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Regional Implications of Public Investments and External Shocks in Papua New Guinea

An Economywide Analysis

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INTRODUCTION

Improvements in telecommunications have enabled a tremendous increase in the flow of information across Papua New Guinea. Although transport costs remain high between various parts of the main island of Papua New Guinea, as well as between the main island and other parts of the country (e.g. the islands of New Britain and Bougainville to the East), phone and internet conditions enable government, traders and entrepreneurs to share market information that reduces transactions costs and improves market function. Nonetheless, there remain major differences in agricultural production, income sources and demand patterns across regions that are important to take into account in analyzing the impacts of external shocks and formulating development strategies.

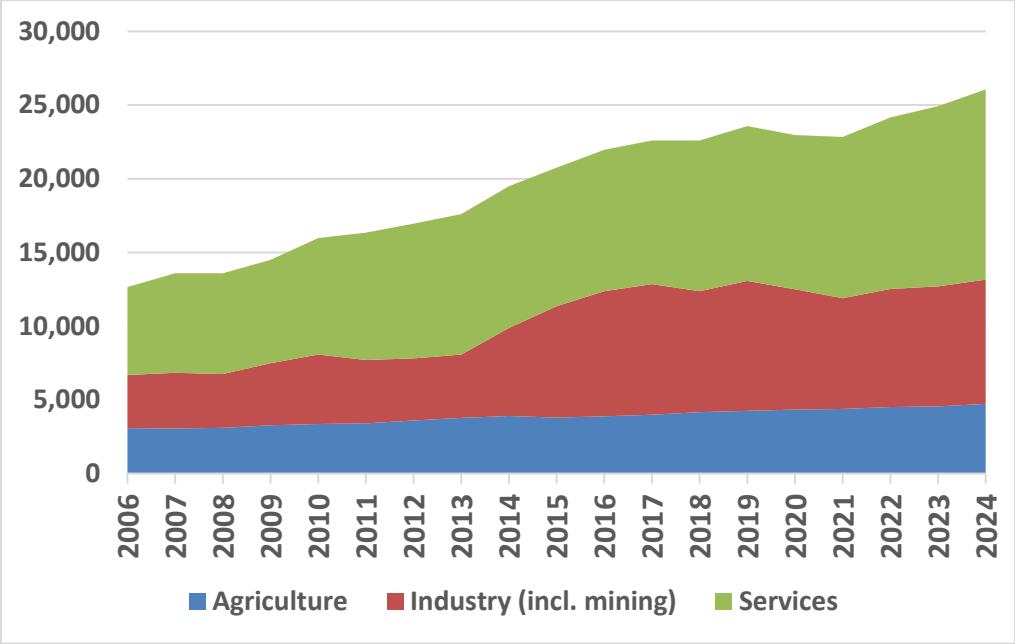
Earlier work on PNG by Schmidt et al., (2021) explored the effects of Covid-related income and world rice price shocks with a partial equilibrium model of PNG's rice economy. Diao et al., (2021) used a regional multi-market model to analyze broader effects of Covid-19 and other shocks to agriculture and household incomes in four regions of PNG. Various other studies, including Dorosh and Pradesha (2022) and Diao et al. (2024), used national computable general equilibrium (CGE) models of PNG to analyze exchange rate, terms of trade, and productivity shocks on various household groups. In this paper, we extend these earlier analyses through use of a new regional CGE model that utilizes recent household survey data, including the 2023 IFPRI PNG rural household survey.

The plan of this paper is as follows. The next section provides an overview of agriculture and economic growth in PNG over the last decade, highlighting the almost constant share of agriculture in GDP and very low per capita agricultural GDP growth rate. Section 3 describes the regional disaggregation of the PNG economy and the structure of household incomes and expenditure as reflected in the economywide database, the Social Accounting Matrix (SAM), used in this analysis. Section 4 then presents a summary of the regional economywide model. (Details of the model are found in the annexes and in the references included in the paper.) Design of the model simulations and simulation results covering investments in agriculture and transport sectors, as well as world price shocks are discussed in Section 5. Chapter 6 concludes with a summary of the main findings and policy implications, as well as suggested areas for further work.

AGRICULTURE AND ECONOMIC GROWTH IN PNG

The petroleum and natural gas sectors have accounted for most of the growth in the PNG economy since 2013, particularly in the period 2013-16 when these sectors contributed to a 97 percent increase in real value added in industry (including mining), (Figure 2.1). Nonetheless, the agricultural sector remains central to the livelihoods of most households. Almost 90 percent of the population lives in rural areas, and more than 80 percent of inhabitants either directly or indirectly depend on subsistence agriculture (Gibson, 2012; Bourke, 2009).

Figure 2.1: Real (2015) GDP by sector (2006-2024) in PNG (mn kina)

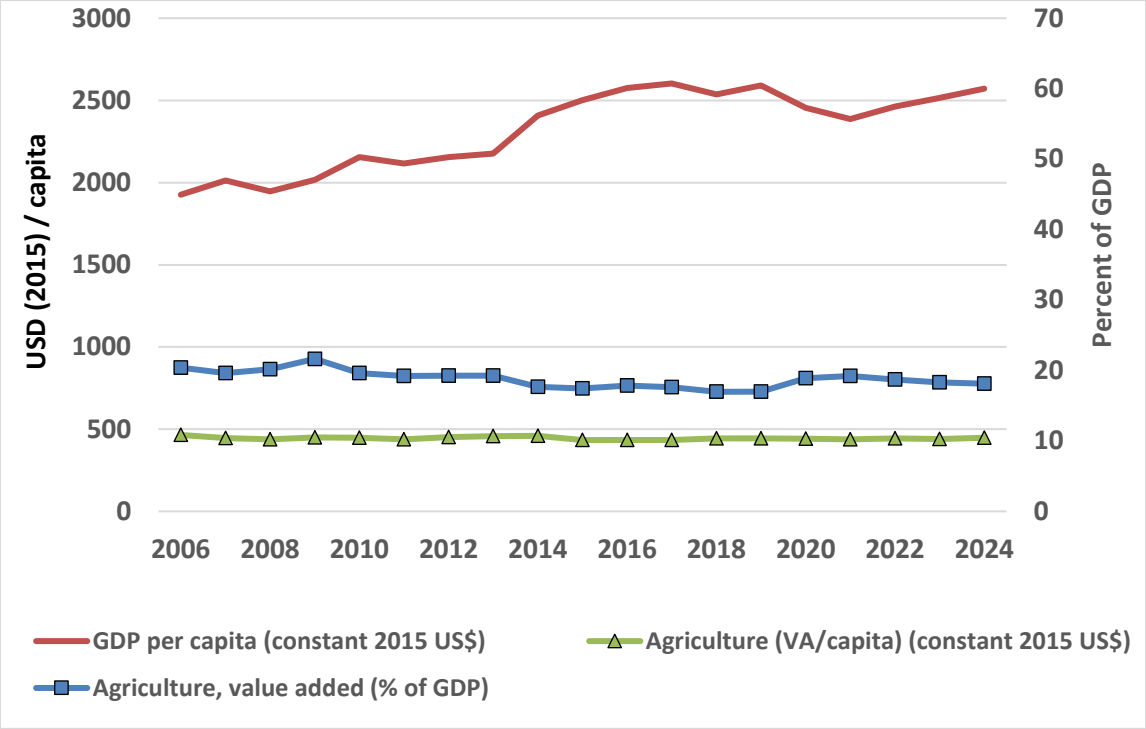


Source: Authors' calculations using World Development Indicators (World Bank, 2025a)

Total growth in PNG's economy has been relatively slow in the last decade, however. Annual GDP per capita (real 2015 values) grew approximately 2.6 percent per year from 2015 to 2024, essentially the same rate of growth as total population. Thus, although real GDP/capita has fluctuated somewhat, it was essentially the same in 2024 (USD 2,572 per person) as it had been in 2015 (2,502 per person), (Figure 2.2). Growth in both the agriculture sector (2.3 percent per year) has been essentially the same as that of population (2.7 percent per year). The services sector increased by 4.1 percent per year.

Economic growth is often accompanied by structural transformation, whereby the shares of agriculture in total employment and value-added decline and the shares of higher productivity sectors (industry and services) increase. However, this transformation is not yet occurring in PNG. The share of agriculture in total GDP in 2024 was 18.1 percent, only slightly less than its share in 2021 (19.2 percent) and slightly **higher** than its share in 2015 (17.5 percent) (World Bank, 2025a).

