}) \tag{94}$$

$$\dot{Dep}_D^{F,cur} = \beta_{Dep}^F \cdot (Dep_D^{F,cur,Tar} - Dep_D^{F,cur}); \tag{95}$$

Similarly, firms keep a certain amount of precautionary deposits in FX (Dep_{FX}^F) in the domestic banking sector, which depends on the total stock of their FX loans (L_{FX}^F).

$$\dot{Dep}_{FX}^F = \beta_{FX}^F \cdot (\eta_F \cdot L_{FX}^F - Dep_{FX}^F) \tag{96}$$

The profits (FN^F, 97) net of current account deposits in domestic currency and FX is then given by:

$$FN^F = (F^F - \dot{Dep}_D^{F,cur} - \dot{Dep}_{FX}^F \cdot e^N) \tag{97}$$

Out of these profits; the firms save a given fraction in saving accounts in domestic currency ($\dot{Dep}_D^{F,sav}$, 98):

$$\dot{Dep}_D^{F,sav} = \beta_{sav}^F \cdot FN^F \tag{98}$$

Total domestic deposit of firms (Dep_D^F, 99) is thus the sum of current account deposits and domestic currency saving deposits.

$$Dep_D^F = Dep_D^{F,sav} + Dep_D^{F,cur} \tag{99}$$

$$\dot{Dep}_D^F = \dot{Dep}_D^{F,sav} + \dot{Dep}_D^{F,cur} \tag{100}$$

Once the saving decision is also made, a fraction of remaining firm profits are distributed as dividends to households (Div_H^F, 102), government (Div_G^F, 103) and the rest of the world (Div_G^F, 104).

$$Div^F = (1 - \beta_{sav}^F) \cdot divrate^F \cdot FN^F \tag{101}$$

$$Div_H^F = divrate_H^F \cdot Div^F \tag{102}$$

$$Div_G^F = divrate_G^F \cdot Div^F \tag{103}$$

$$Div_W^F = divrate_W^F \cdot Div^F \tag{104}$$

The remaining funds are retained to finance investment. Thus, the financing need of the NFC sector (TFN^F, 105).can be found as the total cost of domestic investment minus these retained earnings:

$$TFN^F = p_K^{NF} \cdot I_{F,D} - (1 - \beta_{sav}^F) \cdot (1 - divrate^F) \cdot FN^F \tag{105}$$

Firms desire to finance a fixed fraction $\beta_F^{L,des}$ of their total financing needs via borrowing in foreign currency ($\dot{L}_{FX}^{F,des}$, 106) from domestic banks which, as we will discuss in detail below, act as an intermediary between firms and the rest of the world and lend firms the cross-border funds they borrow from abroad.

$$\dot{L}_{FX}^{F,des} = \beta_F^{L,des} \cdot TFN^F / e^N \tag{106}$$

FX borrowing from abroad by banks is rationed at the endogenous rate rat_{FX}, to be defined below. The actual share of FX financing for firms (β_F^L, 107) is then

$$\beta_F^L = \beta_F^{L,des} \cdot (1 - rat_{FX}) \tag{107}$$

and the actual FX borrowing by NFCs from domestic banks ($\dot{L}_{FX}^F$, 108) is given by:

$$\dot{L}_{FX}^F = \beta_F^L \cdot TFN^F / e^N \tag{108}$$

The rest of the financing need is borriwed from domestic banks in domestic currency ($\dot{L}_D^F$, 109).

$$\dot{L}_D^F = TFN^F - \dot{L}_{FX}^F \cdot e^N \tag{109}$$

Following the literature on non-performing loans rate, cited in the main text, the target general non-performing loans rate ($\beta_{npl}^{F,Tar}$, 110) in the economy depends on gross bank profits (GF^B) to bank equity (OF^B) ratio, inflation (inf^H), real growth rate defined as the growth rate of nominal GDP ($D[NomGDP, t]/NomGDP$) less of inflation and the unemployment rate ($unemp$):

$$\begin{aligned} \beta_{npl}^{F,Tar} \quad = \quad & \epsilon_0^{npl} + \epsilon_1^{npl} \cdot GF^B/OF^B + \epsilon_2^{npl} \cdot inf^H \\ & + \epsilon_3^{npl} \cdot (D[NomGDP, t]/NomGDP - inf^H) + \epsilon_4^{npl} \cdot unemp \end{aligned} \tag{110}$$

The actual non-performing loans rate in the NFC sector (β_{npl}^F) moves towards this target with a time lag of $1/\chi_{npl}$[25]:

$$\dot{\beta}_{npl}^F = \chi_{npl} . (\beta_{npl}^{F,Tar} - \beta_{npl}^F) \tag{111}$$

A.1.4. Banks

The banking sector sets the deposit rates for firms and households, lending rates in domestic currency and FX, as well as comission rates on financial transactions.

The target deposit rate ($i_D^{Dep,Tar}$, 112) on firm's saving accounts is set as a markdown ($depmarkdown$, 113) from the policy rate (i_p). As in Yilmaz and Godin (2020), we assume that the value of the markdown depends on the ratio of total domestic currency assets of the banking sector to financing from the central bank as advances (Ad). As banks finance themselves from via the central bank, they reduce the spread between the policy rate and the deposit rate falls in order to attract deposits.

$$i_D^{Dep,Tar} = i_p - depmarkdown \tag{112}$$

[25] In the simulations, we put a lower bound to the non-performing loans rate at 2% to avoid negative values.

$$depmarkdown = \kappa_4 \cdot \left[\frac{(L_D^F + L_D^H + L_D^A + B_B^G}{Ad}\right]^{\kappa_5} \tag{113}$$

The actual effective deposit rate (i_D^{Dep}) moves slowly towards this target value.

$$\dot{i}_D^{Dep} = \beta_{idDep} \cdot (i_D^{Dep,Tar} - i_D^{Dep}) \tag{114}$$

In line with the data, we assume that firms offer a slighly higher deposit rate to households ($i_D^{Dep,H}$), measured by the term ($hhdp$).

$$i_D^{Dep,H} = i_D^{Dep} \cdot (1 + hhdp) \tag{115}$$

Banks do not pay any interest (i_{FX}^{Dep}) on FX deposits:

$$i_{FX}^{Dep} = 0 \tag{116}$$

In order to determine the lending rates, the banks charge a premium ($prem_2$, 120) over their average funding costs (AFC, 118).

$$i_D^{L,Tar} = AFC + prem_2 \tag{117}$$

The average funding costs are calculated as the weighted average cost of deposit financing and central bank financing.

$$AFC = \frac{i_D^{Dep,H} \cdot Dep_D^{H,sav} + i_D^{Dep} \cdot Dep_D^{F,sav} + i_p \cdot Ad}{Dep_D + Ad} \tag{118}$$

where $Dep_D^{H,sav}$ is the saving accounts of households, $Dep_D^{F,sav}$ is the savin accounts of NFCs, and the total domestic currency deposits in the banking sector (Dep_D) is the sum of total household (Dep_D^H) , firm (Dep_D^F) and the rest of the world (Dep_D^W) deposits to be defined below.

$$Dep_D = Dep_D^H + Dep_D^F + Dep_D^W \tag{119}$$

The premium on domestic currency loans depends on the interest payments to gross operating surplus ratio:

$$prem_2 = \kappa_0 + \kappa_1 \cdot \left[\frac{i_D^L \cdot L_D^F + i_{FX}^L \cdot L_{FX}^F \cdot e^N}{GOS_T^F}\right]^{\kappa_3} \tag{120}$$

The average interest rate moves slowly to the instantenous interest rate with a speed of β_{idL}, which reflects the maturity of domestic loans.

$$\dot{i}_D^L = \beta_{idL} \cdot (i_D^{L,Tar} - i_D^L) \tag{121}$$

As in deposits, the interest rate on household loans is higher than the interest rate on NFC loans, measured by $hhlp$.

$$i_D^{L,H} = i_D^L \cdot (1 + hhlp) \tag{122}$$

As discussed above, we assume that borrowing in foreign currency by domestic firms takes place via the domestic banking sector. Therefore, domestic banks act as an intermediary between these domestic firms and foreign funds, charging the NFCs an instantenous FX lending rate of $i_{FX}^{L,Tar}$ (123) and earning a positive spread over the cross-border bank borrowing rate (i_{FX}^{B}) during the process. This spread is a multiple (ρ_4) of the domestic currency lending premium.

$$i_{FX}^{L,Tar} = i_{FX}^{B} + \rho_4 \cdot prem_2 \tag{123}$$

The effective interest rate on FX loans (i_{FX}^{L}) also moves slowly towards the instantenous rate due to maturity structure.

$$\dot{i}_{FX}^{L} = \beta_{i,LFX} \cdot (i_{FX}^{L,Tar} - i_{FX}^{L}) \tag{124}$$

The banking sector uses cross-border borrowing in order to lend in FX to the NFCs. The rate at which banks acquire FX funds from abroad is determined by a premium ($prem_1$) over the risk-free global rate (i_{FX}^{W}).

$$i_{FX}^{B} = i_{FX}^{W} + prem_1 \tag{125}$$

The premium on cross-border lending rate ($prem_1$, 126) depends on the country risk (rsk, 127) non-linearly, while country risk is measured as financial international investment position (FIP, 128), given by the ratio of country's FX debt to nominal GDP ($NomGDP$).

$$prem_1 = \zeta_0 + \zeta_1 \cdot rsk^{\zeta_2} \tag{126}$$

$$rsk = \nu_1 \cdot FIP^{v_2}; \tag{127}$$

$$FIP = \frac{(L_{FX}^{B} \cdot e^{N} + L_{FX}^{G} \cdot e^{N} + L_{FX}^{G,Adap} \cdot eN)}{NomGDP} \tag{128}$$

As well as its effect on the pricing of cross-border lending via the premiums, the country risk also has a quantity effect on the amount of FX borrowing by banks. More precisely, a higher country risk leads to a higher rationing (rat_{FX}) of FX loan demand by the banking sector. We assume the rationing function has a sigmoid shape, with lower and upper bounds given by LB_{rat} and UB_{rat}, with an inflection point at MP_{rat}.

$$rat_{FX} = \frac{\beta_{1,rat}}{1 + \exp\left[\beta_{2,rat} \cdot (rsk - MP_{rat})\right]} \cdot (UB_{rat} - LB_{rat}) + LB_{rat} \tag{129}$$

The banking sector provides insurance services to agriculture (Ins^{A}, 130), NFCs (Ins^{F},131) and households (Ins^{H}, 132) on their capital stock, charging a constant premium rate.

$$Ins^{A} = insur_{A} \cdot Kap^{A}.p_{K}^{NF} \tag{130}$$

$$Ins^{F} = insur_{F} \cdot Kap^{F}.p_{K}^{NF} \tag{131}$$

$$Ins^{H} = insur_{H} \cdot Kap^{H}.p_{K}^{NF} \tag{132}$$

Total insurance income (Ins, 133) for banks is then:

$$Ins = Ins^H + Ins^F + Ins^A \tag{133}$$

Similarly, agriculture sector, NFCs and households pay comissions (Com) to the banking sector on their liabilities. For simplicity, we assume the value of these comissions are fixed ratios of domestic currency loans to these sectors.

$$Com^A = com \cdot L_D^A \tag{134}$$

$$Com^H = com \cdot L_D^H \tag{135}$$

$$Com^F = com \cdot L_D^F \tag{136}$$

$$Com = Com^A + Com^H + Com^F \tag{137}$$

The sector also holds government bonds (B_G^B) and receives interest (i_B^G) on these bonds, employs labour at the wage rate w^B, and pays employer's social contributions (ESC^B), taxes on production (T_{PR}^{FC}) and other transfers to the government ($Transf_G^B$).

Employer's social contributions for banks (ESC^B, 138) is a fixed ratio of wages as in the agriculture and NFC sectors:

$$ESC^B = \tau_{ESC}^B \cdot w^B \cdot N^B \tag{138}$$

while we define taxes on production as a fixed ratio of interest income:

$$Tpr^B = \tau pr^B \cdot (i_D^L \cdot L_D^F \cdot (1 - \beta_{npl}) + i_H^L \cdot L_D^H \cdot (1 - \beta_{npl}^H) + i_D^L \cdot L_D^A \cdot (1 - \beta_{npl}^A)) \tag{139}$$

Employment in the banking sector (N^B, 140) is a fixed fraction of population.

$$N^B = emp^B \cdot Pop \tag{140}$$

Thus, the gross profits of the banking sector (GF^B, 141) is given by the sum of its revenues and expenses, taking into account the non-performing loans by firms, agriculture sector and households.

$$\begin{aligned} GF^B \;=\; & i_D^L \cdot L_D^F.(1 - \beta_{npl}^F) + i_D^{L,H} \cdot L_D^H \cdot (1 - \beta_{npl}^H) + i_D^L \cdot L_D^A.(1 - \beta_{npl}^A) + \\ & (i_{FX}^L - i_{FX}^B) \cdot L_{FX}^B \cdot e^N + i_B^G \cdot B_B^G - i_D^{Dep} \cdot Dep_D^{F,sav} - i_D^{Dep,H} \cdot Dep_D^{H,sav} - i_p \cdot Ad \\ & -w^B \cdot N^B - ESC^B - IC_B^{NF} \cdot p_{IC}^{NF} - T_{PR}^{FC} + Com + Ins - Transf_G^B \end{aligned} \tag{141}$$

where w^B is the wage level in the banking sector.

The sector pays taxes on profits at the rate τ^B. Net banking profits (F^B, 142) are then defined as:

$$F^B = (1 - \tau^B) \cdot GF^B \tag{142}$$

Banks are subject to a Basel-type capital adequacy ratio which determines the target own funds of the sector ($OF^{B,Tar}$, 143). This target is defined as a percentage of the risk-weighted assets.

$$OF^{B,Tar} = of \cdot (\chi_F \cdot L_D^F + \chi_A \cdot L_D^A + \chi_H \cdot L_D^H + \chi_{FX} \cdot L_{FX}^F \cdot e^N + \chi_B \cdot B_G^B) \tag{143}$$

We assume that in order to strengthen the capital position of the banking sector, the capital adequacy ratio (of, 144) smoothly rises over time from its initial value at the initial time of simulations (t_0):

$$of = of_1 - \frac{of_2}{\exp\left[of_3 \cdot (t - t_0)\right]} \tag{144}$$

The sector retains part of its profits (RE^B, 145) in order to attain the necessary own funds:

$$RE^B = OF^{B,Tar} - OF^B \tag{145}$$

$$\dot{O}F^B = RE^B \tag{146}$$

The rest of the profits are distributed as dividends (Div^B) to households (Div_H^B), government (Div_G^B) and the rest of the world (Div_W^B) in fixed proportions:

$$Div^B = F^B - RE^B = Div_W^B + Div_G^B + Div_H^B \tag{147}$$

$$Div_W^B = divrate_w^B \cdot Div^B \tag{148}$$

$$Div_G^B = divrate_G^B \cdot Div^B \tag{149}$$

$$Div_H^B = divrate_H^B \cdot Div^B \tag{150}$$

In order to derive the financing needs of the banking sector, we start with the asset and liability dynamics. First we assume that the sector buys ($\dot{B}_B^G$, 151) all the domestic currency government bonds not purchased by households ($\dot{B}_H^G$) or the central bank ($\dot{B}_{CB}^G$).

$$\dot{B}_B^G = \max[\dot{B}^G - \dot{B}_H^G - \dot{B}_{CB}^G, -B_B^G] \tag{151}$$

There is a constant reserve requirement ratio (rrr) on domestic currency deposits

$$\dot{R}_D = rrr \cdot (\dot{D}ep_D) \tag{152}$$

where

$$\dot{Dep}_D = \dot{Dep}_D^F + \dot{Dep}_D^H + \dot{Dep}_D^W \tag{153}$$

The domestic currency financing needs of the banking sector (TFN^B) is then given by:

$$TFN^B = (\dot{L}_D^F + \dot{L}_D^H + \dot{L}_D^A + \dot{B}_B^G) + rrr \cdot (\dot{Dep}_D) - (\dot{Dep}_D + \dot{O}F^B + FDI^B) \tag{154}$$

We assume that the banking sector does not receive any FDI (FDI^B, 155) in the simulations:

$$FDI^B = 0 \tag{155}$$

The central bank acts as a lender of last resort to sector and financing needs are thus met by borrowing from the central bank in the form of advances (Ad):

$$\dot{A}d = TFN^B \tag{156}$$

A strict no open position applies in the FX side of the banking sector's balance sheet such that FX assets of the banking sector is greater or equal to its FX-denominated liabilities.So the reauired no-open-position change in bank FX reserves ($\dot{R}_{FX}^{NOP}$, 157) is

$$\dot{R}_{FX}^{NOP} \geq \dot{Dep}_{FX} + \dot{L}_{FX}^B - \dot{L}_{FX}^F \tag{157}$$

where

$$\dot{Dep}_{FX} = \dot{Dep}_{FX}^W + \dot{Dep}_{FX}^F + \dot{Dep}_{FX}^H \tag{158}$$

and because banks are only intermediaries between NFCs and cross-border funds,

$$\dot{L}_{FX}^B = \dot{L}_{FX}^F \tag{159}$$

also holds.

We assume that the no open position requirement always holds with equality So the change in FX reserves of the banking sector ($\dot{R}_{FX}^B$, 160) is:

$$\dot{R}_{FX}^B = \dot{R}_{FX}^{NOP} \tag{160}$$

A.1.5. Government

In order to derive the budget constraint of the government, we start with the nominal value of intermediate consumption of government (IC_N^G, 161) from other sectors:

$$IC_N^G = IC_G^A \cdot p_{IC}^A + IC_G^{NF} \cdot p_{IC}^{NF} + IC_G^{PF} \cdot p_{IC}^{PF} \tag{161}$$

Government employs public workers (N^G, 162) to provide public services, at the wage rate w^G. The number of public workers is constant fraction of the population:

$$N^G = emp^G \cdot Pop \tag{162}$$

Government pays employer's social contributions (ESC^G, 163) for public workers and also receives it. The value per public employee is a fixed fraction of public wages (w^G):. Similarly, employers' social contributions per employee in the processed food and non-food sectors are fixed fractions of respective wages in these sectors:

$$ESC^i = \tau^i_{ESC} \cdot w^i \cdot N^i, i \in \{PF, NF, G\} \tag{163}$$

Thus, the total employer's social contributions received by the government (ESC, 164) is:

$$ESC = ESC^A + ESC^{NF} + ESC^{PF} + ESC^B + ESC^G \tag{164}$$

As well as the social contributions paid by employers, labourers also pay social contributions (WSC) out of their gross nominal wages, received by the government:

$$WSC = \tau_{WSC} \cdot (w^A \cdot N^A + w^{NF} \cdot N^{NF} + w^{PF} \cdot N^{PF} + w^B \cdot N^B + w^G \cdot N^G) \tag{165}$$

The government levies value-added tax on consumption goods (VAT) from each sector, determined by sectoral rates τ^i_{VA}.

$$VAT^A = \tau^A_{VA} \cdot \left[(1 - \sigma^A_{M,C}) \cdot C^A \cdot p^A_P + IM^A_C \cdot p^{A,w}_C \cdot e^N\right] \tag{166}$$

$$VAT^{NF} = \tau^{NF}_{VA} \cdot \left[(1 - \sigma^{NF}_{M,C}) \cdot C^{NF} \cdot p^{NF}_P + \sigma^{NF}_{MC} \cdot C^{NF} \cdot p^{NF,w} \cdot e^N\right] \tag{167}$$

$$VAT^{PF} = \tau^{PF}_{VA} \cdot \left[(1 - \sigma^{NF}_{M,C}) \cdot C^{PF} \cdot p^{PF}_P + \sigma^{PF}_{M,C} \cdot C^{PF} \cdot p^{PF,w} \cdot e^N\right] \tag{168}$$

$$VAT = VAT^A + VAT^{NF} + VAT^{PF} \tag{169}$$

Similarly, import taxes (TIM) are levied on all sectoral imports at different rates τ^i_M.

$$TIM^A = \tau^A_M \cdot (IM^A_C \cdot p^{A,w}_C + IM^A_{IC} \cdot p^{A,w}_{IC}) \cdot e^N \tag{170}$$

$$TIM^i = \tau^i_M \cdot IM^i \cdot p^{i,w} \cdot e^N, i \in \{PF, NF\} \tag{171}$$

$$TIM = TIM^A + TIM^{PF} + TIM^{NF} \tag{172}$$

The government subsidizes agricultural sector at the rate $subr_a$ and the processed food/non-food sectors at $subr_{PF}$ and $subr_{NF}$ respectively. Total subsidies (sub) are given by the sum of all subsidies.

$$sub^A = subr_a \cdot \left[Y^{D,A} \cdot p^A_P + (IM^A_C \cdot p^{A,w}_C + IM^A_{IC} \cdot p^{A,w}_{IC}) \cdot e^N\right] \tag{173}$$

$$sub^{PF} = subr_{PF} \cdot \left[\begin{array}{c} (1-\sigma^{PF}_{M,C}) \cdot C^{PF} \cdot p^{PF}_{P} + \sigma^{PF}_{M,C} \cdot C^{PF} \cdot p^{PF,w} \cdot e^{N} + \\ (1-\sigma^{PF}_{M,IC}) \cdot IC^{PF} \cdot p^{PF}_{P} + \sigma^{PF}_{M,IC} \cdot IC^{PF} \cdot p^{PF,w} \cdot e^{N} \end{array} \right] \tag{174}$$

$$sub^{NF} = subr_{NF} \cdot \left[\begin{array}{c} (1-\sigma^{NF}_{M,C}) \cdot C^{NF} \cdot p^{NF}_{P} + \sigma^{NF}_{M,C} \cdot C^{NF} \cdot p^{NF,w} \cdot e^{N} + \\ (1-\sigma^{NF}_{M,IC}) \cdot IC^{NF} \cdot p^{NF}_{P} + \sigma^{NF}_{M,IC} \cdot IC^{NF} \cdot p^{NF,w} \cdot e^{N} \end{array} \right] \tag{175}$$

$$sub = sub^{A} + sub^{NF} + sub^{PF} \tag{176}$$

Other taxes ($Otaxes$) are levied on domestic demand and imports in the agriculture, processed food and non-food sectors.

$$Otaxes^{A} = otax_{A} \cdot \left[(Y^{P,A}_{C} + Y^{P,A}_{IC}) \cdot p^{A}_{p} + (IM^{A}_{C} \cdot p^{A,w}_{C} + IM^{A}_{IC} \cdot p^{A,w}_{IC}) \cdot e^{N} \right] \tag{177}$$

$$Otaxes^{PF} = otax_{PF} \cdot \left[(Y^{D,PF} - X^{PF}) \cdot p^{PF}_{P} + IM^{PF} \cdot p^{PF,w} \cdot e^{N} \right] \tag{178}$$

$$Otaxes^{NF} = otax_{NF} \cdot \left[(Y^{D,NF} - X^{NF}) \cdot p^{NF}_{P} + IM^{NF} \cdot p^{NF,w} \cdot e^{N} \right] \tag{179}$$

$$Otaxes = Otaxes^{A} + Otaxes^{F} + Otaxes^{PF} \tag{180}$$

And finally, taxes on production (Tpr) are levied on the total production including production for exports:

$$Tpr^{A} = \tau pr_{A} . (Y^{P,A} \cdot p^{A}_{P} + X^{A} . p^{A}_{X} \cdot e^{N}) \tag{181}$$

$$Tpr^{i} = \tau pr_{i} \cdot \left[(Y^{P,i} - X^{i}) \cdot p^{i}_{P} + X^{i} \cdot p^{i}_{X} \cdot e^{N} \right], i \in \{PF, NF\} \tag{182}$$

$$Tpr^{B} = \tau pr^{B} \cdot \left[i^{L}_{D} \cdot L^{F}_{D} \cdot (1-\beta_{npl}) + i^{L}_{H} \cdot L^{H}_{D} \cdot (1-\beta^{H}_{npl}) + i^{L}_{D} \cdot L^{A}_{D} \cdot (1-\beta^{A}_{npl}) \right] \tag{183}$$

$$Tpr = Tpr^{A} + Tpr^{PF} + Tpr^{NF} + Tpr^{B} \tag{184}$$

Total taxes on income and profits (T, 185) are the sum of taxes on agricultural mixed income, on firm profits, bank profits and household wage income plus gross operating surplus:

$$\begin{aligned} T \quad = \quad & \tau^{A} \cdot MI^{A} + \tau^{F} \cdot GF^{F} + \tau^{B} \cdot GF^{B} + \tau^{H} \cdot (w^{A} \cdot N^{A} + \\ & w^{NF} \cdot N^{NF} + w^{PF} \cdot N^{PF} + w^{B} \cdot N^{B} + w^{G} \cdot N^{G} + GOS^{F}_{H}) \end{aligned} \tag{185}$$

The government spends on social security and welfare (GE, 186), which depends on the number of unemployed people and the average wage rate in the non-financial sector.

$$GE = \phi_{2} \cdot w^{NF} \cdot \left[Pop - (N^{A} + N^{PF} + N^{NF} + N^{G} + N^{B}) \right] \tag{186}$$

It also distributes other transfers to households ($Transf^G_H$, 187):

$$Transf^G_H = tr^G_H \cdot \begin{bmatrix} (Y^{P,PF} - X^{PF}) \cdot p^{PF}_P + X^{PF} \cdot p^{PF}_X \cdot e^N + \\ (Y^{P,NF} - X^{NF}) \cdot p^{NF}_P + X^{NF} \cdot p^{NF}_X \cdot e^N) \end{bmatrix} \tag{187}$$

Public investment has two components: Investment in adaptation ($I_{G,irrig}$) and investment in capital ($I_{G,cap}$). In line with the Water 2050 plan, cited in the main text, we set the public investment in adaptation a constant fraction of nominal GDP. As with private investment in capital, public adaptation investment moves slowly to its target value.

$$I^{Tar}_{G,irrig} = \gamma^G_{ir} \cdot (NomGDP/p^{NF}_K) \tag{188}$$

$$\dot{I}_{G,irrig} = \beta_{irrig} \cdot (I^{Tar}_{G,irrig} \cdot - I_{G,irrig}) \tag{189}$$

On the other and, public investment in capital stock has a constant growth rate gr_{ig}.

$$\dot{I}_{G,cap} = I_{G,cap} \cdot gr_{ig} \tag{190}$$

$$I^{NF}_G = I_{G,irrig} + I_{G,cap} \tag{191}$$

$$\dot{K}^G = I^{NF}_G - \delta_G \cdot K^G \tag{192}$$

where δ_G is the depreciation rate of public capital.