Figure 2.2: Agriculture contribution to GDP and Agricultural GDP per capita (2006-2024)



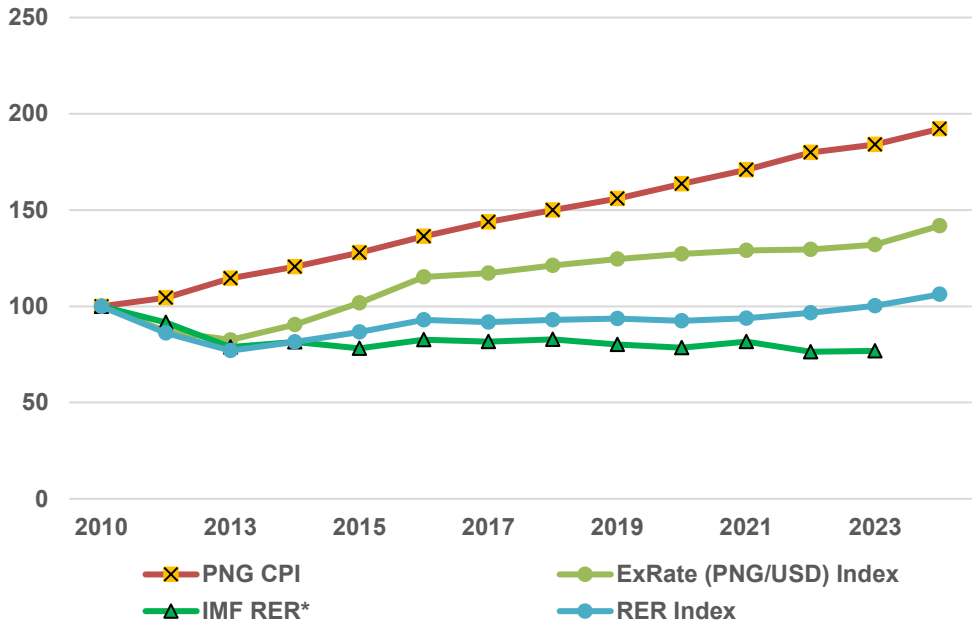
Source: Authors' calculations using World Development Indicators (WB, 2022a)

PNG's large oil and natural gas exports dominate the country's economy, requiring careful management to avoid real exchange rate appreciation that has plagued many resource-rich developing countries. Major macro-imbalances originated in 2011 when a large-scale inflow of foreign capital to fund PNG investments in natural gas pipeline and processing infrastructure resulted in a surge in inflation. Costs of production of tradable goods such as coffee and palm oil rose more (in kina terms) than their output prices, reducing the profitability of these sectors. These price distortions have continued to the present day, as restrictions on access to foreign exchange (mainly through delays in the release of funds) as demand for foreign exchange exceeds supply made available to the public (Dorosh and Pradesha, 2025).

As shown in Figure 2.3, domestic inflation in PNG resulted in a total increase of 92 percent in the Consumer Price Index between 2010 and 2024. In this same period, the nominal exchange rate (Kina/USD) depreciated by only 42 percent, from 2.72 to 3.86 kina/USD. Thus, the **real exchange rate** (measured here as RER = ER * PW / CPI) appreciated by 26.1 percent between 2010 and 2012. Thereafter, from 2012 to 2018, the real exchange rate depreciated by an average of 5.9 percent per year, restoring the RER to approximately its 2006 level. There has been relatively little change from 2018 through 2024.[1]

[1] Using the weighted average of a basket of currencies and other adjustments, the IMF's calculation of the real exchange rate indicates total appreciation of 23 percent between 2010 and 2024. See Wangi (2025) for a discussion of recent movements in the nominal exchange rate of the Kina relative to the US dollar, along with policy options to increase the supply of foreign exchange in PNG.

Figure 2.3: PNG: Real Exchange Rates, Balance of Payments, 2010 – 2024



Source: Dorosh and Pradesha (2025), IMF IFS (2025) and authors' calculations;

Note that this simple measure of the distortion in the real exchange rate captures only the changes in its level. A more exact measure of the overvaluation of the real exchange rate is the difference between the actual real exchange rate and an estimated **equilibrium real exchange rate** (the real exchange rate that would result from the removal of all trade and foreign exchange rate distortions, given world prices and assumed normal foreign capital flows). Using the estimates of the equilibrium real exchange rate from the IMF's simulation model, the average overvaluation of the kina in the years 2019, 2022 and 2023 was 10 percent.[2]

PNG's REGIONAL ECONOMIC STRUCTURE

Our modeling analysis uses a detailed regional 2023 SAM that draws on the earlier 2019 SAM (IFPRI, 2022) and various household surveys, including IFPRI's 2023 PNG Rural Household Survey, the national macro-economic data from the national accounts, and data on supply-side estimates of value-added by economic sector.

National Economic Structure

In the 2019 national SAM, household incomes and consumption for rural households were disaggregated by rural / urban per capita expenditure quintiles using data from IFPRI rural household surveys. Because there has not been a nationally representative urban survey since

[2] Estimates of the overvaluation of the kina were 11 percent in 2019 (IMF, 2020; p. 17), 13 percent in 2022 (IMF, 2023; p. 35) and 5 percent at the end of 2023 (IMF, 2024; p. 34). See Krueger, Schiff and Valdés (1988) for a discussion of calculations of the equilibrium real exchange rate, and Davies and Schroder (2022) for further analysis and estimates of PNG's real exchange rate misalignment.

the HIES of 2009/10, the 2019 SAM calculated urban consumption by assuming that the ratio of rural to urban per capita consumption remained constant for all SAM commodity items between 2010 and 2019.[3] The regional disaggregation of households was done in a similar manner, using regional differences in production and consumption reflected in the 2009/10 and subsequent household survey data.

Table 3.1 shows the structure of PNG's production and trade. The mining sector, including crude oil and natural gas, dominates the economy, accounting for 29.2 percent of GDP. Agriculture accounts for 18.3 percent of GDP, with 10.5 percent of GDP coming from food crops. The industrial sector remains very small, only 4.0 percent of GDP. Trade (9.6 percent of GDP) and other private services (including housing and business services, 20.6 percent) are major components of the large services sector that accounts for nearly half (48.5 percent) of GDP.

Household incomes by source are estimated using data on education levels of household members and levels of total household expenditures by household type from IFPRI's 2023 PNG Rural Household Survey. Labor accounts for an estimated 91.8 percent of household incomes of the poorest 20 percent of the rural population, but less than 20 percent of income of the richest 20 percent of the rural population (Table 3.2). The largest share of rural household incomes (46.0 percent) derives from non-agricultural capital, including informal sector capital used for processing, storage and transport of agricultural products.

Because of a lack of recent survey data on the structure of urban incomes, the 2023 PNG regional SAM adopts the assumption that urban households do not have agricultural incomes. Given the small size of the urban population and lack of recent data, this SAM also does not disaggregate urban households by region.

Estimated per capita consumption in rural areas (3,561 kina per person) is less than one-third that in urban areas (11,058 kina per person) (Table 3.3). Savings rates, based on estimates of total incomes and expenditures of each household group, range from 10 percent in rural areas to 34 percent in urban areas, with almost no savings by the lowest three quintiles in rural areas.

[3] See Pradesha and Dorosh (2022) and IFPRI (2022).