In order to finance its deficit, the government borrows in domestic currency bonds (B^G) and in FX from international markets (L^G_{FX}). We assume that public adaptation investment is financed by FX loans from multilateral organizations ($\dot{L}^{G,Adap}_{FX}$, 193) and/or development banks at the preferential interest rate $i^{L,G,Adap}_{FX}$.

$$\dot{L}^{G,Adap}_{FX} = I_{G,irrig} \cdot p^{NF}_K / e^N \tag{193}$$

The instantenous interest rate on domestic currency bonds ($i^{G,Tar}_B$, 194) is a premium ($prem_{gov}, 195$) over the CPI inflation rate.

$$i^{G,Tar}_B = inf^H + prem_{gov} \tag{194}$$

where the premium depends on the total public debt to GDP ratio.

$$prem_{gov} = \Phi_1 \cdot (\frac{L^G_{FX} \cdot e^N + B^G + L^{G,Adap}_{FX} \cdot e^N}{NomGDP})^{\Phi_2} \tag{195}$$

The actual interest rate over the stock of bonds moves slowly towards the instantenous rate as with other interest rates:

$$\dot{i}^G_B = \beta_{ibg} \cdot (i^{G,Tar}_B - i^G_B); \tag{196}$$

The interest rate on FX borowing by the public sector ($i_{FX}^{L,G}$, 197) is a premium over the risk-free world rate (i_{FX}^{W}). As in the banking sector, the premium depends on the country risk:

$$i_{FX}^{L,G} = i_{FX}^{W} + \Phi_3 \cdot rsk \tag{197}$$

Thus, the total spending of the government (G_T, 198) at each point in time can be found as the sum of public wages and employer's social contributions, intermediate consumption of the government, interest payments on public debt and transfers to households:

$$\begin{aligned} G_T \quad = \quad & w^G \cdot N^G + IC_N^G + ESC^G + G_E + sub + L_{FX}^{G,Adap} \cdot e^N \cdot i_{FX}^{L,G,Adap} + I_{cap}^G \cdot p_K^{NF} + \\ & i_B^G \cdot B^G + i_{FX}^{L,G} \cdot L_{FX}^G \cdot e^N + Transf_H^G \end{aligned} \tag{198}$$

The government also keeps a certain amount of domestic currency deposits at the central bank for operational purposes ($Dep_D^{G,cur}$). The level of these deposits depends on the public wage bill and employer's social contributions:

$$Dep_D^{G,cur,Tar} = \eta_g \cdot (w^G \cdot N^G + ESC^G) \tag{199}$$

$$\dot{D}ep_D^{G,cur} = \beta_{Dep}^G \cdot (Dep_D^{G,cur,Tar} - Dep_D^{G,cur}) \tag{200}$$

And finally, in line with the national accounts data, the government receives other transfers ($Transf_G^i$) from the NFC sector, banking sector, the central bank and the rest of the world. We define these transfers as a fixed fraction of total production of PF and NF sector goods measured in producer prices:

$$Transf_G^i = tr_G^i \cdot \left[\begin{array}{l} (Y^{P,PF} - X^{PF}) \cdot p_P^{PF} + X^{PF} \cdot p_X^{PF} \cdot e^N + \\ (Y^{P,NF} - X^{NF}) \cdot p_P^{NF} + X^{NF} \cdot p_X^{NF} \cdot e^N) \end{array} \right], i \in \{F, CB, B, W\} \tag{201}$$

Thus, the financing needs of the government (TFN^G,202) is the difference between its total spending and revenues, taking into account its deposit accumulation ($\dot{D}ep_D^{G,cur}$):

$$\begin{aligned} TFN^G \quad = \quad & G_T - WSC - ESC - T - VAT - TIM - Otaxes - Tpr - F^{CB} - Div_G^F \\ & - Div_G^B - Transf_G^W - Transf_G^F - Transf_G^B - Transf_G^{CB} + \dot{D}ep_D^{G,cur} \end{aligned} \tag{202}$$

where F^{CB} is the profits of the central bank transferred to the government, to be defined in the next section.

As part of fiscal policy, the government borrows a fixed fraction of the trade deficit as FX loans ($\dot{L}_{FX}^G$, 203), in order to provide the economy part of its FX needs. We assume that there is no rationing on public FX borrowing due to higher country risk.

$$\dot{L}_{FX}^G = \Psi \cdot (-X + IM) \tag{203}$$

The remaining part of the public deficit is financed by issuing domestic currency bonds (B^G):

$$\dot{B}^G = \max[TFN^G - L^G_{FX} \cdot e^N, 0] \tag{204}$$

A.1.6. Central Bank

The central bank implements a pure inflation-targeting Taylor Rule to determine target policy rate (i_p^{tar}, 205):

$$i_p^{tar} = \iota_1 + \iota_2 \cdot inf^H \tag{205}$$

The actual policy rate (i_p) moves towards this target rate:

$$\dot{i}_p = \beta_{ip} \cdot (i_p^{Tar} - i_p) \tag{206}$$

On the asset side, the central bank buys a fixed fraction of public bonds emission at each point in time ($\dot{B}^G_{CB}$, 207):

$$\dot{B}^G_{CB} = \max[\varsigma \cdot \dot{B}^G, -B^G_{CB}] \tag{207}$$

FX reserve accumulation of the central bank ($\dot{R}^{CB}_{FX}$) is equal to the total FX accumulation of the country ($\dot{R}_{FX}$) less of bank FX reserve accumulation ($\dot{R}^B_{FX}$):

$$\dot{R}^{CB}_{FX} = \dot{R}_{FX} - \dot{R}^B_{FX} \tag{208}$$

The bank does not earn any interest rate on its FX reserve holdings. For simplicity, we assume away employment and other operational costs. Thus, central bank profits (F^{CB}) are given by

$$F^{CB} = i^G_B \cdot B^G_{CB} + i_p \cdot Ad \tag{209}$$

and are fully transferred to the government.

A.1.7. Households

Households income is composed of productive income and financial income. Productive income (YD^H_P, 210) includes after-tax wage payments, after tax agricultural mixed income and gross operating surplus, transfers from the government, social security receipts minus workers' social security contributions.

$$\begin{aligned} YD^H_P &= (1-\tau^H) \cdot (w^{NF} \cdot N^{NF} + w^{PF} \cdot N^{PF} + w^B \cdot N^B + w^G \cdot N^G + w^A \cdot N^A + GOS^F_H) \\ &\quad + (NF^A - S^A) + Transf^G_H + G_E - WSC \end{aligned} \tag{210}$$

On the other hand, financial income (YD^H_F, 211) consists of interest payments on household savings, dividends from NFCs and banks, interest income on government bonds held by households and remittances less of interest paid on household loans (taking into account non-performing loans), comissions and net insurance costs.

$$YD_F^H = i_D^{Dep,H} \cdot Dep_D^{H,sav} + Div_H^F + Div_H^B + i_B^G \cdot B_H^G - (1-\beta_{npl}^H) \cdot L_D^H \cdot i_D^{L,H} - Com^H - Ins^H + Rem \cdot e^N \quad (211)$$

We assume that non-performing loans rate for households (β_{npl}^H, 212) follows the general non-performing loans rate, defined above in (111).

$$\beta_{npl}^H = \beta_{npl}^F \quad (212)$$

Households have a two-stage decision making process to determine consumption demand for each sector's products. In the first stage, they decide on a target aggregate nominal consumption (Con^{Tar}, 213) via their marginal propensity to consume (mpc, 215) out of their total income;

$$Con^{Tar} = mpc \cdot (YD_P^H + YD_F^H) \quad (213)$$

Aggregate consumption (Con) displays inertia and slowly moves towards this target level.

$$\dot{Con} = \beta_{con} \cdot (Con^{Tar} - Con) \quad (214)$$

The marginal propensity to consume depends on the real interest rate on household deposits and follows a sigmoidal function, with its lower bound given by LB_{MPC}, inflection point by MP_{MPC} and upper bound by UB_{MPC}.

$$mpc = \frac{1}{1 + \exp\left[\beta_{mpc} \cdot (i_{real}^{dep} - MP_{MPC})\right]} \cdot (UB_{MPC} - LB_{MPC}) + LB_{MPC} \quad (215)$$

where i_{real}^{dep} is the real deposit rate, defined as nominal interest rate on deposits deflated by CPI inflation to be defined below[26].

$$i_{real}^{dep} = i_D^{Dep,H} - inf^H \quad (216)$$

At the second stage, households allocate their consumption to agriculture, processed food and non-food goods. This allocation follows a Linear Expenditure System specification:

$$C^{A,tar} = \frac{rca \cdot Pop \cdot p_C^A + eps_1 \cdot (Con - rca \cdot Pop \cdot p_C^A - rcpf \cdot Pop \cdot p_C^{PF} - rcnf \cdot Pop \cdot p_C^{NF})}{p_C^A} \quad (217)$$

$$C^{PF} = \frac{rcpf \cdot Pop \cdot p_C^{PF} + eps_2 \cdot (Con - rca \cdot Pop \cdot p_C^A - rcpf \cdot Pop \cdot p_C^{PF} - rcnf \cdot Pop \cdot p_C^{NF})}{p_C^{PF}} \quad (218)$$

[26]Thus, monetary transmission mechanism operates via higher nominal deposit rates, which increase real deposit rates, reduce marginal propensity to consume and dampen demand. A lower demand feeds into lower producer price markups, slowing down price inflation.

$$C^{NF} = \frac{rcnf \cdot Pop \cdot p_C^{NF} + (1 - eps_1 - eps_2) \cdot (Con - rca \cdot Pop \cdot p_C^A - rcpf \cdot Pop \cdot p_C^{PF} - rcnf \cdot Pop \cdot p_C^{NF})}{p_C^{NF}} \tag{219}$$

where rca, $rcpf$ and $rcnf$ respectively denote the minimum levels of consumption of agricultural, processed food and non-food goods. LES allows for non-homothetic demand, implying that food demand is less likely to be overestimated as the income share of minimum food consumption falls with growing incomes. However, LES also violates Engel's law that marginal income elasticities of food must decrease with growing income, whereas the LES specification above implies fixed marginal budget shares. We therefore adjust the parameters eps_1 and eps_2 in order to ensure that this elasticity falls as real consumption of households grow.

$$eps_1^{tar} = eps_3 - eps_4 \cdot (Con/CPI)^{eps5} \tag{220}$$

$$eps_2^{tar} = eps_6 - eps_7 \cdot (Con/CPI)^{eps8} \tag{221}$$

$$\dot{eps_1} = \beta_{eps1} \cdot (eps_1^{tar} - eps_1) \tag{222}$$

$$\dot{eps_2} = \beta_{eps2} \cdot (eps_2^{tar} - eps_2) \tag{223}$$

$$\dot{C}^A = \beta_{CA} \cdot (C^{A,tar} - C^A) \tag{224}$$

The consumer price index for households (CPI, 225) is given by:

$$CPI = p_C^A \cdot \gamma_H^A + p_C^{PF} \cdot \gamma_H^{PF} + p_C^{NF} \cdot (1 - \gamma_H^A - \gamma_H^{PF}); \tag{225}$$

where

$$\gamma_H^A = \frac{C^A}{C^A + C^{PF} + C^{NF}} \tag{226}$$

$$\gamma_H^{PF} = \frac{C^{PF}}{C^A + C^{PF} + C^{NF}} \tag{227}$$

are the shares of agricultural and processed food goods in the consumption basket.

Thus, inflation faced by households (inf^H, 228) at each point in time is measured as:

$$inf^H = D(CPI, t)/CPI \tag{228}$$

Households have a target real investment ($I_H^{NF,Tar}$, 229), which is determined as a fraction of their gross disposable income (in the form of housing and durable goods).

$$I_H^{NF,Tar} = \xi \cdot (YD_P^H + YD_F^H)/p_K^{NF} \tag{229}$$

$$\dot{I}_H^{NF} = \beta_{IH} \cdot (I_H^{NF,Tar} - I_H^{NF}) \tag{230}$$

$$K^H = I_H^{NF} - \delta_H \cdot K^H \tag{231}$$

A fraction of this investment is financed by borrowing from banks ($\dot{L}_D^H$, 232):

$$\dot{L}_D^H = \varphi \cdot I_H^{NF} \cdot p_K^{NF} \tag{232}$$

Total savings of households (S_H, 233}) is the difference between all sources of disposable income and saving-financed investment plus consumption.

$$S_H = YD_P^H + YD_F^H - Con - (1 - \varphi) \cdot I_H^{NF} \cdot p_K^{NF} \tag{233}$$

Households hold their savings in the form of bank deposits (Dep_D^H, 238) and government bonds (B_H^G). We assume that the change in current account deposits ($\dot{D}ep_D^{H,cur}$, 234) follow the change in consimption:

$$\dot{D}ep_D^{H,cur} = cc_1 \cdot \dot{C}on \tag{234}$$

On the other hand, part of remittances received by households is accumulated as FX current accounts ($\dot{D}ep_{FX}^H$, 235):

$$\dot{D}ep_{FX}^H = cc_2 \cdot Rem \tag{235}$$

After these deductions from their savings, households purchase a share of government bonds:

$$\dot{B}_H^G = Max[\upsilon_H \cdot (S_h - \dot{D}ep_D^H - \dot{D}ep_{FX}^H \cdot e^N), -B_H^G] \tag{236}$$

The rest of the savings are accumulated in domestic currency saving accounts ($\dot{D}ep^{H,sav}$, 237):

$$\dot{D}ep_D^{H,sav} = S_H - \dot{D}ep_D^{H,cur} - \dot{B}_H^G - \dot{D}ep_{FX}^H \cdot e^N \tag{237}$$

$$Dep_D^H = Dep_D^{H,sav} + Dep_D^{H,cur} \tag{238}$$

$$\dot{D}ep_D^H = \dot{D}ep_D^{H,sav} + \dot{D}ep_D^{H,cur} \tag{239}$$

Wages in all sectors are fully indexed to inflation and productivity gains. We assume that initial wage levels and wage growth rates are equal in the processed food and non-food sectors.

$$\dot{w}^{NF} = w^{NF} \cdot (gr_a + inf^H) \tag{240}$$

$$\dot{w}^{PF} = \dot{w}^{NF} \tag{241}$$

$$\dot{w}^A = w^A \cdot (gr_a^A + inf^H) \tag{242}$$

$$\dot{w}^G = w^G \cdot (gr_a + inf^H) \tag{243}$$

$$\dot{w}^B = w^B \cdot (gr_a + inf^H) \tag{244}$$

Labour productivity in the agriculture sector (a^A) grows exogenously:

$$\dot{a}^A = gr_a^A \cdot a^A \tag{245}$$

On the other hand, labour productivity in processed food and non-food sectors depend on the growth rate of public investment[27]. We specify a sigmoid function for this relationship, with a lower bound at LB_{gra}, an upper bound at UB_{gra} and an inflection point at MP_{gra}.

$$\dot{a}^{PF} = gr_a \cdot a^{PF} \tag{246}$$

$$\dot{a}^{NF} = gr_a \cdot a^{NF} \tag{247}$$

$$gr_a^{Tar} = \frac{\beta_{1,gra}}{1 + \text{exp}\left[\beta_{2,gra} \cdot (gr_{ig} - MP_{gra})\right]} \cdot (UB_{gra} - LB_{gra}) + LB_{gra} \tag{248}$$

$$\dot{gr}_a = \beta_{gra} \cdot (gr_a^{Tar} - gr_a) \tag{249}$$

Unemployment is defined over the active labour force, determined by the participation rate $part$ and population (Pop).

$$unemp = 1 - \frac{(N^A + N^{NF} + N^G + N^B + N^{PF})}{part \cdot Pop} \tag{250}$$

And finally population grows at an exogenous rate:

$$\dot{Pop} = \alpha_{pop} \cdot Pop \tag{251}$$

A.1.8. Exchange Rate Dynamics

In order to determine the evolution of the nominal exchange rate, we start by specfying the demand and supply of FX in the economy. The demand for FX (D_{FX}, 252) depends on nominal value of imports in foreign exchange (IM, 254), the income account of the balance of payments (IA, 257) and the bank demand for FX reserves ($\dot{R}^B_{FX}$):

$$D_{FX} = IM + IA + \dot{R}^B_{FX} \tag{252}$$

On the other hand, supply of FX (S_{FX}, 253) is given by nominal value of exports in foreign exchange (X, 255), cross border borrowing by banks and the government, transfers from the rest of the world to the government, remittances (Rem) and deposits flow by rest of the world to the Tunisian economy ($\dot{Dep}^W_{FX} + \dot{Dep}^W_D / e^N$):

[27] See the text for the motivation for this specification

$$
\begin{aligned}
S_{FX} \quad &= \quad X + \dot{L}^B_{FX} + \dot{L}^G_{FX} + FDI^F/e^N + FDI^B + Transf^W_G/e^N + Rem \\
&\quad + \dot{Dep}^W_{FX} + \dot{Dep}^W_D/e^N + \dot{L}^{G,Adap}_{FX}
\end{aligned} \tag{253}
$$

The nominal value of imports and exports in FX can be written as:

$$
IM = IM^A_C \cdot p^{A,w}_C + IM^A_{IC} \cdot p^{A,w}_{IC} + IM^{NF} \cdot p^{NF,w} + IM^{PF} \cdot p^{PF,w} \tag{254}
$$

$$
X = X^{NF} \cdot p^{NF}_X + X^A \cdot p^A_X + X^{PF} \cdot p^{PF}_X + mrg^{PF}_X \cdot X^{PF} \cdot p^{PF}_X + mrg^A_X \cdot X^A \cdot p^A_X \tag{255}
$$

The nominal exchange rate (e^N) then depends on the difference between demand and supply of FX. An excess demand for FX leads to a depreciation of the domestic currency, the speed of which is measured by β_{eN}.

$$
\dot{e}^N = \beta_{eN} \cdot (D_{FX} - S_{FX})/S_{FX} \tag{256}
$$

A.1.9. Rest of the World and Balance of Payments

The income account of the balance of payments is defined as the interest and dividend payments abroad:

$$
IA = i^B_{FX} \cdot L^B_{FX} + i^{L,G}_{FX} \cdot L^G_{FX} + i^{L,G,Adap}_{FX} \cdot L^{G,Adap}_{FX} + (Div^F_W + Div^B_W)/e^N) \tag{257}
$$

Remittances are a fixed fraction of the world nominal GDP, given by the real world GDP (GDP^W) multiplied by the world CPI (CPI^W):

$$
Rem = rem \cdot GDP^W \cdot CPI^W \tag{258}
$$

We use the marginal budget shares of households to calculate the world price level as a weighted average of global agricultural, processed food and non-food prices.

$$
CPI^W = eps_1 \cdot p^{A,w}_C + eps_2 \cdot p^{PF,w} + (1 - eps_1 - eps_2) \cdot p^{NF,w} \tag{259}
$$

The growth rates of real world GDP (GDP^W) and labour productivity (a^W) are exogenous:

$$
G\dot{D}P^W = gr_w \cdot GDP^W \tag{260}
$$

$$
\dot{a}^W = gr_{aw} \cdot a^W \tag{261}
$$

Similarly, risk-free FX lending rate is exogenous:

$$
i^W_{FX} = i^W_{FX,0} \tag{262}
$$

The change in deposit holdings of the rest of the world in domestic currency ($\dot{Dep}_D^W$, 264) and FX ($\dot{Dep}_{FX}^W$, 263) are fixed fractions of remittances:

$$\dot{Dep}_{FX}^W = \theta_1 \cdot Rem \tag{263}$$

$$\dot{Dep}_D^W = \theta_2 \cdot Rem \cdot e^N \tag{264}$$

The current account balance ($CurAC$, 265) can then be defined as:

$$CurAC = -IA + Rem + X - IM + Transf_G^W / e^N \tag{265}$$

The FX accumulation of the country ($\dot{R}_{FX}$, 266) at each point in time is:

$$\begin{aligned} \dot{R}_{FX} \quad = \quad & X + \dot{L}_{FX}^B + \dot{L}_{FX}^G + FDI^F / e^N + Transf_G^W / e^N + Rem + \dot{Dep}_{FX}^W \\ & + \dot{Dep}_D^W / e^N - IM - IA + \dot{L}_{FX}^{G,Adap} \end{aligned} \tag{266}$$

And finally, we define nominal GDP ($NomGDP$, 267) from the demand side:

$$\begin{aligned} NomGDP \quad = \quad & Con + I^{NF} \cdot p_K^{NF} + X \cdot e^N - IM \cdot e^N + IC_N^G + w^G \cdot N^G + ESC^G \\ & + \delta_G \cdot K^G \cdot p_K^{NF} + \dot{V}^{NF} \cdot p_P^{NF} + \dot{V}^{PF} \cdot p_P^{PF} + Com^H + Ins^H + FISIM^H \end{aligned} \tag{267}$$

where $FISIM^H$ (268) is the Financial Intermediation Services Indirectly Measured for households and it is computed as:

$$FISIM^H = (i_D^{L,H} - i^P) \cdot (1 - \beta_{npl}^H) \cdot L_D^H + (i^P - i_D^{Dep,H}) \cdot Dep_D^{H,sav} + i^P \cdot Dep_D^{H,cur} \tag{268}$$

The resulting model is a *differential algebraic* system, which can be reduced to an 84-dimensional differential equation system. The state variables and their initial values are reported below.

A.1.10. Simulations

Beginning from end of 2017 for which we could obtain the latest detailed data on integrated economic accounts, we simulate the model using the program *Mathematica.* Due to the lack of explicit differential equations for CPI inflation in (228) and growth rate of nominal GDP (267), which appear in various equations, we cannot utilize the well-known Runge-Kutta algorithm for our simulations. Thus, we implement the "*Equation Simplification*: *Residual*" method in-built in Mathematica, which can provide robust simulation results in such cases. The algorithm is also efficient with stiff differential equation systems and stops the simulation if the system displays such behaviour. We have not encountered any such stiffness in our exercise.

A.1.11. Definitions

The Transactions Flow Matrix presented in the main text is defined in terms of nominal domestic currency values and a group of variables are defined either as real or in foreign currency. Thus, this section presents the definitions used in the TFM for consistency.

$$C^A_{nom} = C^A \cdot p^A_C$$

$$MRG^A = mrg^A_C \cdot (Y^{P,A}_C \cdot p^A_P + IM^A_C \cdot p^{A,w}_C \cdot e^N) + mrg^A_{IC} \cdot (Y^{P,A}_{IC} \cdot p^A_P + IM^A_{IC} \cdot p^{A,w}_{IC} \cdot e^N) + mrg^A_X \cdot (X^A \cdot p^A_X \cdot e^N)$$

$$C^{PF}_{nom} = C^{PF} \cdot p^{PF}_C$$

$$C^{NF}_{nom} = C^{NF} \cdot p^{NF}_C$$

$$I^{NF}_{A,nom} = p^{NF}_K \cdot I^{NF}_A$$

$$I^{NF}_{F,nom} = p^{NF}_K \cdot I^{NF}_F$$

$$I^{NF}_{G,nom} = p^{NF}_K \cdot I^{NF}_G$$

$$I^{NF}_{H,nom} = p^{NF}_K \cdot I^{NF}_H$$

$$I^{NF}_{nom} = p^{NF}_K \cdot I^{NF}$$

$$IM^A_N = IM^A_C \cdot p^{A,w}_C \cdot e^N + IM^A_{IC} \cdot p^{A,w}_{IC} \cdot e^N$$

$$IM_{nom} = IM^A_N + IM^{PF}_N + IM^{NF}_N$$

$$X^A_{nom} = X^A \cdot p^A_X \cdot e^N + mrg^A_X \cdot X^A * p^A_X \cdot e^N$$

$$X^{NF}_{nom} = X^{NF} \cdot p^{NF}_X \cdot e^N$$

$$X^{PF}_{nom} = X^{PF} \cdot p^{PF}_X \cdot e^N + mrg^{PF}_X \cdot X^{PF} \cdot p^{PF}_X \cdot e^N$$

$$X_{nom} = X^A_{nom} + X^{PF}_{nom} + X^{NF}_{nom}$$

$$IC^A_{A,nom} = IC^A_A \cdot p^A_{IC}$$

$$IC^{A}_{PF,nom} = IC^{A}_{PF} \cdot p^{A}_{IC}$$

$$IC^{A}_{NF,nom} = IC^{A}_{NF} \cdot p^{A}_{IC}$$

$$IC^{A}_{G,nom} = IC^{A}_{G} \cdot p^{A}_{IC}$$

$$IC^{A}_{nom} = IC^{A} \cdot p^{A}_{IC}$$

$$IC^{A}_{PF,NF,nom} = IC^{A}_{PF} \cdot p^{A}_{IC} + IC^{A}_{NF} \cdot p^{A}_{IC}$$

$$IC^{A}_{PF,NF,G,nom} = IC^{A}_{PF} \cdot p^{A}_{IC} + IC^{A}_{NF} \cdot p^{A}_{IC} + IC^{A}_{G} \cdot p^{A}_{IC}$$

$$IC^{PF}_{A,nom} = IC^{PF}_{A} \cdot p^{PF}_{IC}$$

$$IC^{PF}_{G,nom} = IC^{PF}_{G} \cdot p^{PF}_{IC}$$

$$IC^{PF}_{A,G,nom} = IC^{PF}_{A} \cdot p^{PF}_{IC} + IC^{PF}_{G} \cdot p^{PF}_{IC}$$

$$IC^{NF}_{A,nom} = IC^{NF}_{A} \cdot p^{NF}_{IC}$$

$$IC^{NF}_{B,nom} = IC^{NF}_{B} \cdot p^{NF}_{IC}$$

$$IC^{NF}_{G,nom} = IC^{NF}_{G} \cdot p^{NF}_{IC}$$

$$IC^{NF}_{A,B,G,nom} = IC^{NF}_{A} \cdot p^{NF}_{IC} + IC^{NF}_{B} \cdot p^{NF}_{IC} + IC^{NF}_{G} \cdot p^{NF}_{IC}$$

$$WB^{F} = w^{PF} \cdot N^{PF} + w^{NF} \cdot N^{NF}$$

$$WB^{G} = w^{G} \cdot N^{G}$$

$$WB^{B} = w^{B} \cdot N^{B}$$

$$WB = WB^{A} + WB^{F} + WB^{G} + WB^{B}$$

$$ESC^{F} = ESC^{NF} + ESC^{PF}$$

$$VAT^F = VAT^{PF} + VAT^{NF}$$

$$TIM^F = TIM^{PF} + TIM^{NF}$$

$$sub^F = sub^{PF} + sub^{NF}$$

$$Otaxes^{PF} = Otaxes^{PF} + Otaxes^{NF}$$

$$Tpr^F = Tpr^{PF} + Tpr^{NF}$$

$$RE^F = (1 - \beta^F_{sav}) \cdot (1 - divrate^F) \cdot FN^F$$

$$\dot{V}^F = \dot{V}^{PF} + \dot{V}^{NF}$$

$$T^A = \tau^A \cdot MI^A$$

$$T^F = \tau^F \cdot GF^F$$
$$T^B = \tau^B \cdot GF^B$$

$$T^H = \tau^H \cdot (w^{NF} \cdot N^{NF} + w^{PF} \cdot N^{PF} + w^B \cdot N^B + w^G \cdot N^G + w^A \cdot N^A + GOS^F_H)$$

$$Transf_G = \Sigma Transf^i_G, i \in \{F, B, CB, W\} - Transf^G_H$$

$$IntD^F = i^{Dep}_D \cdot Dep^{F,sav}_D$$

$$IntD^H = i^{Dep,H}_D \cdot Dep^{H,sav}_D$$

$$IntD = i^{Dep}_D \cdot Dep^{F,sav}_D + i^{Dep,H}_D \cdot Dep^{H,sav}_D$$

$$IntB^H = i^G_B. \cdot B^H_G$$

$$IntB^{CB} = i^G_B \cdot B^G_{CB}$$

$$IntB^B = i^G_B \cdot B^B_G$$

$$IntB = i_B^G \cdot B_G^B + i_{B^.}^G \cdot B_G^H + i_B^G \cdot B_{CB}^G$$

$$IntA = i_p \cdot Ad$$

$$IntL_D^F = (1 - \beta_{npl}^F) \cdot i_D^L \cdot L_D^F$$

$$IntL_D^H = (1 - \beta_{npl}^H) \cdot L_D^H \cdot i_D^{L,H}$$

$$IntL_D = (1 - \beta_{npl}^A) \cdot i_D^L \cdot L_D^A + (1 - \beta_{npl}^F) \cdot i_D^L \cdot L_D^F + (1 - \beta_{npl}^H) \cdot L_D^H \cdot i_D^{L,H}$$

$$IntL_{B,FX}^F = i_{FX}^L \cdot L_{FX}^F \cdot e^N$$

$$IntL_{D,FX}^B = i_{FX}^B \cdot L_{FX}^B \cdot e^N$$

$$IntL_{D,FX}^G = i_{FX}^{L,G,Adap} \cdot L_{FX}^{G,Adap} \cdot e^N + i_{FX}^{L,G} \cdot L_{FX}^G \cdot e^N$$

$$IntL_{D,FX} = i_{FX}^B \cdot L_{FX}^B \cdot e^N + i_{FX}^{L,G,Adap} \cdot L_{FX}^{G,Adap} \cdot e^N + i_{FX}^{L,G} \cdot L_{FX}^G \cdot e^N$$

$$FDI^W = FDI^F + FDI^B$$

$$\dot{L}_{FX}^{G,Tot} = \dot{L}_{FX}^{G,Adap} + \dot{L}_{FX}^G$$

$$\dot{L}_{FX} = \dot{L}_{FX}^{G,Tot} + \dot{L}_{FX}^B$$

$$K = \sum K^i, i \in A, F, G, H$$

$$EQ^W = EQ_F^W + EQ_B^W$$

A.2. Variables

Table 7: Nomenclature

Variable	Description	Type	Currency	Equation Number
$Y^{P,A}$	Total output of Agriculture Sector	Real		1
$Y_C^{P,A}$	Total output of Agriculture Sector for Consumption	Real		2
$Y_{IC}^{P,A}$	Total output of Agriculture Sector for Intermediate Consumption	Real		3
$Y_W^{P,A}$	Total output of Agriculture Sector for Exports	Real		4
$Y^{D,A}$	Domestic Aggregate Demand for Agriculture Goods	Real		5
$Y_C^{D,A}$	Domestic Consumption Demand for Agriculture Goods	Real		6
$Y_{IC}^{D,A}$	Domestic Intermediate Consumption Demand for Agriculture Goods	Real		7
X^A	Exports of Agriculture Goods	Real		8
IC_A^A	Intermediate Consumption of Agriculture Goods by Agriculture Sector	Real		9
IC_A^{PF}	Intermediate Consumption of Processed Food by Agriculture Sector	Real		9
IC_A^{NF}	Intermediate Consumption of Non-Food Goods by Agriculture Sector	Real		9
IM_C^A	Imports of Agriculture Goods for Consumption	Real		10