Table 3.1: PNG Structure of Production and Trade, 2023

	Share of total demand (%)	Exports / Output (%)	Imports / GDP (%)	Exports (bn kina)	Imports (bn kina)
Agriculture	5.6%	19.0%	0.3%	3,800.8	256.7
Crops	3.1%	5.4%	0.3%	607.1	230.5
Livestock	0.7%	35.9%	0.0%	5.8	25.1
Forestry	1.2%	72.8%	0.0%	3,182.7	0.2
Fishing	0.6%	0.3%	0.0%	5.1	0.8
Mining	11.0%	81.7%	2.0%	32,038.7	1,604.8
Manufacturing	9.6%	169.5%	26.0%	5,849.3	20,938.1
Electricity, Water	1.8%	0.0%	2.4%	0.0	1,918.1
Construction	2.5%	1.3%	3.4%	117.2	2,757.1
Trade	4.2%	0.0%	0.4%	0.0	313.3
Transport	3.2%	0.5%	0.0%	61.4	0.0
Other Private Services	8.7%	32.6%	1.9%	1,196.6	1,516.9
Public Administration	2.6%	1.6%	0.0%	145.6	0.0
Other Public Services	**2.3%**	**0.4%**	**0.2%**	**3.3**	**161.2**
Total	51.6%	23.5%	36.7%	43,212.9	29,466.1

	Share of GDP (%)	Exports / Output (%)	Imports / GDP (%)	Exports (bn kina)	Imports (bn kina)
Agriculture	**18.3%**	**19.0%**	**0.3%**	**3,801**	**257**
Crops	10.5%	5.4%	0.3%	607	231
Livestock	1.7%	35.9%	0.0%	6	25
Forestry	4.3%	72.8%	0.0%	3,183	0
Fishing	1.8%	0.3%	0.0%	5	1
Mining	**29.2%**	**81.7%**	**2.0%**	**32,039**	**1,605**
Industry	**4.0%**	**14.4%**	**28.4%**	**5,849**	**22,856**
Manufacturing	3.1%	169.5%	26.0%	5,849	20,938
Electricity, Water	0.9%	0.0%	2.4%	0	1,918
Services	**48.5%**	**1.8%**	**5.9%**	**1,524**	**4,749**
Construction	5.5%	1.3%	3.4%	117	2,757
Trade	9.6%	0.0%	0.4%	0	313
Transport	2.3%	0.5%	0.0%	61	0
Other Private Services	20.6%	32.6%	1.9%	1,197	1,517
Public Administration	5.2%	1.6%	0.0%	146	0
Other Public Services	5.3%	0.4%	0.2%	3	161
Total	**100.0%**	**23.5%**	**71.0%**	**50,586**	**57,071**

Source: 2023 PNG Regional SAM.

Table 3.2: Household Income Sources in PNG, 2023

	Labor	Labor	Labor	Labor	Labor		Agric		Non-agric	
	Total	No educ	Low educ	Medium educ	High Educ	Land	Capital	Livestock	Capital	Total
Rural Households										
Quintile 1	91.8	47.7	17.9	13.2	13.1	0.8	3.6	0.4	3.3	100.0
Quintile 2	60.5	21.0	14.8	9.2	15.5	3.6	10.6	0.5	24.7	100.0
Quintile 3	62.6	18.1	13.3	10.8	20.5	4.6	10.2	2.0	20.6	100.0
Quintile 4	33.0	6.2	8.0	7.6	11.3	5.6	8.8	2.5	50.1	100.0
Quintile 5	18.6	2.8	3.4	3.9	8.5	8.5	14.8	2.8	55.2	100.0
All Rural	**32.6**	**8.2**	**6.9**	**6.2**	**11.2**	**6.8**	**12.3**	**2.4**	**46.0**	**100.0**
Urban Households										
Quintile 1	96.3	48.6	14.7	23.0	10.0	0.0	0.0	0.0	3.7	100.0
Quintile 2	90.3	27.2	13.5	19.5	30.1	0.0	0.0	0.0	9.7	100.0
Quintile 3	83.1	33.8	11.7	16.2	21.4	0.0	0.0	0.0	16.9	100.0
Quintile 4	62.0	12.6	5.7	12.6	31.0	0.0	0.0	0.0	38.0	100.0
Quintile 5	**55.1**	**2.3**	**3.6**	**8.8**	**40.4**	**0.0**	**0.0**	**0.0**	**44.9**	**100.0**
All Urban	**58.9**	**6.8**	**4.7**	**10.3**	**37.1**	**0.0**	**0.0**	**0.0**	**41.1**	**100.0**

Notes: The skill level of labor in the PNG SAM is defined by the maximum level of education achieved: No education = no formal schooling; Low education = Up to 6 years; Medium education = 7-11 years; High education = 12 years or more.

Based on the micro-level household survey data, transfers from the Rest of World to households are almost zero in the 2023 PNG Regional SAM.

Source: PNG Regional SAM.

Table 3.3: Household Population and Expenditures in PNG, 2023

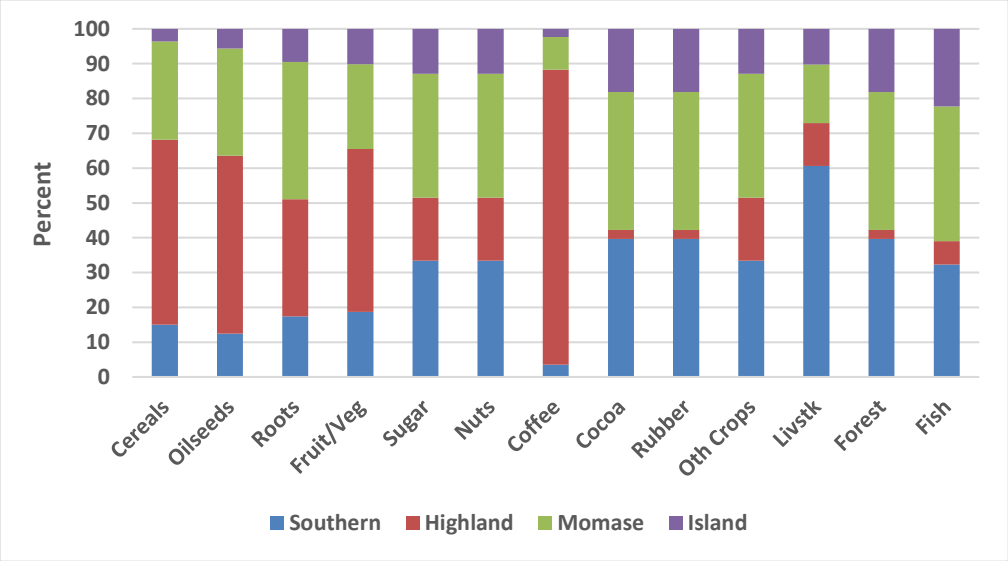
	Population		Consumption spending			Total spending	
	Millions of people	Share of total (%)	Share of total (%)	Per capita (1000 Kina)	Food share (%)	Per capita (1000 Kina)	Savings rate (%)
Rural Households							
Quintile 1	1.79	20.0%	2.6%	701	48.7%	713	0.7%
Quintile 2	1.79	20.0%	6.2%	1,651	47.0%	1,703	1.5%
Quintile 3	1.79	20.0%	8.1%	2,158	46.4%	2,274	2.7%
Quintile 4	1.79	20.0%	14.6%	3,871	39.9%	4,553	10.2%
Quintile 5	**1.79**	**20.0%**	**35.4%**	**9,424**	**28.1%**	**11,530**	**12.8%**
Total Rural	**8.96**	100.0%	66.9%	**3,561**	35.5%	**4,155**	**9.8%**
Urban Households							
Quintile 1	0.29	20.0%	0.3%	585	46.9%	620	3.8%
Quintile 2	0.29	20.0%	1.1%	1,802	22.2%	2,045	9.2%
Quintile 3	0.29	20.0%	2.5%	4,136	10.9%	5,007	12.5%
Quintile 4	0.29	20.0%	7.9%	13,260	10.5%	20,475	27.5%
Quintile 5	0.29	20.0%	21.2%	35,505	8.4%	70,637	38.8%
Total Urban	**1.43**	**100.0%**	**33.1%**	**11,058**	**10.0%**	**19,757**	**34.3%**
Total PNG	**10.39**	**100.0%**	**100.0%**	**4,590**	**27.0%**	**6,296**	**20.3%**

Source: PNG Regional SAM.

Regional Patterns of Agricultural Production and Household Expenditures

The regional SAM includes four geographic regions: Southern, Highlands, Momase (the northern side of the main island) and Islands (Bougainville and other islands).[4] These regions approximate three agro-ecological regions, of which the highlands have the highest rainfall. As shown in Figure 3.1, the Southern region accounts for relatively large shares of national production of sugar (33%), nuts (33%), cocoa (40%), rubber (40%), other crops (33%), livestock (61%), forest (40%) and fish (32%). Likewise, Momase accounts for about 30 to 40 percent of all products except for coffee and livestock. Over 80 percent of PNG's coffee is cultivated in the highlands, a region that also accounts for large shares of cereals (69%), oilseeds (51%) and fruits/vegetables (47%). The Islands region accounts for relatively small shares of all products except for cocoa (18%), rubber (18%), forest (18%) and fish (22%).