Continued on next page

Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
IM^A_{IC}	Imports of Agriculture Goods for Intermediate Consumption	Real		11
$\sigma^A_{M,C}$	Imports propensity of Agriculture Goods for Consumption			12
$\sigma^A_{M,IC}$	Imports propensity of Agriculture Goods for Intermediate Consumption			13
IC^A	Total Intermediate Consumption Demand for Agriculture Goods	Real		14
$Y^{D,PF}$	Demand for Domestically Produced Processed Food Goods	Real		15
$Y^{D,NF}$	Demand for Domestically Produced Non-Food Goods	Real		16
I^{NF}	Total Investment Demand Non-Food Goods	Real		17
IC^A_{PF}	Intermediate Consumption of Agriculture Goods by Processed Food Sector	Real		18
IC^{PF}_{PF}	Intermediate Consumption of Processed Food Goods by Processed Food Sector	Real		18
IC^{NF}_{PF}	Intermediate Consumption of Non-Food Goods by Processed Food Sector	Real		18
IC^A_{NF}	Intermediate Consumption of Agriculture Goods by Non-Food Sector	Real		19
IC^{PF}_{NF}	Intermediate Consumption of Processed Food Goods by Non-Food Sector	Real		19

Continued on next page

Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
IC^{NF}_{NF}	Intermediate Consumption of Non-Food Goods by Non-Food Sector	Real		19
IC^{A}_{G}	Intermediate Consumption of Agriculture Goods by Government	Real		20
IC^{PF}_{G}	Intermediate Consumption of Processed Food Goods by Government	Real		20
IC^{NF}_{G}	Intermediate Consumption of Non-Food Goods by Government	Real		21
IC^{NF}_{B}	Intermediate Consumption of Non-Food Goods by Banks	Real		22
IC^{PF}	Total Intermediate Consumption Demand for Processed Food Goods	Real		23
IC^{NF}	Total Intermediate Consumption Demand for Non-Food Goods	Real		24
$Y^{e,PF}$	Expected Demand for Domestically Produced Processed Food Goods	Real		25
$Y^{e,NF}$	Expected Demand for Domestically Produced Non-Food Goods	Real		26
V^{PF}	Stock of Inventories for Processed Food Goods	Real		27
V^{NF}	Stock of Inventories for Non-Food Goods	Real		27
$V^{des,PF}$	Desired Level of Inventories for Processed Food Goods	Real		28

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
$V^{des,NF}$	Desired Level of Inventories for Non-Food Goods	Real		28
I_V^{PF}	Production for inventory replacement Processed Food Sector	Real		29
I_V^{NF}	Production for inventory replacement Non-Food Sector	Real		29
$Y^{P,PF}$	Domestic Production of Processed Food Goods	Real		30
$Y^{P,NF}$	Domestic Production of Non-Food Goods	Real		30
N^{NF}	Emplyment Non-Food Sector			31
N^{PF}	Emplyment Processed Food Sector			32
IM^{PF}	Total Imports of Processed Food Sector	Real		33
IM^{NF}	Total Imports of Non-Food Sector	Real		34
IM_N^{PF}	Total Imports of Processed Food Sector	Nominal	Domestic Cur	35
IM_N^{NF}	Total Imports of Non-Food Sector	Nominal	Domestic Cur	36
$\sigma_{M,C}^{PF,Tar}$	Target Import Propensity of Processed Food for Consumption			37
$\sigma_{M,IC}^{PF,Tar}$	Target Import Propensity of Processed Food for Intermediate Consumption			37
$\sigma_{M,C}^{NF,Tar}$	Target Import Propensity of Non-Food for Consumption			37
$\sigma_{M,IC}^{NF,Tar}$	Target Import Propensity of Non-Food for Intermediate Consumption			37

Continued on next page

Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
$\sigma_{M,I}^{NF,Tar}$	Target Import Propensity of Non-Food for Investment			37
$\sigma_{M,C}^{PF}$	Actual Import Propensity of Processed Food for Consumption			38
$\sigma_{M,IC}^{PF}$	Actual Import Propensity of Processed Food for Intermediate Consumption			38
$\sigma_{M,C}^{NF}$	Actual Import Propensity of Non-Food for Consumption			38
$\sigma_{M,IC}^{NF}$	Actual Import Propensity of Non-Food for Intermediate Consumption			38
$\sigma_{M,I}^{NF}$	Actual Import Propensity of Non-Food for Investment			38
X^{PF}	Exports of Processed Food	Real		39
X^{NF}	Exports of Non-Food Goods	Real		40
$\sigma_{X}^{NF,Tar}$	Target Export Propensity of Non-Food	Real		41
σ_{X}^{NF}	Actual Export Propensity of Non-Food	Real		42
$p_{C}^{A,w}$	Import Price of Agricultural Goods for Consumption	Nominal	FX	43
$p_{IC}^{A,w}$	Import Price of Agricultural Goods for Intermediate Consumption	Nominal	FX	43
$p^{PF,w}$	Import Price of Processed Food Goods	Nominal	FX	44
$p^{NF,w}$	Import Price of Non Food Goods	Nominal	FX	44
p_{X}^{A}	Export Price of Agricultural Goods	Nominal	FX	45
p_{X}^{PF}	Export Price of Processed Food Goods	Nominal	FX	45

Continued on next page

Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
p_X^{NF}	Export Price of Non-Food Goods	Nominal	FX	45
UC^A	Unit Costs in Agriculture Sector	Nominal	Domestic Cur	46
HUC^A	Historical Unit Costs in Agriculture Sector	Nominal	Domestic Cur	47
$p_P^{A,Tar}$	Target Producer Price of Agricultural Goods	Nominal	Domestic Cur	48
p_P^A	Actual Producer Price of Agricultural Goods	Nominal	Domestic Cur	49
p_C^A	Consumer Price of Agricultural Goods	Nominal	Domestic Cur	50
p_{IC}^A	Intermediate Consumption Price of Agricultural Goods	Nominal	Domestic Cur	51
UC^{PF}	Unit Costs in Processed Food Sector	Nominal	Domestic Cur	52
HUC^{PF}	Historical Unit Costs in Processed Food Sector	Nominal	Domestic Cur	53
$p_P^{PF,Tar}$	Target Producer Price of Processed Food Goods		Domestic Cur	54
μ^{PF}	Mark-up in Processed Food Sector			55
p_P^{PF}	Actual Producer Price of Processed Food Goods	Nominal	Domestic Cur	56
p_C^{PF}	Consumer Price of Processed Food Goods	Nominal	Domestic Cur	57
p_{IC}^{PF}	Intermediate Consumption Price of Processed Food Goods	Nominal	Domestic Cur	58
UC^{NF}	Unit Costs in Non Food Sector	Nominal	Domestic Cur	59
HUC^{NF}	Historical Unit Costs in Non-Food Sector	Nominal	Domestic Cur	60
$p_P^{NF,Tar}$	Target Producer Price of Non-Food Goods	Nominal	Domestic Cur	61
μ^{NF}	Mark-up in Non-Food Sector			62

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
p_P^{NF}	Actual Producer Price of Non-Food Goods	Nominal	Domestic Cur	63
p_C^{NF}	Consumer Price of Non-Food Goods	Nominal	Domestic Cu	64
p_{IC}^{NF}	Intermediate Consumption Price of Non-Food Goods	Nominal	Domestic Cur	65
p_K^{NF}	Investment Price of Non-Food Goods	Nominal	Domestic Cur	66
WB^A	Wage Bill in Agriculture Sector	Nominal	Domestic Cur	67
N^A	Employmentl in Agriculture Sector			68
ESC^A	Employer's Social Contribution in Agriculture Sector	Nominal	Domestic Cur	69
T_{pr}^A	Taxes on Production in Agriculture Sector	Nominal	Domestic Cur	70
MI^A	Mixed Income in Agriculture Sector	Nominal	Domestic Cur	71
NI^A	Net Income in Agriculture Sector	Nominal	Domestic Cur	72
β_A^{npl}	Non-Performing Loans Rate of Agriculture Sector			73
$K^{A,Tar}$	Target Capital Stock in Agriculture Sector	Real		74
I_A^{NF}	Real Investment by Agriculture Sector	Real		75
RE^A	Retained Earnings in Agriculture Sector	Nominal	Domestic Cur	76
L_D^A	Bank Loans to Agriculture Sector	Nominal	Domestic Cur	77
K^A	Capital Stock in Agriculture Sector	Real		78
GOS_T^F	Total Gross Operating Surplus of NFC Sector	Nominal	Domestic Cur	79
GOS_H^F	Gross Operating Surplus of NFC Sector Distributed to Households	Nominal	Domestic Cur	80

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
GOS^F	Gross Operating Surplus of NFC Sector Retained by NFCs	Nominal	Domestic Cur	81
GF^F	Gross Sectoral Profits of NFC Sector After Distribution to Households	Nominal	Domestic Cur	82
F^F	Net Sectoral Profits of NFC Sector	Nominal	Domestic Cur	83
$I_{F,D}^{Tar}$	Target Total Investment of NFC Sector	Real		84
$I_{F,irrig}$	Adaptation Investment of NFC Sector	Real		85
$I_{F,D}$	Non-Adaptation Capital Investment of NFC Sector	Real		86
$FDI^{F,Tar}$	Target Foreign Direct Investment to NFC Sector	Real		87
FDI^F	Actual Foreign Direct Investment to NFC Sector	Real		88
I_F^{NF}	Total Capital Investment in NFC Sector	Real		89
K^F	Capital Stock of NFC Sector	Real		90
GF_T^F	Gross Sectoral Profits of NFC Sector Before Distribution to Households	Nominal	Domestic Cur	91
F_T^F	Net Sectoral Profits of NFC Sector Including Households	Nominal	Domestic Cur	92
r^F	Profit Rate NFC Sector			93
$Dep_D^{F,cur,Tar}$	Target Current Account Deposits of NFC Sector	Nominal	Domestic Cur	94
$Dep_D^{F,cur}$	Actual Current Account Deposits of NFC Sector	Nominal	Domestic Cur	95
Dep_{FX}^F	FX Current Account Deposits of NFC Sector	Nominal	FX	96

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
FN^F	Profits Net of Current Accounts in NFC Sector	Nominal	Domestic Cur	97
$Dep_D^{F,sav}$	Saving Account Deposits of NFC Sector	Nominal	Domestic Cur	98
Dep_D^F	Total Domestic Currency Deposits of NFC Sector	Nominal	Domestic Cur	99
Div^F	Dividens Distributed by NFC Sector	Nominal	Domestic Cur	101
Div_H^F	Dividens Distributed to Households by NFC Sector	Nominal	Domestic Cur	102
Div_G^F	Dividens Distributed to the Government by NFC Sector	Nominal	Domestic Cur	103
Div_W^F	Dividens Distributed to Rest of the World by NFC Sector	Nominal	Domestic Cur	104
TFN^F	Total Financing Needs of NFC Sector	Nominal	Domestic Cur	105
$L_{FX}^{F,des}$	Desired FX Borrowing from Banks by NFC Sector	Nominal	FX	106
β_F^L	Share of FX Financing by NFC Sector			107
L_{FX}^F	Actual FX Borrowing from Banks by NFC Sector	Nominal	FX	108
L_D^F	Domestic Currency Loans to NFC Sector by Banks	Nominal	Domestic Cur	109
$\beta_{npl}^{F,Tar}$	Target Non-Performing Loans Rate in the economy			110
β_{npl}^F	Actual Non-Performing Loans Rate of NFC Sector			111
$i_D^{Dep,Tar}$	Target Interest Rate on NFC Domestic Currency Saving Deposits	Nominal		112
$depmarkdown$	Mark-down from policy rates			113

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
i_D^{Dep}	Actual Interest Rate on NFC Domestic Currency Saving Deposits	Nominal		114
$i_D^{Dep,H}$	Actual Interest Rate on Household Domestic Currency Saving Deposits	Nominal		115
i_{FX}^{Dep}	Actual Interest Rate on FX Deposits	Nominal		116
$i_D^{L,Tar}$	Target Interest Rate on Domestic Currency Loans to Agriculture and NFCs	Nominal		117
AFC	Average Funding Costs of Banks			118
Dep_D	Total Domestic Currency Deposits Held at Banks	Nominal	Domestic Cur	119
$prem2$	Premium over average funding costs			120
i_D^L	Effective average interest rate on Domestic Currency Loans to Agriculture and NFCs	Nominal		121
$i_D^{L,H}$	Effective average interest rate on Domestic Currency Loans to Households	Nominal		122
$i_{FX}^{L,Tar}$	Target interest rate on FX Loans to NFCs	Nominal		123
i_{FX}^L	Effective average interest rate on FX Loans to NFCs	Nominal		124
i_{FX}^B	Interest Rate on Cross-border FX Lending to Banks from abroad	Nominal		125
$prem1$	Premium over risk-free world interest rate			126
rsk	Country Risk			127
FIP	FX Debt to GDP Ratio			128

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
rat_{FX}	Rationing Rate on Cross-Border lending to Domestic Banks			129
Ins^A	Insurance Costs of Agiculture Sector	Nominal	Domestic Cur	130
Ins^F	Insurance Costs of NFC Sector	Nominal	Domestic Cu	131
Ins^H	Insurance Costs of Households	Nominal	Domestic Cur	132
Ins	Total Insurance Income for Banks	Nominal	Domestic Cur	133
Com^A	Comissions Paid by Agiculture Sector	Nominal	Domestic Cur	134
Com^H	Comissions Paid by Households	Nominal	Domestic Cur	135
Com^F	Comissions Paid by NFC Sector	Nominal	Domestic Cur	136
Com	Total Comission Income for Banks	Nominal	Domestic Cur	137
ESC^B	Employer's Social Contributions Paid by Banks	Nominal	Domestic Cur	138
Tpr^B	Taxes on Production Paid by Banks	Nominal	Domestic Cur	139
N^B	Employment in Banking Sector			140
GF^B	Gross Profits of Banks	Nominal	Domestic Cur	141
F^B	Net Profits of Banks	Nominal	Domestic Cur	142
$OF^{B,Tar}$	Target Own Funds of Banks	Nominal	Domestic Cur	143
of	Capital Adequacy Ratio for Banks			144
RE^B	Retained Earnings of Banks	Nominal	Domestic Cur	145
OF^B	Actual Own Funds of Banks	Nominal	Domestic Cur	146
Div^B	Dividends Distributed by Banks	Nominal	Domestic Cur	147

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Table 7 – *Continued from previous page*

Variable	**Description**	**Type**	**Currency**	**Equation Number**
Div_W^B	Dividends Distributed by Banks to Rest of the World	Nominal	Domestic Cur	148
Div_G^B	Dividends Distributed by Banks to Government	Nominal	Domestic Cur	149
Div_H^B	Dividends Distributed by Banks to Households	Nominal	Domestic Cur	150
B_B^G	Government Bonds Held by Banks	Nominal	Domestic Cur	151
R_D	Reserves of Banks Held at the Central Bank	Nominal	Domestic Cur	152
TFN^B	Total Fiancing Needs of Banks	Nominal	Domestic Cur	154
FDI^B	Foreign Direct Investment Received by Banks	Nominal	Domestic Cur	155
Ad	Borrowing from the Central Bank by Banks	Nominal	Domestic Cur	156
R_{FX}^{NOP}	No-Open-Position Level of Bank FX Reserves	Nominal	FX	157
Dep_{FX}	Total FX Deposits Held at Banks	Nominal	FX	158
L_{FX}^B	Cross-Border Borrowing by Banks	Nominal	FX	159
R_{FX}^B	FX Reserves of Banks Held at Central Bank	Nominal	FX	160
IC_N^G	Total Value of Public Sector Intermediate Consumption	Nominal	Domestic Cur	161
N^G	Employment in Public Sector			162
ESC^G	Employer's Social Contributions Paid by Public Sector	Nominal	Domestic Cur	163
ESC	Total Employer's Social Contributions Received by Public Sector	Nominal	Domestic Cur	164
WSC	Total Employer's Social Contributions Paid by Workers	Nominal	Domestic Cur	165

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
VAT^{A}	Value-Added Taxes Paid on Agricultural Products	Nominal	Domestic Cur	166
VAT^{NF}	Value-Added Taxes Paid on Non-Food Products	Nominal	Domestic Cur	167
VAT^{PF}	Value-Added Taxes Paid on Processed Food Products	Nominal	Domestic Cur	168
VAT	Total Value-Added Taxes Received by Government	Nominal	Domestic Cur	169
TIM^{A}	ImportTaxes on Agricultural Goods	Nominal	Domestic Cur	170
TIM^{PF}	ImportTaxes on Processed Food Goods	Nominal	Domestic Cur	171
TIM^{NF}	ImportTaxes on Non-Food Goods	Nominal	Domestic Cur	171
TIM	Total Value-Added Taxes Received by Government	Nominal	Domestic Cur	172
sub^{A}	Subsidies on Agricultural Goods	Nominal	Domestic Cur	173
sub^{PF}	Subsidies on Processed Food Goods	Nominal	Domestic Cur	174
sub^{NF}	Subsidies on Non-Food Goods	Nominal	Domestic Cur	175
sub	Total Subsidies Paid by Government	Nominal	Domestic Cur	176
$Otaxes^{A}$	Other Taxes on Agricultural Goods	Nominal	Domestic Cur	177
$Otaxes^{PF}$	Other Taxes on Processed Food Goods	Nominal	Domestic Cur	178
$Otaxes^{NF}$	Other Taxes on Non-Food Goods	Nominal	Domestic Cur	179
$Otaxes$	Total Other Taxes Received by Government	Nominal	Domestic Cur	180
Tpr^{A}	Taxes on production Paid by Agriculture Sector	Nominal	Domestic Cur	181
Tpr^{PF}	Taxes on production Paid by Processed Food Sector	Nominal	Domestic Cur	182
Tpr^{NF}	Taxes on production Paid by Non-Food Sector	Nominal	Domestic Cur	182

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
Tpr^B	Taxes on production Paid by Banks	Nominal	Domestic Cur	183
Tpr	Total Other Taxes Received by Government	Nominal	Domestic Cur	184
T	Total Taxes on Income and Profits Received by Government	Nominal	Domestic Cur	185
GE	Total Social Security Spending by Government	Nominal	Domestic Cur	186
$Transf_H^G$	Transfers from Government to Households	Nominal	Domestic Cur	187
$I_{G,irrig}^{Tar}$	Target Adaptation Investment by Government	Real		188
$I_{G,irrig}$	Actual Adaptation Investment by Government	Real		189
$I_{G,cap}$	Actual Non-Adaptation Capital Investment by Government	Real		190
I_G^{NF}	Actual Total Capital Investment by Government	Real		191
K^G	Public Capital Stock	Real		192
$L_{FX}^{G,Adap}$	FX Borrowing by Government for Adaptation Investment	Nominal	FX	193
$i_B^{G,Tar}$	Target Interest Rate on Domestic Currency Public Bonds	Nominal		194
$prem_{gov}$	Premium on Domestic Currency Public Bonds			195
i_B^G	Effective Interest Rate on Domestic Currency Public Bonds	Nominal		196
$i_{FX}^{L,G}$	Effective Interest Rate on Public FX Borrowing	Nominal		197
G_T	Total Public Spending	Nominal	Domestic Cur	198

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
$Dep_D^{G,cur,Tar}$	Target Public Deposits Held at the Central Bank	Nominal	Domestic Cur	199
$Dep_D^{G,cur}$	Actual Public Deposits Held at the Central Bank	Nominal	Domestic Cur	200
$Transf_G^F$	Transfers from NFCs to Government	Nominal	Domestic Cur	201
$Transf_G^B$	Transfers from Banks to Government	Nominal	Domestic Cur	201
$Transf_G^{CB}$	Transfers from Central Bank to Government	Nominal	Domestic Cur	201
$Transf_G^W$	Transfers from Rest of the World to Government	Nominal	Domestic Cur	201
TFN^G	Total Financing Needs of the Government	Nominal	Domestic Cur	202
L_{FX}^G	Public (Non-Adaptation) FX Borrowing	Nominal	FX	203
B^G	Total Public Domestic Currency Bonds	Nominal	Domestic Cur	204
i_p^{tar}	Target Central Bank Policy Rate	Nominal		205
i_p	Actual Central Bank Policy Rate	Nominal		206
B_{CB}^G	Central Bank Holding of Domestic Currency Government Bonds	Nominal	Domestic Cur	207
R_{FX}^{CB}	FX Reserves of Central Bank	Nominal	FX	208
F^{CB}	Central Bank Profits	Nominal	Domestic Cur	209
YD_P^H	Productive Income of Households	Nominal	Domestic Cur	210
YD_F^H	Financial Income of Households	Nominal	Domestic Cur	211
β_{npl}^H	Non-performing Loans Rate of Households			212
Con^{Tar}	Target Level of Household Consumption	Nominal	Domestic Cur	213
Con	Actual Level of Household Consumption	Nominal	Domestic Cur	214

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
mpc	Aggregate Marginal Propensity to Consume for Households			215
i_{real}^{dep}	Real Deposit Rate for Household Savings	Nominal		216
$C^{A,tar}$	Target Household Consumption of Agriculture Goods	Real		217
C^{PF}	Household Consumption of Processed Food Goods	Real		218
C^{NF}	Household Consumption of Non-Food Goods	Real		219
$eps1^{tar}$	Target Marginal Budget Share for Consumption of Agricultural Goods			220
$eps2^{tar}$	Target Marginal Budget Share for Consumption of Processed Food Goods			221
$eps1$	Actual Marginal Budget Share for Consumption of Agricultural Goods			222
$eps2$	Actual Marginal Budget Share for Consumption of Processed Food Goods			223
C^{A}	Actual Household Consumption of Agriculture Goods	Real	224	
CPI	Consumer Price Index			225
γ_H^A	Share of Agricultural Goods in the Inflation Basket			226
γ_H^{PF}	Share of Processed Food Goods in the Inflation Basket			227
inf^H	Consumer Price Inflation			228
$I_H^{NF,Tar}$	Target Household Residential Investment	Real		229
I_H^{NF}	Actual Household Residential Investment	Real		230

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
K^H	Household Residential Capital	Real		231
L_D^H	Household Residential Loans	Nominal	Domestic Cur	232
S^H	Household Savings	Nominal	Domestic Cur	233
$Dep_D^{H,cur}$	Household Current Account Deposits	Nominal	Domestic Cur	234
Dep_{FX}^H	Household FX Deposits	Nominal	FX	235
B_H^G	Household Holding of Domestic Currency Public Bonds	Nominal	Domestic Cur	236
$Dep_D^{H,sav}$	Household Saving Account Deposits	Nominal	Domestic Cur	237
Dep_D^H	Total Household Deposits in Domestic Currency	Nominal	Domestic Cur	238
w^{NF}	Average Wage in Non-Food Sector	Nominal	Domestic Cur	240
w^{PF}	Average Wage in Processed Food Sector	Nominal	Domestic Cur	241
w^A	Average Wage in Agriculture Sector	Nominal	Domestic Cur	242
w^G	Average Wage in Public Sector	Nominal	Domestic Cur	243
w^B	Average Wage in Banking Sector	Nominal	Domestic Cur	244
a^A	Labour Productivity in Agriculture Sector			245
a^{PF}	Labour Productivity in Processed Food Sector			246
a^{NF}	Labour Productivity in Non-Food Sector			247
gr_a^{Tar}	Target Labour Productivity Growth Rate in NFCs			248
gr_a	Actual Labour Productivity Growth Rate in NFCs			249
$unemp$	Unemployment Rate			250

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Table 7 – *Continued from previous page*

Variable	Description	Type	Currency	Equation Number
Pop	Population			251
D_{FX}	Demand for Foreign Exchange	Nominal	FX	252
S_{FX}	Supply of Foreign Exchange	Nominal	FX	253
IM	Nominal Value of Total Imports	Nominal	FX	254
X	Nominal Value of Total Exports	Nominal	FX	255
e^N	Nominal Exchange Rate	Nominal		256
IA	Income Account of Balance of Payments Net of Remittances	Nominal	FX	257
Rem	Remittances	Nominal	FX	258
CPI^W	World Consumer Price Index & GDP Deflator			259
GDP^W	World GDP	Real		260
a^W	World Labour Productivity			261
i^W_{FX}	Risk free world interest rate	Nominal		262
Dep^W_{FX}	FX Deposits of Foreigners in Banking Sector	Nominal	FX	263
Dep^W_D	Domestic Currency Deposits of Foreigners in Banking Sector	Nominal	Domestic Cur	264
$CurAC$	Current Account Balance	Nominal	FX	265
R_{FX}	Total FX Reserves of the Country	Nominal	FX	266
$NomGDP$	GDP in Current Prices	Nominal	Domestic Cur	267

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Table 7 – *Continued from previous page*

Variable	**Description**	**Type**	**Currency**	**Equation Number**
$FISIM^{H}$	Financial Intermediation Services Indirectly Measured for Households	Nominal	Domestic Cur	268

A.3. Initial points

Table 8: Initial conditions

Variable	Initial Value	Variable	Initial Value
$Y_0^{e,PF}$	7400.47	$Y_0^{e,NF}$	57019
V_0^{PF}	371.4	V_0^{NF}	6132
X_0^{PF}	479.31	$\sigma_{M,C,0}^{PF}$	0.0709
$\sigma_{M,IC,0}^{PF}$	0.2209	$\sigma_{M,C,0}^{NF}$	0.14
$\sigma_{M,I,0}^{NF}$	0.2864	$\sigma_{M,IC,0}^{NF}$	0.4885
GDP_0^W	18 604 700	$\sigma_{X,0}^{NF}$	0.0009
a_0^A	11.785	a_0^{PF}	77.5914
a_0^{NF}	26.5304	a_0^W	29.8
$p_0^{PF,w}$	0.847	$p_0^{NF,w}$	0.8518
$p_{C,0}^{A,w}$	1.041	$p_{IC,0}^{A,w}$	1.041
$p_{X,0}^{PF}$	1.7289	$p_{X,0}^{NF}$	0.7408
$p_{P,0}^{A}$	2.0484	$p_{P,0}^{PF}$	1.853
$p_{P,0}^{NF}$	1.8138	HUC_0^A	0.88
HUC_0^{PF}	1.6253	HUC_0^{NF}	1.306
$L_{D,0}^A$	2650	K_0^A	16792.20
K_0^F	60469.24	$I_{F,D,0}$	3440.91
$L_{FX,0}^F$	5650.6	$L_{D,0}^F$	40 412
$\beta_{npl,0}^F$	0.139	FDI_0^F	1805
$Dep_{D,0}^{F,cur}$	7478	$Dep_{D,0}^{F,sav}$	5176