Figure 3.1: PNG: Shares of Crop Production by Region, 2023

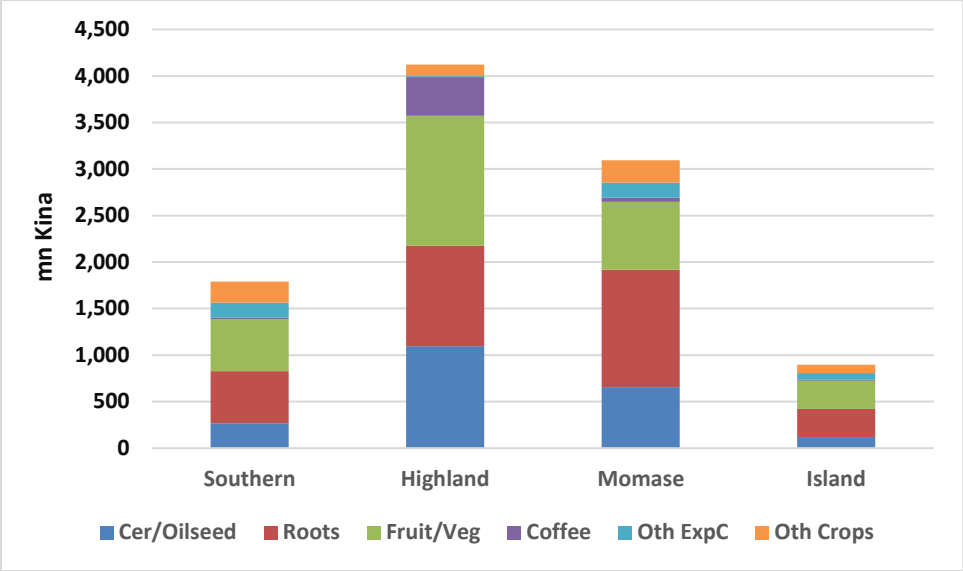


Source: 2023 IFPRI PNG rural household survey data.

The Highlands and Southern regions have the highest total values of crop production (42 and 31 percent of the national total, respectively), (Figure 3.2). In all regions, roots and fruits / vegetables account for large shares of the value of crop production (Table 3.4). The shares of cereals / oilseeds in the total value of agricultural production of the region are high in the Highlands and Momase, but small in the other two regions. Coffee (mainly *Arabica* coffee) and other stimulants account for 10.1 percent of the value of food production in the highlands, but less than two percent in other regions. Other export crops (mainly oil palm and cocoa) account for 8.2 and 9.0 percent of the value of food production in the Island and Southern regions, but only 5.2 percent in Momase and only 0.3 percent in the Highlands region.

[4] These geographic regions are comprised of the following provinces: **Southern:** Central, Gulf, Milne Bay, National Capital District, Northern (Oro), Western; **Highlands**: Chimbu (Simbu), Eastern Highlands, Enga, Hela, Jiwaka, Southern Highlands and Western Highlands; **Momase**: East Sepik, Madang, Morobe and West Sepik; **Islands:** Autonomous Region of Bougainville, East New Britain, Manus, New Ireland and West New Britain.

Figure 3.2 PNG: Value of Crop Production by Region (mn Kina), 2023



Source: 2023 IFPRI PNG rural household survey data.

Table 3.4: PNG: Shares of the Value of Food Crop Production within the Region, 2023

Region	Cereals & Oilseeds	Roots	Fruit & Vegetables	Coffee	Other Export Crops	Other Crops	Crop subtotal
Southern	15.0	31.1	31.2	1.0	9.0	12.7	100.0
Highland	26.6	26.1	33.9	10.1	0.3	3.0	100.0
Momase	21.2	40.8	23.6	1.5	5.2	7.8	100.0
Island	13.2	33.9	33.7	1.3	8.2	9.8	100.0
Total	**21.6**	**32.3**	**30.2**	**5.0**	**4.1**	**6.9**	**100.0**

Source: 2023 IFPRI PNG rural household survey data and authors' calculations.

Household Incomes and Expenditures

The SAM classifies households in PNG by per capita expenditure quintiles (defining poor households as those in the lower two quintiles and nonpoor households as those in the upper three quintiles. Rural households are also split by the four geographic regions: Southern, Highlands, Momase and Island. Thus, the SAM includes accounts for eight rural households groups (poor and non-poor for each region) and two urban household groups (poor and non-poor), a total of ten household groups.

Table 3:5 PNG SAM Household Groups: Population and Expenditures

	Population (thousands)	Population Share (percent)	Income (mn kina)	Per Capita Income (kina/person)
Southern Rural Poor	1,103	7.6	562	510
Southern Rural Nonpoor	2,105	14.6	8,835	4,198
Southern Urban Poor	101	0.7	389	3,855
Southern Urban Nonpoor	560	3.9	14,701	26,250
Highland Rural Poor	1,212	8.4	1,879	1,551
Highland Rural Nonpoor	1,753	12.1	11,046	6,303
Highland Urban Poor	228	1.6	108	472
Highland Urban Nonpoor	379	2.6	3,651	9,644
Momase Rural Poor	1,359	9.4	1,260	927
Momase Rural Nonpoor	1,044	7.2	7,972	7,634
Momase Urban Poor	216	1.5	205	948
Momase Urban Nonpoor	358	2.5	6,307	17,635
Island Rural Poor	1,567	10.8	653	417
Island Rural Nonpoor	1,622	11.2	5,113	3,153
Island Urban Poor	253	1.7	55	217
Island Urban Nonpoor	606	4.2	2,673	4,411
Total Rural Poor	5,240	36.2	4,354	831
Total Rural Nonpoor	6,523	45.1	32,966	5,054
Total Urban Poor	798	5.5	756	947
Total Urban Nonpoor	1,902	13.2	27,331	14,368
Total PNG	14,464	100.0	65,408	4,522

Source: PNG Regional SAM, 2023.

THE PNG REGIONAL ECONOMYWIDE MODEL

In this study, we use the Rural Investment and Policy Analysis (RIAPA) model, a neo-classical type of Computable General Equilibrium (CGE) model, calibrated to data from the 2023 Social Accounting Matrix (SAM) for PNG and other parameters describing responsiveness of demand and supply across different sectors. The RIAPA model measures how impacts of policies and external shocks are mediated through prices and resource reallocations and ensures that resource and macroeconomic constraints are respected. The model consists of both behavioral equations that describe the economic decisions related to production, marketing, consumption, etc. of economic agents (firms, households, and institutions) and structural equations that specify accounting relationships between the incomes and expenditures of individual agents and within the macroeconomy.[5]

The model divides the economy into sectors and household groups that act as individual economic agents. Producers maximize profits and supply output to national markets by choosing levels of inputs, given the technology available, as determined by flexible production functions that allow substitution between factors in response to relative factor price changes. Demand for intermediate

[5] Model equations are presented in Annex A. See Diao and Thurlow (2013) for details on the model parameters and equations.

inputs by producers, however, is determined by fixed input-output coefficients. Producers then combine factors and intermediate inputs using sector-specific technologies. On the other hand, consumer demand is determined by demand equations derived from a linear expenditure system that implicitly maximize utility given budget constraints. Income elasticities for various food commodities used in this study follows Diao et al. (2021).

Producers and households pay taxes to the government, who uses these and other revenues to finance public services and social transfers. Remaining revenues – the recurrent budget surplus – are added to private savings and foreign capital inflows to finance investment. National market prices adjust to clear overall supply and demand for each product. Domestically produced goods and services are modeled as imperfect substitutes with goods and services that are exported or imported. World prices are fixed (exogenous) under the assumption that changes in PNG demand for imports or supply of exports do not affect world prices (i.e., a small country assumption).

The model defines eight types of labor: four skill types, according to highest level of education completed (less than primary school, primary school, secondary school, more than secondary school) in each of two areas (rural and urban). Total supply of labor of each type is fixed, with wage rates adjusting in each period to equate supply and demand. There are forty types of households in the model differentiated by four geographical areas, rural or urban, and five income quintiles, with the first quintile representing the poorest households.

SIMULATION RESULTS

In this chapter, we present the results of six simulations. Simulations 1 to 3 explore the effects of 5 percent increases in total factor productivity (TFP) in food crops (Simulation 1) and export crops (Simulation 2), and a 10 percent increase in TFP in the trade and transport sectors (Simulation 3). Simulation 4 models a five percent increase in TFP for all sectors. Simulation 5 shows the effects of a 10 percent reduction in all world prices, illustrating the effects of a recession in the world economy. Finally, Simulation 6 shows the combined effects of the productivity and world price shocks of Simulations 4 and 5.

Total GDP rises by 0.7 percent in Simulation 1 (increased food crop productivity), but by less than 0.1 percent in Simulation 2 (increased export crop productivity). The 10 percent increase in TFP for trade & transport sectors has relatively large effect on total GDP (1.1 percent) in Simulation 3 because it lowers transaction cost margins and raises competitiveness of other sectors throughout the economy. Furthermore, reduced transport costs lower the costs of imports to PNG households and enterprises, resulting in increased import demand and exacerbating the large trade deficit. The real exchange rate depreciates (i.e., the relative price of tradable to non-tradables increases) by 2.4 percent to restore equilibrium in the balance of payments (Figure 5.2).

The largest gains from increases in food crop productivity accrue to urban poor households who devote a high share of their incomes to non-tradable food products for which prices decline (Figure 5.3). The rural non-poor in the highlands enjoy the largest gains in total expenditures with increases in export crop productivity, but the magnitude of these effects is small because export crops account for only a small share of household incomes in this region (and throughout PNG), (Figure 5.4). Rural households benefit most from reduced transport costs since this raises the price of agricultural products for farmers, (Figure 5.5).

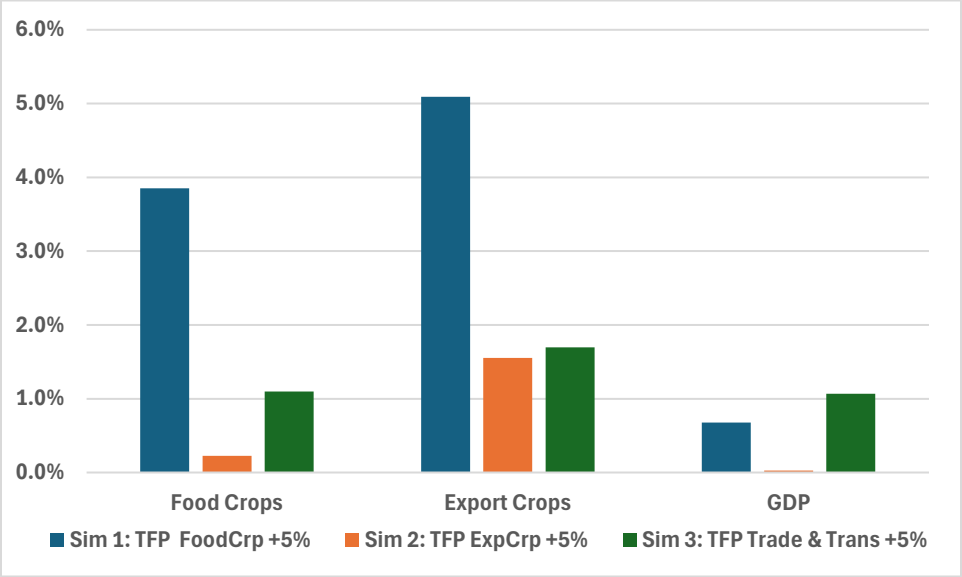
A 5 percent increase in TFP in all sectors results in a corresponding 5 percent increase in real GDP (Simulation 4). Domestic absorption (the sum of consumption, investment, and government demand) increases by 5.7 percent as the increase in production leads to increases in incomes and

imports. Imports rise by 6.6 percent, but exports increase by only 4.9 percent as higher demand and inelastic supply limit the gains in exportable surplus.

In Simulation 5, because PNG has a large trade surplus, a 10 percent reduction in all world prices (measured in foreign currency) leads to a real exchange rate appreciation as the price shock reduces the foreign currency value of imports more than the corresponding value of exports. The real exchange rate appreciation nonetheless reduces profitability of export crops, leading to a small (0.7 percent) increase in output of cereal crops as farmers shift labor and other inputs to other crops (see Figure 5.6). The overall impact on real GDP is negligible, however (Figure 5.7).

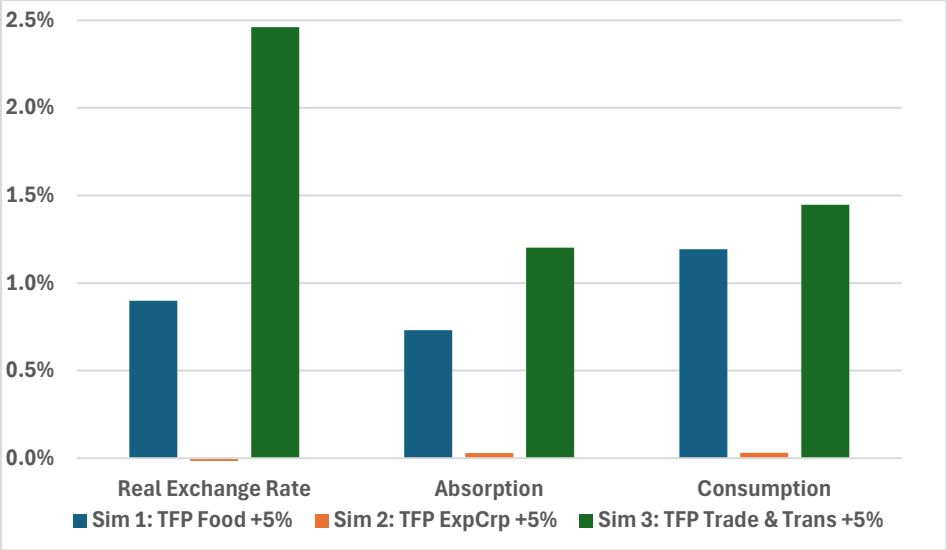
Consumption of all household groups in all regions rises significantly in Simulation 4 (by 7.2 to 8.2 percent) (Figure 5.8). All households except those in the Islands region benefit from lower prices of tradable goods in Simulation 5 (Figure 5.9), but the magnitude of these effects are small (-1.9 to 2.4 percent) in comparison to the large gains in Simulation 4. Thus, the combined effects of the productivity and world price shocks on household incomes in Simulation 6 are positive, ranging from 3.4 to 5.2 percent in the Islands region and 7.1 to 8.1 percent elsewhere (Figure 5.10).

Figure 5.1: Sectoral Effects of Productivity Shocks: Simulations 1-3



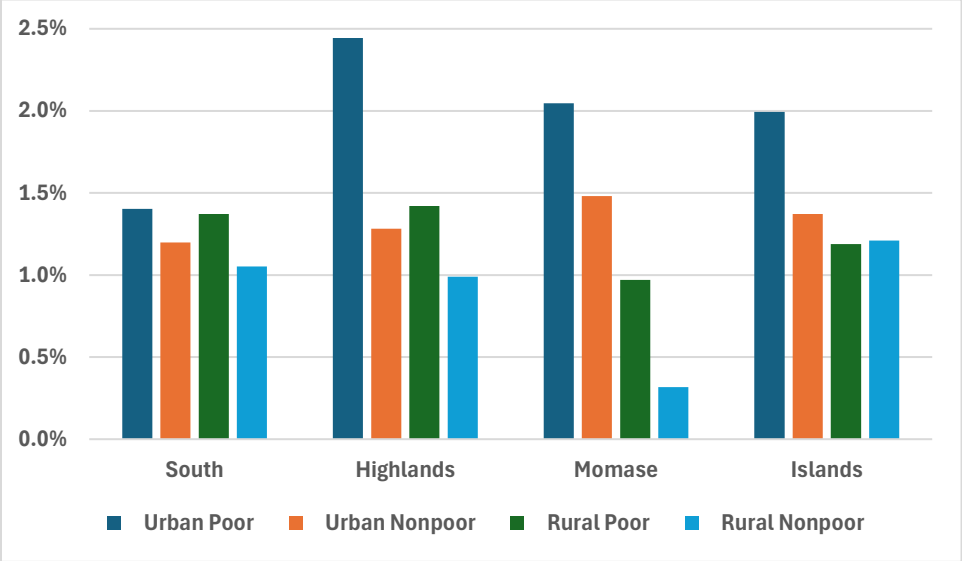
Source: Model simulations.