Variable	Initial Value	Variable	Initial Value
$Dep^{F}_{FX,0}$	605.3	$B^{G}_{B,0}$	10 088
Ad_0	8484	OF^{B}_{0}	10 000
$i^{L}_{D,0}$	0.07473	$i^{Dep}_{D,0}$	0.0456
$R^{B}_{FX,0}$	1844.3	$L^{B}_{FX,0}$	5650.6
$R_{D,0}$	12 151	K^{G}_{0}	17 666.98
B^{G}_{0}	20 997	$L^{G}_{FX,0}$	14 377.8
$L^{G,Adap}_{FX,0}$	0	$Dep^{G,cur}_{D,0}$	3396
$B^{G}_{CB,0}$	1019	$R^{CB}_{FX,0}$	3715.7
i^{p}_{0}	0.0523	R_{FX}	5560
w^{F}_{0}	6.7565	w^{A}_{0}	3.1374
w^{G}_{0}	20.9459	w^{B}_{0}	43.6589
$B^{G}_{H,0}$	9890	$I^{NF}_{H,0}$	1544.744
$Dep^{H,cur}_{D,0}$	17 833	$Dep^{H}_{FX,0}$	465
$Dep^{H,sav}_{D,0}$	23376	Con_0	67355.61
K^{H}_{0}	28 241.58	$L^{H}_{D,0}$	23336
$i^{G}_{B,0}$	0.0598	$Dep^{W}_{FX,0}$	2867.6
$Dep^{W}_{D,0}$	2235	e^{N}_{0}	3
$p^{A}_{X,0}$	0.8113	$I_{G,cap,0}$	2170.793
$I_{G,irrig,0}$	0	Pop	11 304.483
$Y^{P,A}_{C,0}$	2360.6	$Y^{P,A}_{IC,0}$	3282.2
$Y^{P,A}_{W,0}$	329.0	$eps_{1,0}$	0.07485
$eps_{2,0}$	0.1960	C^{A}_{0}	2513.1

Variable	Initial Value	Variable	Initial Value
$gr_{a,0}$	0.015	$i^{L}_{FX,0}$	0.0167

A.4. Parameters

[28]

Table 9: Nomenclature

Parameter	Description	Value	Method
α_A^A	Technical coefficient of IC_A^A	0.0675	Calibrated to SUT (2017)
α_A^{PF}	Technical coefficient of IC_A^{PF}	0.0871	Calibrated to SUT (2017)
α_A^{NF}	Technical coefficient of IC_A^{NF}	0.0777	Calibrated to SUT (2017)
β_y^{PF}	Adjustment speed of expectations to excess demand of PF sector	7.9790	Estimated
β_y^{NF}	Adjustment speed of expectations to excess demand of NF sector	2.8044	Estimated
α_{pop}	Population growth rate	0.0070	Calbrated to UN Population Stats
α_V^{PF}	Desired inventory to expected sales ratio for PF sector	0.0631	Estimated
α_V^{NF}	Desired inventory to expected sales ratio for NF sector	0.1229	Estimated
Ω_V^{PF}	Adjustment speed to the desired level of inventories in PF	0.6685	Estimated
Ω_V^{NF}	Adjustment speed to the desired level of inventories in NF	0.2844	Estimated
α_{NF}^A	Technical coefficient of IC_{NF}^A	0.0113	Calibrated to SUT (2017)
α_{PF}^A	Technical coefficient of IC_{PF}^A	0.3946	Calibrated to SUT (2017)
α_{NF}^{PF}	Technical coefficient of IC_{NF}^{PF}	0.0184	Calibrated to SUT (2017)

Continued on next page

[28] In this section, SUT refers to *Supply-Use Table*, SNA to *System of National Accounts*, BOP to *Balance of Payments* and BCT to *Central Bank of Tunisia* and UN to *United Nations*.

Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
α^{NF}_{NF}	Technical coefficient of IC^{NF}_{NF}	0.4172	Calibrated to SUT (2017)
α^{NF}_{PF}	Technical coefficient of IC^{NF}_{PF}	0.1268	Calibrated to SUT (2017)
α^{PF}_{PF}	Technical coefficient of IC^{PF}_{PF}	0.1456	Calibrated to SUT (2017)
α^{NF}_{G}	Technical coefficient of $IC^{N}F_{G}$	0.063	Calibrated to SUT (2017)
α^{PF}_{G}	Technical coefficient of $IC^{P}F_{G}$	0.1755	Calibrated to SUT (2017)
α^{A}_{G}	Technical coefficient of IC^{A}_{G}	0.1322	Calibrated to SUT (2017)
α^{NF}_{B}	Technical coefficient of $IC^{N}F_{B}G$	10.6462	Calibrated to SUT (2017)
$\Gamma^{PF}_{1,C}$	Scaling Coefficient of $\sigma^{PF}_{M,C}$ wrt relative prices	0	Estimated
$\epsilon^{PF}_{1,C}$	Elasticity of $\sigma^{PF}_{M,C}$ wrt relative prices	0	Estimated
$\Gamma^{PF}_{2,C}$	Scaling Coefficient of $\sigma^{PF}_{M,C}$ wrt relative labour productivity	0	Estimated
$\epsilon^{PF}_{2,C}$	Elasticity of $\sigma^{PF}_{M,C}$ wrt relative labour productivity	0	Estimated
$\Gamma^{PF}_{1,IC}$	Scaling Coefficient of $\sigma^{PF}_{M,IC}$ wrt relative prices	0.2491	Estimated
$\epsilon^{PF}_{1,IC}$	Elasticity of $\sigma^{PF}_{M,IC}$ wrt relative prices	0.3757	Estimated
$\Gamma^{PF}_{2,IC}$	Scaling Coefficient of $\sigma^{PF}_{M,IC}$ wrt relative labour productivity	0.0027	Estimated
$\epsilon^{PF}_{2,IC}$	Elasticity of $\sigma^{PF}_{M,IC}$ wrt relative prices	0.1784	Estimated
$\Gamma^{NF}_{1,C}$	Scaling Coefficient of $\sigma^{NF}_{M,C}$ wrt relative prices	0.1789	Estimated
$\epsilon^{NF}_{1,C}$	Elasticity of $\sigma^{NF}_{M,C}$ wrt relative prices	1.2546	Estimated
$\Gamma^{NF}_{2,C}$	Scaling Coefficient of $\sigma^{NF}_{M,C}$ wrt relative labour productivity	0.0128	Estimated
$\epsilon^{NF}_{2,C}$	Elasticity of $\sigma^{NF}_{M,C}$ wrt relative labour productivity	0.3758	Estimated
$\Gamma^{NF}_{1,IC}$	Scaling Coefficient of $\sigma^{NF}_{M,IC}$ wrt relative prices	0.3696	Estimated

Continued on next page

Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
$\epsilon_{1,IC}^{NF}$	Elasticity of $\sigma_{M,IC}^{NF}$ wrt relative prices	0.002	Estimated
$\Gamma_{2,IC}^{NF}$	Scaling Coefficient of $\sigma_{M,IC}^{NF}$ wrt relative labour productivity	0.0904	Estimated
$\epsilon_{2,IC}^{NF}$	Elasticity of $\sigma_{M,IC}^{NF}$ wrt relative prices	1.9050	Estimated
$\Gamma_{1,I}^{NF}$	Scaling Coefficient of $\sigma_{M,I}^{NF}$ wrt relative prices	0.2334	Estimated
$\epsilon_{1,I}^{NF}$	Elasticity of $\sigma_{M,I}^{NF}$ wrt relative prices	2.2784	Estimated
$\Gamma_{2,I}^{NF}$	Scaling Coefficient of$\sigma_{M,I}^{NF}$ wrt relative labour productivity	0.1054	Estimated
$\epsilon_{2,I}^{NF}$	Elasticity of $\sigma_{M,I}^{NF}$ wrt relative labour productivity	4.2184	Estimated
$\beta_{M,C}^{PF}$	Speed of adjustment to the target propensity $\sigma_{M,C}^{PF,Tar}$	0	Estimated
$\beta_{M,IC}^{PF}$	Speed of adjustment to the target propensity $\sigma_{M,IC}^{PF,Tar}$	19.666	Estimated
$\beta_{M,C}^{NF}$	Speed of adjustment to the target propensity $\sigma_{M,C}^{NF,Tar}$	1.0050	Estimated
$\beta_{M,IC}^{NF}$	Speed of adjustment to the target propensity $\sigma_{M,IC}^{NF,Tar}$	2.5264	Estimated
$\beta_{M,I}^{NF}$	Speed of adjustment to the target propensity $\sigma_{M,I}^{NF,Tar}$	0.8830	Estimated
β_{X}^{NF}	Speed of adjustment to the targeted propensity of NF exports	1	Estimated
$\Gamma_{1,X}^{NF}$	Scaling Coefficient of σ_{X}^{NF} wrt its relative prices	0.0004	Estimated
$\epsilon_{1,X}^{NF}$	Elasticity of σ_{X}^{NF} wrt its relative prices	1.3623	Estimated
$\Gamma_{2,X}^{NF}$	Scaling Coefficient of σ_{X}^{NF} wrt relative labour productivity	0.0005	Estimated
$\epsilon_{2,X}^{NF}$	Elasticity of σ_{X}^{NF} wrt relative labour productivity	1.3815	Estimated
β_{HUC}^{A}	Speed of adjustment of HUC^{A} to actual UC^{A}	25	Set to a realistic value
μ^{A}	Constant markup in the agriculture sector	1.5	Set to match SUT (2017)
β_{p}^{A}	Speed of adjustment of A producer price to target	0.95	Set to a realistic value

Continued on next page

Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
τ_{VA}^{A}	Value added tax rate on A goods	0.0012	Calibrated to SUT (2017)
$otax^{A}$	Other tax rate on A goods	0.0082	Calibrated to SUT (2017)
$subr^{A}$	Subsidy rate of A goods	0.0757	Calibrated to SUT (2017)
mrg_{C}^{A}	Transport and commerce margins rate on consumption agricultural goods	0.1268	Calibrated to SUT (2017)
mrg_{IC}^{A}	Transport and commerce margins rate on intermediate consumption agricultural goods	0.1277	Calibrated to SUT (2017)
mrg_{X}^{A}	Transport and commerce margins rate on exported agricultural goods	0.1351	Calibrated to SUT (2017)
τ_{M}^{A}	Import taxes rate on A goods	0.0468	Calibrated to SUT (2017)
μ_{0}^{PF}	Constant term in PF producer price markup	0.2373	Estimated and adjusted
μ_{1}^{PF}	Sensitivity of PF price markup to deviation of actual inventories from their desired level	0.2062	Estimated
β_{HUC}^{PF}	Speed of adjustment of HUC^PF to actual UC^PF	15.855	Estimated
β_{P}^{PF}	Speed of adjustment of PF producer price to target	0.8304	Estimated
τ_{VA}^{PF}	Value added tax rate on PF goods	0.0761	Calibrated to SUT (2017)
$otax^{PF}$	Other tax rate on PF goods	0.0489	Calibrated to SUT (2017)
$subr^{PF}$	Subsidy rate on PF goods	0.0263	Calibrated to SUT (2017)
mrg_{C}^{PF}	Transport and commerce margins rate on PF consumption goods	0.1103	Calibrated to SUT (2017)
mrg_{IC}^{PF}	Transport and commerce margins rate on IC^{PF} goods	0.1034	Calibrated to SUT (2017)

Continued on next page

Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
mrg_X^{PF}	Transport and commerce margins rate on exports of PF goods	0.1	Calibrated to SUT (2017)
τ_M^{PF}	Import tax rate on PF goods	0.0388	Calibrated to SUT (2017)
μ_0^{NF}	Constant term in NF producer price markup	0.6246	Estimated
μ_1^{NF}	Sensitivity of NF price markup to deviation of actual inventories from their desired level	0.6524	Estimated
β_{HUC}^{NF}	Speed of adjustment of actual UC^NF to HUC^NF	8.1325	Estimated
β_P^{NF}	Speed of adjustment of NF producer price to target	0.2994	Estimated
τ_{VA}^{NF}	Value added tax rate on NF goods	0.1174	Calibrated to SUT (2017)
$otax^{NF}$	Other tax rate on NF goods	0.0241	Calibrated to SUT (2017)
τ_M^{NF}	Import tax rate of NF goods	0.0149	Calibrated to SUT (2017)
$subr^{NF}$	Subsidy rate on NF goods	0.0217	Calibrated to SUT (2017)
τ_M^{NF}	Import tax rate on NF goods	0.0149	Calibrated to SUT (2017)
κ^A	Capital-output ratio of Agriculture sector	2.9248	Set to match investment by Agriculture Sector in SNA (2017)
τ^A	Income tax rate paid by farmers	0.0613	Calibrated to SNA (2017)
λ	Fraction of investment financed by retained earnings of farmers	0.778	Calibrated to sectoral loans from BCT
δ_A	Agriculture Capital Stock depreciation rate	0.03	Calibrated to a realistic value
$gosh$	Share of gross operating surplus of NFCs distributed to households	0.6552	Calibrated to SNA (2017)

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
τ^F	Tax rate on profits of NFC sector	0.2827	Calibrated to SNA (2017)
κ_0^F	Autonomous investment	0.026	Calibrated to match SNA (2017)
κ_1^F	Sensitivity of investment to real profit rate	0.15	Set to a realistic value (2017)
fdi	Ratio of FDI to total expected production of NFC sector	0.016	Calibrated to SNA (2017)
γ_{ir}^F	Ratio of private adaptation investment to Nominal GDP	0.011	Calibrated to Water 2050 Plan (see text)
β_{id}^F	Adjustment speed of actual investment to its target	1	Calibrated to match one-year lag in investment
β_{fdi}	Adjustment speed of foreign direct investment to its target	1	Calibrated to match one-year lag in investment
δ_F	NFC Capital Stock depreciation rate	0.05	Calibrated to a realistic value
η_D	Fraction of wage bill kept as current account deposits by NFCs	0.45	Calibrated to match IMF Banking Sector Statistics (2017)
β_{Dep}^F	Speed of adjustment of NFCs current account deposits to its target	0.6466	Calibrated to match IMF Banking Sector Statistics (2017)
η_F	Fraction of firms FX debt held as FX deposits by NFCs	0.15	Calibrated to match IMF Banking Sector Statistics (2017)
β_{FX}^F	Speed of adjustment of FX deposits of NFCs to its target	0.8	Calibrated to match IMF Banking Sector Statistics (2017)
β_{sav}^F	Fraction of net profits kept in saving accounts by NFCs	0.0558	Calibrated to match IMF Banking Sector Statistics (2017)

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
$divrate^F$	fraction of Firm profits distributed to shareholders	0.754	Calibrated to SNA (2017)
$divrate^F_W$	Part of firms equities held by the rest of the world	0.4156	Calibrated to SNA (2017)
$divrate^F_G$	Part of firms equities held by government	0.2752	Calibrated to SNA (2017)
$divrate^F_H$	Part of firms equities held by households	0.3091	Calibrated to SNA (2017)
$\beta^{des}_{L,F}$	Desired Fraction of firms financing needs demanded as FX Loans	0.1127	Calibrated to match BOP (2017)
ϵ^{npl}_0	Intercept, non-performing loans rate	0.0172	Estimated
ϵ^{npl}_1	Coefficient of gross return on bank equity in non-performing loans rate	-0.276	Estimated
ϵ^{npl}_2	Coefficient of inflation in non-performing loans rate	-0.109	Estimated
ϵ^{npl}_3	Coefficient of real GDP growth rate in non-performing loans rate	-0.103	Estimated
ϵ^{npl}_4	Coefficient of unemployment in non-performing loans rate	1.337	Estimated
χ_{npl}	Speed of adjustment of non-performing loans rate to its target	0.14	Estimated
κ_4	Scaling coefficient in deposit rate mark-down	0.0008	Calibrated to match NFC deposit rate from BCT
κ_5	Elasticity of deposit rate mark-down Assets/Advances ratio	0.9	Set to a realistic value
β_{idDep}	Adjustment speed of deposit rate to its target	4	Set to three-month average maturity of deposits

Continued on next page

Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
hhdp	Household deposits interest rate premium over NFC deposit interest rate	0.1417	Calibrated to match Household deposit rate from BCT
κ_0	Constant premium on average funding costs	0.0276	Set to a realistic value
κ_1	Scaling coefficient in domestic currency lending rate premium	0.1325'	Calibrated to match domestic currency lending rate from BCT
κ_3	Elasticity of domestic currency lending rate premium to interest/GOS ratio	0.75	Set to a realistic value
β_{idL}	Adjustment speed of interest rate on domestic currency loans to its target	0.25	Set to four-year maturity for NFC loans
$hhlp$	Households loans interest rate premium over NFC loan interest rate	0.1237	Calibrated to match household lending rate from BCT
ρ_4	Scaling coefficient of $prem_2$ in FX loan rate to NFCs	0.18	Calibrated to match interest payments abroad in BOP (2017)
$\beta_{i,LFX}$	Adjustment speed of i^L_{FX} to its target	0.5	Set to ensure two-year maturity for NFC FX loans
ζ_0	Autonomous level of premium in cross-border lending rate to banks	0.002	Set to a realistic value
ζ_1	Scaling coefficient in premium in cross-border lending rate to banks	1.078	Calibrated to match interest payments abroad in BOP (2017)
ζ_2	Elasticity of cross-border lending rate to banks to country risk	2	Set to a realistic value
ν_1	Scaling coefficient in country risk	0.1598	Calibrated to match Tunisia's CDS premium in 2017

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
ν_2	Elasticity of the country risk to FX debt/GDP ratio	2	Set to a realistic value
$\beta_{1,rat}$	Scaling coefficient of logistic function for FX rationing	0.01	Set to a realistic value
$\beta_{2,rat}$	Slope of logistic function for FX rationing	35	Set to a realistic value
MP_{rat}	Midpoint of logistic function for FX rationing	0.1201	Set to a realistic value
UB_{rat}	The upper bound of the logistic function for FX rationing	80	Set to a realistic value
LB_{rat}	The lower bound of the logistic function for FX rationing	0.01	Set to a realistic value
$insur_H$	Net insurance cost as a share of value of capital, households	0.0034	Calibrated to SNA (2017)
$insur_F$	Net insurance cost as a share of value of capital, NFCs	0.0034	Calibrated to SNA (2017)
$insur_A$	Net insurance cost as a share of value of capital, agriculture	0.0034	Calibrated to SNA (2017)
com	Comission rate on domestic currency loans	0.0142	Calibrated to SNA (2017)
emp^B	Bank Employment to population ratio	0.0031	Calibrated to Labour Force Survey INS
τ^B	Tax rate on banks profits	0.2232	Calibrated to SNA (2017)
χ_F	Weight coefficient for domestic currency loans to NFC in capital adequacy ratio	1.25	Calibrated to the weight range in Bank for International Settlements (2017)
χ_A	Weight coefficient for domestic currency loans to Agriculture in capital adequacy ratio	1.25	Calibrated to the weight range in Bank for International Settlements (2017)

Continued on next page

Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
χ_H	Weight coefficient for domestic currency loans to Households in capital adequacy ratio	1.25	Calibrated to the weight range in Bank for International Settlements (2017)
χ_{FX}	Weight coefficient for FX loans to NFC in capital adequacy ratio	1.25	Calibrated to the weight range in Bank for International Settlements (2017)
χ_B	Weight coefficient for domestic currency loans to NFC in capital adequacy ratio	0.5	Calibrated to the weight range in Bank for International Settlements (2017)
of_1	Target capital adequacy ratio	0.1595	Set to a value in line with EU Tier 1 Capital Adequacy Ratio
of_2	Scaling parameter in capital adequacy ratio	0.06	Set to a realistic value
of_3	Speed of adjustment to target capital adequacy ratio	0.1	Set to a realistic value
$divrate_w^B$	Part of banks equities held by the rest of the world	0.4156	Calibrated to SNA (2017)
$divrate_G^B$	Part of banks equities held by the rest of the government	0.4080	Calibrated to SNA (2017)
$divrate_H^B$	Part of banks equities held by the rest of households	0.1764	Calibrated to SNA (2017)
rrr	Required reserves ratio for household deposits (including cash & coin demand) in domestic currency	0.2739	Calibrated to IMF Banking Sector Statistics (2017)
τ_{ESC}^A	Employers' social security contribution rate by Agriculture	0.251	Calibrated to SNA (2017)
τ_{ESC}^{PF}	Employers' social security contributions rate by PF sector	0.251	Calibrated to SNA (2017)
τ_{ESC}^{NF}	Employers' social security contributions rate by NF sector	0.251	Calibrated to SNA (2017)

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
τ^B_{ESC}	Employers' social security contributions rate by banks	0.2575	Calibrated to SNA (2017)
τ^G_{ESC}	Employers' social security contributions rate by government	0.1409	Calibrated to SNA (2017)
τ_{WSC}	Employees' social security contributions rate	0.0862	Calibrated to SNA (2017)
emp^G	Public Employment to population ratio	0.0585	Calibrated to Labour Force Survey INS
τ^A_{pr}	Taxes less subsidies on production rate paid by Agriculture sector	0.0124	Calibrated to SNA (2017)
τ^B_{pr}	Taxes less subsidies on production paid by Banks sector	0.0105	Calibrated to SNA (2017)
τ^{NF}_{pr}	Taxes less subsidies on production paid by Non Food sector	0.0095	Calibrated to SNA (2017)
τ^{PF}_{pr}	Taxes less subsidies on production paid by Processed Food sector	0.0095	Calibrated to SNA (2017)
ϕ_2	Ratio of social benefits per unemployed to average wage in NF sector	0.1537	Calibrated to SNA (2017)
γ^G_{ir}	Ratio of public adaptation investment to Nominal GDP	0.011	Calibrated to Water 2050 Plan (see text)
β_{irrig}	Adjustment speed of public adaptation investment to its target	4	Calibrated to a realistic value
gr_{ig}	Public non-adaptation capital investment growth rate	0.02	Calibrated to historical tendency
δ_G	Public Capital Stock depreciation rate	0.045	Calibrated to a realistic value
Φ_1	Scaling coefficient in public domestic currency bond interest rate premium	0.0168	Calibrated to public bond interest rate from BCT

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
Φ_2	Elasticity of premium of bonds interest rates to public debt to GDP ratio	2	Set to a realistic value
β_{ibg}	Speed of adjustment of public bond rate to its target	1	Calibrated to 100% PSBR
Φ_3	Sensitivity of public FX borrowing interest rates to country risk	0.1505	Calibrated to match External Debt Statistics (2017)
tr_H^G	Ratio of public transfers to households to NFC production	0.0137	Calibrated to balance the TFM
tr_G^W	Ratio of transfers to government from rest of the world to NFC production	0.0079	Calibrated to balance the TFM
tr_G^F	Ratio of transfers to government from NFCs to NFC production	0.01	Calibrated to balance the TFM
tr_G^B	Ratio of transfers to government from Banks to NFC production	0.0022	Calibrated to balance the TFM
tr_G^{CB}	Ratio of transfers to government from Central Bank to NFC production	0.0033	Calibrated to balance the TFM
η_g	Ratio of government current account deposits to public wages and employers social contribution	0.3	Calibrated to IMF Banking Sector Statistiscs (2017)
β_{Dep}^G	Speed of adjustment of public current account deposits its target	0.7734	Calibrated to IMF Banking Sector Statistiscs (2017)
Ψ	Share of trade deficit borrowed as FX by the government	0.4289	Calibrated to match BOP (2017)
ι_1	Intercept of the Taylor Rule of Central Bank policy rate	0.01	Set to a realistic value
ι_2	Sensitivity of target policy rate to inflation	1.2	Calibrated to match actual policy rate

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
ς	Share of public domestic currency bond issuance purchased by Central Bank	0.1	Calibrated to IMF Banking Sector Statistics (2017)
β_{ip}	Speed of adjustment of policy rate to its target	1	Set to a realistic value
τ^H	Income tax rate on household income	0.0679	Calibrated to SNA (2017)
β_{con}	Speed of adjustment of aggregate real consumption to its target	4	Calibrated to a relaistic value
UB_{MPC}	Upper bound of the logistic function of the marginal propensity to consume	0.95	Calibrated to a relaistic value
LB_{MPC}	Lower bound of the logistic function of the marginal propensity to consume	0.86	Calibrated to a relaistic value
MP_{MPC}	Mid point of the logistic function of the marginal propensity to consume	0.036	Calibrated to a relaistic value
β_{mpc}	Slope of the logistic function wrt real interest rate for marginal propensity to consume	55	Calibrated to a relaistic value
rca	Subsistence-level per capita consumption of agricultural goods	0.0615	Estimated
$rcpf$	Subsistence-level per capita consumption of processed food goods	0.042	Estimated
$rcnf$	Subsistence-level per capita consumption of non-food goods	0.4132	Estimated
eps_3	Intercept in marginal budget share of agricultural goods	0.0657	Estimated
eps_4	Scaling coefficient in marginal budget share of agricultural goods	0.0004	Estimated

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
eps_5	Elasticity of marginal share of agricultural goods to real aggregate consumption	0.0616	Estimated
eps_6	Intercept in marginal budget share of processed food goods	0.3854	Estimated
eps_7	Scaling coefficient in marginal budget share of processed food goods	0.0407	Estimated
eps_8	Elasticity of marginal share of processed food goods to real aggregate consumption	0.1498	Estimated
β_{eps1}	Speed of adjustment of marginal share of consumption of agricultural goods to its target	0.3443	Estimated
β_{eps2}	Speed of adjustment of marginal share of consumption of processed food goods to its target	0.66	Estimated
β_{CA}	Speed of adjustment of consumption of agricultural goods to its target	10^5	Set high to ensure Stock-Flow Consistency
ξ	Fraction of household target investment in their gross disposable income	0.0456	Calibrated to sectoral investment by INS
β_{IH}	Speed of adjustment of housing investment to its target	1	Set to ensure one year lag in investment
δ_H	Housing Capital Stock depreciation rate	0.03	Set to a realistic value
φ	Fraction of household investment financed by residential loans	0.6406	Calibrated to IMF Banking Sector Statistics (2017)
cc_1	Ratio of change in household current account deposits in domestic currency to changes in consumption	0.3733	Calibrated to IMF Banking Sector Statistics (2017)

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Table 9 – *Continued from previous page*

Parameter	Description	Value	Method
cc_2	Ratio of household's deposits in foreign currency to remittances	0.0697	Calibrated to IMF Banking Sector Statistics (2017) and BOP (2017)
υ_H	Share of Household Savings allocated to government bond purchases	0.1	Set to historical averages
$\beta_{1,gra}$	Scaling parameter of the logistic function for labour productivity growth rate	0.5	Set to a realistic value in line with Xiao and Le (2019)
$\beta_{2,gra}$	Slope of the logistic function for labour productivity growth rate	138.629	Set to a realistic value in line with Xiao and Le (2019)
MP_{gra}	Mid-point of the logistic function for labour productivity growth rate	0.03	Set to a realistic value in line with Xiao and Le (2019)
LB_{gra}	Lower bound of the logistic function for labour productivity growth rate	0.01	Set to a realistic value in line with Xiao and Le (2019)
UB_{gra}	Upper bound of the logistic function for labour productivity growth rate	0.06	Set to a realistic value in line with Xiao and Le (2019)
β_{gra}	Adjustment speed of Tunisia labour productivity growth rate to its target	0.15	Set to a realistic value
$part$	Labour force participation rate	0.3615	Calibrated to Calibrated to Labour Force Survey INS (2017)
α_{pop}	Population growth rate	0.007	Calibrated to UN Population Statistics, High Variant
β_{eN}	Sensitivity of Nominal exchange rate to FX market disequilibrium	7	Set to a realistic value

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Table 9 – *Continued from previous page*

Parameter	**Description**	**Value**	**Method**
$i^W_{FX,0}$	Risk-free world interest rate	0.005	Calibrated to US Federal Funds rate (2016)
rem	Ratio of remittances to real world GDP	$9.33.10^{-5}$	Calibrated to BOP (2017)
θ_1	Fraction of Remittances kept as FX deposits in banks by non-residents	0.2725	Calibrated to IMF Banking Sector Statistics (2017)
θ_2	Fraction of Remittances kept as domestic currency deposits in banks by non-residents	0.1109	Calibrated to IMF Banking Sector Statistics (2017)

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