Figure 5.2: Macro-economic Effects of Productivity Shocks: Simulations 1-3



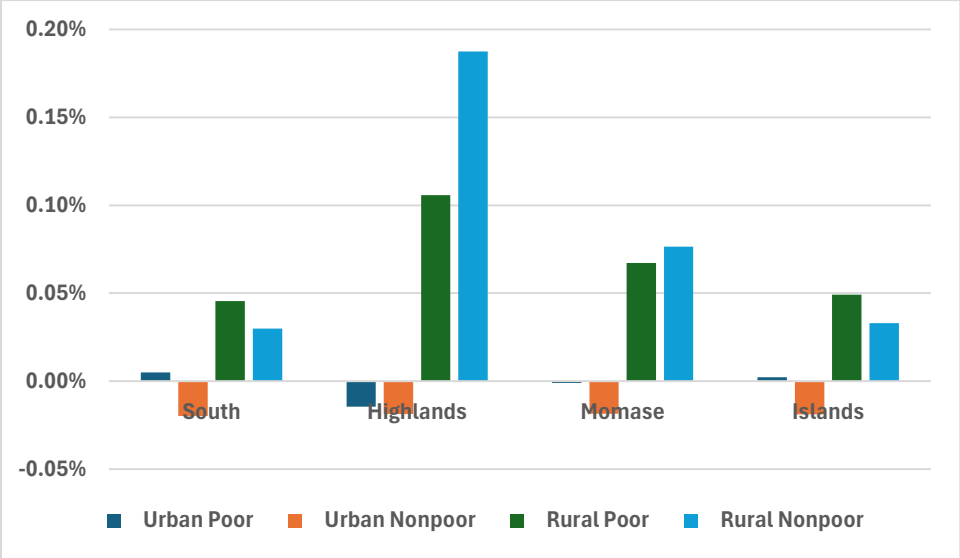
Source: Model simulations.

Figure 5.3: Household Effects of a 5% Increase in Food Crop Productivity (Simulation 1)



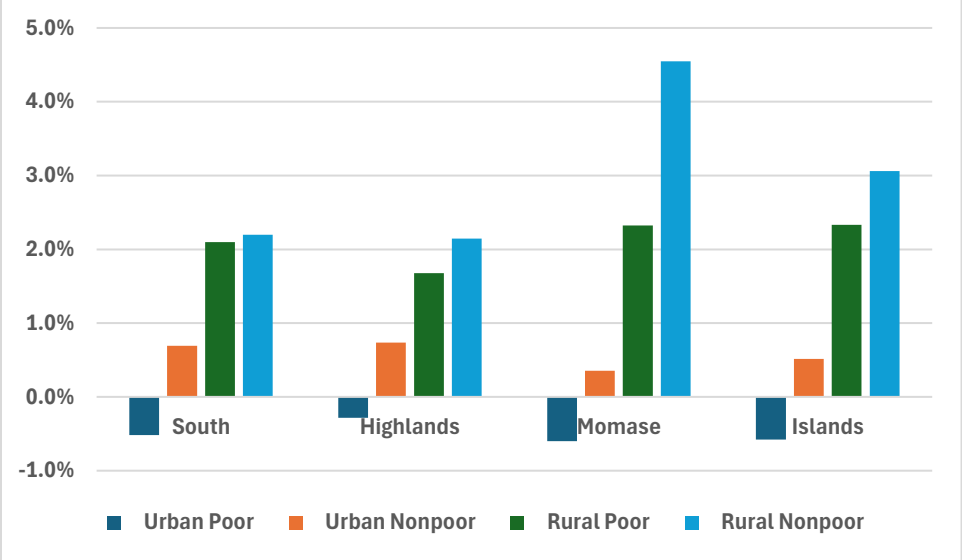
Source: Model simulations.

Figure 5.4: Household Effects of a 5% Increase in Export Crop Productivity (Simulation 2)



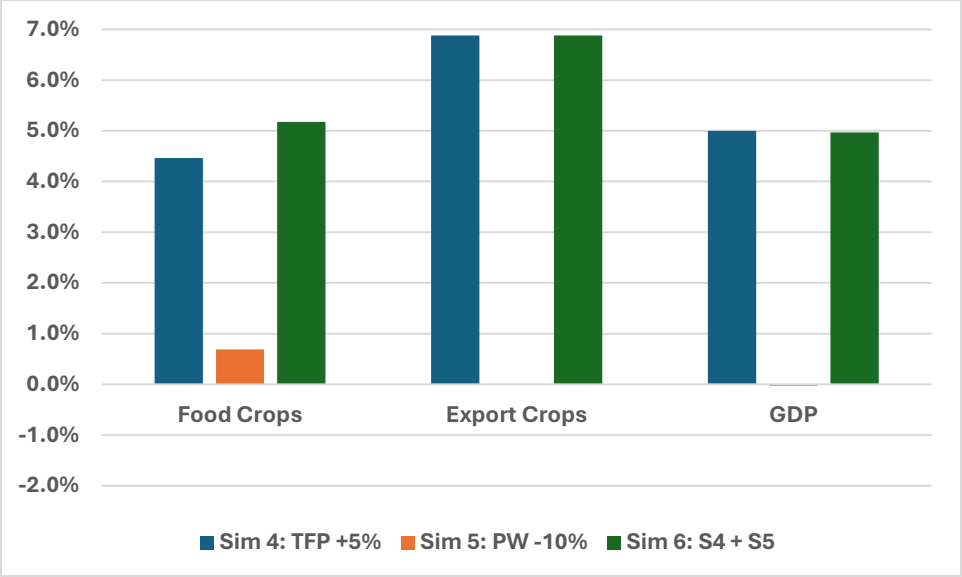
Source: Model simulations.

Figure 5.5: Household Effects of a 5% Increase in Trade and Transport Productivity (Simulation 3)



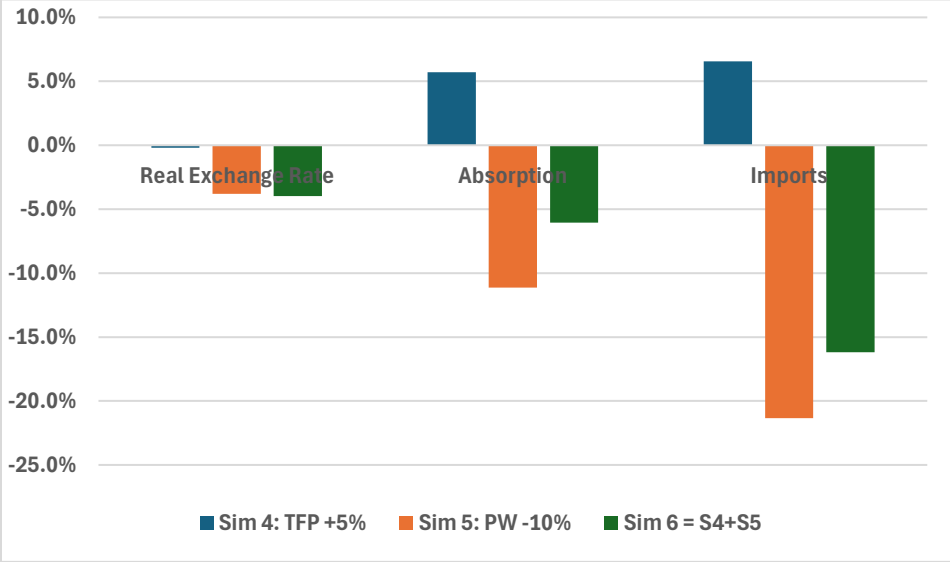
Source: Model simulations.

Figure 5.6: Sectoral Effects of Economy-Wide Shocks: Simulations 4-6



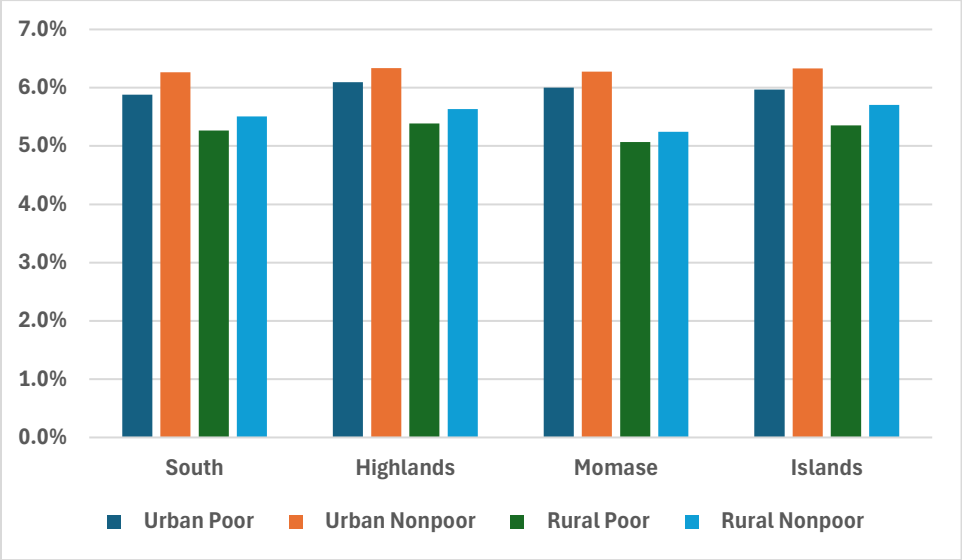
Source: Model simulations.

Figure 5.7: Macroeconomic Effects of Economy-Wide Shocks: Simulations 4-6



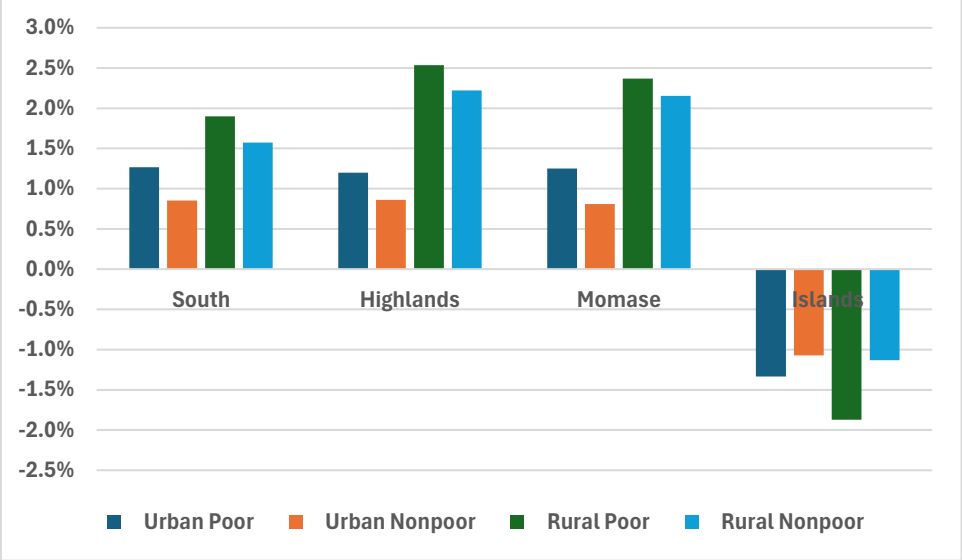
Source: Model simulations.

Figure 5.8: Household Effects of a 5% Increase in Economywide TFP (Simulation 4)



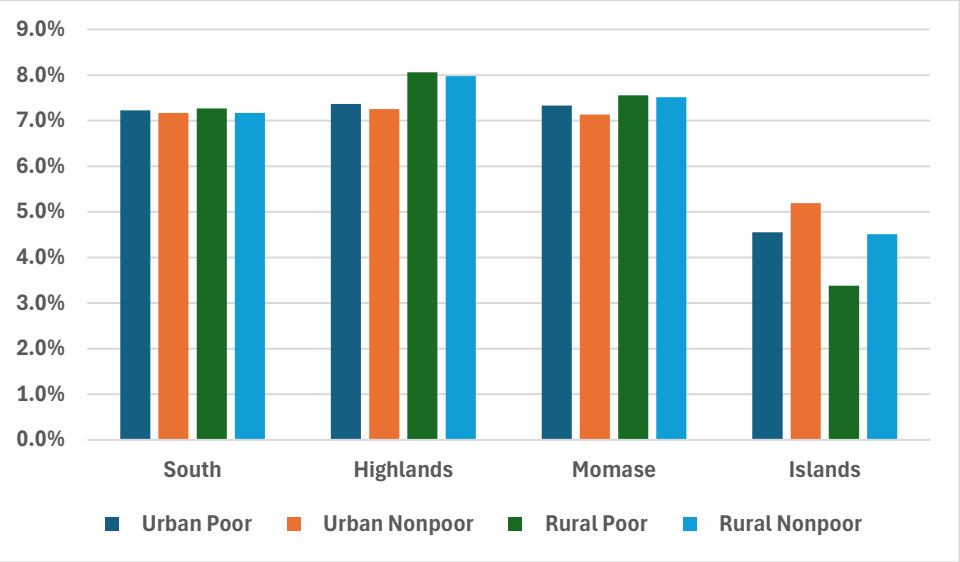
Source: Model simulations.

Figure 5.9: Household Effects of 10% Decline in World Prices (Simulation 5)



Source: Model simulations.

Figure 5.10: Household Effects of Combined TFP and World Price Shocks (Simulation 6)[a]



[a] Combined effects of an economywide 5 percent increase in TFP and a 10 percent reduction in world commodity prices.

Source: Model simulations.

SUMMARY AND CONCLUSIONS

There are major differences in agricultural production, income sources and demand patterns across regions of PNG. Moreover, there is only limited trade between these regions for many commodities, including most food crops, so that shortfalls or surpluses in one region are not necessarily mitigated by inter-regional trade flows.[6] Thus, the effects of weather and world price shocks, as well as government trade and investment policies may differ substantially across regions.

This paper presents an analysis of regional effects of external shocks and domestic policies utilizing an integrated database on production, incomes, household consumption and trade (a 2023 Social Accounting Matrix) and an economywide CGE model. The model simulations highlight important linkages between the agricultural and non-agricultural sectors of the PNG economy, as well as the differential impacts of shocks and policies on incomes and consumption of poor and nonpoor households across regions.

The model simulations of increased agricultural productivity in the food crop sector indicate that there are widespread benefits to both rural and urban households as output increases and prices of non-tradable crops decline. Increasing productivity in remote regions of the country may prove difficult, however, given the relatively low population densities, relative lack of agricultural extension services, and minimal transport and electricity infrastructure.

Increased productivity in the export crop sector has relatively small effects on the macro-economy and household incomes since this sector is considerably smaller than the food crop sector, though there are important regional variations.

A decline in world commodity prices, resulting from a major recession or other factors, has major costs to the PNG economy since it results in a real exchange rate appreciation which reduces the

[6] The SAM and CGE model (RIAPA) used in this paper assumes a single, national commodity market for each product, however. Future analysis could be done that relaxes this assumption, allowing differences in the price of a commodity across regions of PNG.

competitiveness of import-competing and export sectors in the economy. Model simulations indicate that a 10 percent reduction in world prices could result in a sharp drop in total domestic spending and a more than 20 percent decline in imports as the foreign currency value of oil and natural gas revenues decline.

A Comparison with Risk Analysis Results

Earlier work by Mukashov et al. (2025) examined whether volatility in key variables (exogenous shocks to world prices, foreign exchange capital flows, crop yields and per capita production of selected sectors) has major impacts on selected outcomes (GDP, poverty, etc.). In their analysis, the level of risk associated with a given outcome for each exogenous variable was determined by: 1) the volatility of the variable as estimated from historical time series data; and 2) the impact of changes in the variable, estimated using CGE model simulations. They found that fluctuations in foreign capital inflows and fish production contribute most to the volatility in PNG's GDP. Variations in crop yields pose very little risk to GDP, in part because, historically, crop yields (as reported by FAO) do not change much, and because crops are a relatively small share of GDP.

In this paper, we model a 10 percent decline in all commodity prices (as in a global recession), not the effects of a price increase or decrease of specific commodities. In this simulation (Simulation 5), prices of PNG's exports (oil, coffee, cocoa, etc.) decline, but so do prices of PNG's imports (mostly non-agricultural industrial and consumer goods and services). Thus, quantities and values of both exports and imports decline. Moreover, because demand for imports is generally more price responsive than supply of exports (since production of export goods is constrained by fixed levels of capital, and for some crops by fixed land, as well), the decline in the value of imports is approximately the same size as the value of the decline in exports, even though the initial level of the value of imports was greater than that of exports.

In summary, the two analyses differ substantially in the design of simulations and the focus of the analysis (volatility of various outcomes versus the levels of the outcomes, themselves). In particular, Mukashov et al. (2025) modeled shocks to individual commodity prices, while this working paper modeled a world price shock scenario with the same percentage price increase for all commodities. Second, Mukashov et al. (2025) showed that volatility of foreign capital inflows has a much bigger effect on GDP than does volatility of crop yields or world prices. This working paper showed that a global price shock has only small net effects on GDP, while increased crop yields have positive effects on household incomes and GDP.

Suggestions for Further Work and Conclusions

This paper presents the regional database (SAM) and initial policy simulations. There is a large scope to use this and other regional models to explore other shocks and policies, including weather shocks and public investments in various regions and within-PNG regional migration.

Further work on modeling regional effects of shocks and policies could usefully incorporate regional differences in transport and marketing costs modeling regional commodity markets, though this would require significant changes to the current model's equations. A dynamic version of the model could be used for scenarios in multi-year development plans. And if more data becomes available, urban households could be disaggregated by the same regions as rural households.

In conclusion, the simulations presented in this paper highlight important differences in the structure of the economies of various regions in PNG. The analysis also shows the importance of economic linkages between agriculture and the overall economy in PNG in determining policy

outcomes. Periodic updates to the data, along with additional capacity strengthening are needed, however, to maximize the usefulness of the model and simulations to PNG researchers, analysts and decision-makers.

ANNEX A: THE PAPUA NEW GUINEA ECONOMY-WIDE MODEL[7]

Consumer and producer behavior

Representative consumers and producers in the model are treated as individual economic agents. We assume that households (consumers) make decisions so as to maximize welfare (utility) subject to a budget constraint. For this we employ a linear expenditure system (LES) of demand:

$$P_i \cdot C_{ia} = P_i \cdot \gamma_{ia} + \beta_{iha} \cdot \left(\frac{(1 - s_a - td_a) \cdot Y_a}{LS_a} - \sum_{i'} P_{i'} \cdot \gamma_{i'a}\right) \quad (1)$$

where *C* is per capita consumption of good *i* in area *a* (i.e., cities, towns or rural areas), *γ* is a minimum subsistence level, *β* is the marginal budget share, *P* is the market price of each good, *Y* is total household income, *LS* is total labor supply (a proxy for population), and *s* and *td* are savings and direct tax rates, respectively. Our demand functions allow consumption patterns and income elasticities to vary across households in cities, towns and rural areas.

We assume producers maximize profits subject to input and output prices. A constant elasticity of substitution (CES) function determines output quantity *X* from sector *i* in area *a*:

$$X_{ia} = \alpha_{ia} \cdot \left(\delta_{ia} \cdot L_{ia}^{-\rho_{ia}} + (1 - \delta_{ia}) \cdot K_{ia}^{-\rho_{ia}}\right)^{-1/\rho_{ia}} \quad (2)$$

where *α* reflects total factor productivity (TFP), *L* and *K* are labor and capital demands, and *δ* and *ρ* are share and substitution parameters. Our production functions permit technologies to vary across producers and areas. Maximizing profits subject to Equation 2 gives the factor demand equations:

$$\frac{L_{ia}}{K_{ia}} = \left(\frac{r \cdot D_{ia}}{W_a} \cdot \frac{1 - \delta_{ia}}{\delta_{ia}}\right)^{1/(1+\rho_{ia})} \quad (3)$$

where *W* is the labor wage in area *a*, and *r* is a fixed economywide capital rental rate adjusted by a sector/area-specific distortion term *D*. The factor substitution elasticity is a transformation of *ρ*. Higher elasticities means producers can more readily substitute between labor and capital when relative prices change. We do not show intermediate demand in the equations, although this is included in our model.

The producer price *PX* is the sum of factor payments per unit of output:

[7] This annex describes the core equations of the Papua New Guinea Economy-Wide Model used in this analysis. This PNG model is a variant of the model described in Diao and Thurlow (2012).

$$PX_{ia} \cdot X_{ia} = W_a \cdot L_{ia} + r \cdot D_{ia} \cdot K_{ia} \quad (4)$$

National product markets and international trade

Products are traded in national markets at a single market-clearing price *P*. The national market assumption is needed because internal trade data is unavailable. Output from each area is combined into a composite national good *Q* using a CES function:

$$Q_i = \phi_i \cdot (\sum_a \lambda_{ia} \cdot X_{ia\tau i}^{-})^{-1/\tau i} \quad (5)$$

Equation 5 permits imperfect substitution between goods from different areas. Relative producer prices are determined by the following first order condition, derived from minimizing the composite supply price of each good:

$$PX_{ia} = P_i \cdot (1 - ti_i) \cdot Q_i \cdot (\sum_{a'} \lambda_{ia'} \cdot X_{ia'}^{-\tau i})^{-1} \cdot \lambda_{ia} \cdot X_{ia-\tau i-1} \quad (6)$$

where *ti* is the indirect tax rate applied to domestic sales. This function implies that demand for an area's output rises when its supply price falls relative to those in other areas.

We do not show the equations governing international trade. However, our model permits two-way trade assuming imperfect substitution between domestic and foreign goods. A constant elasticity of transformation (CET) function determines exports and a CES function determines imports. World commodity prices are fixed under a small country assumption. The current account balance is fixed in foreign currency units and the real exchange rate is flexible (i.e., a price index of tradable to non-tradable goods).

Government and investment demand

Assuming all factors in an area are owned by households in that area, then total income *Y* is

$$Y_a = \sum_i (W_a \cdot L_{ia} + r \cdot D_{ia} \cdot K_{ia}) + h_a \cdot LS_a \quad (7)$$

where *h* is per capita transfer payments from the government. The government is treated as a separate agent. Total domestic revenue is the sum of direct and indirect taxes, as shown on the left-hand side of the following equation:

$$\sum_a td_a \cdot Y_a + \sum_i ti_i \cdot P_i \cdot Q_i = \sum_i P_i \cdot A \cdot g_i + \sum_a h_a \cdot LS_a + B \quad (8)$$

The government uses revenues to purchase goods and make transfers (i.e., recurrent spending) and to save (i.e., finance public capital investment). This is shown on the right-hand side of Equation 8. Our macroeconomic closure for the government account assumes that public consumption spending is

equal to base-year quantities *g* multiplied by an exogenous adjustment factor *A*. The fiscal balance *B* adjusts to equalize total revenues and expenditures.

We assume a balance closure, i.e., share of consumption, government and investment are fixed while savings in the economy adjust to finance investment demand. As shown below, a national savings pool finances investment:

$$\sum_a s_a \cdot Y_a + B = \sum_i (P_i \cdot I \cdot ip_i + P_i \cdot G \cdot ig_i) \tag{9}$$

where *ip* and *ig* are fixed base-year quantities of private and public investment, respectively, multiplied by adjustment factors *I* (endogenous) and *G* (exogenous).

Factor and product market equilibrium

We assume labor is fully employed. As such, total labor supply *LS* in each area is fixed and, in equilibrium, must equal the sum of all sector labor demands:

$$LS_a = \sum_i L_{ia} \tag{10}$$

Unlike labor, which is mobile across sectors, capital is sector/area-specific. Both factor demand *K* and the economywide rental rate *r* are therefore fixed (see Equation 3) and the rental rate distortion term *D* adjusts so that sectoral profit rate equate capital demand and supply.

Finally, product market equilibrium requires that the composite supply of each good *Q* equals total private and public consumption and investment demand:

$$Q_i = \sum_a C_{ia} \cdot LS_a + A \cdot g_i + I \cdot ip_i + G \cdot ig_i \tag{11}$$

Market prices *P* adjust to ensure equilibrium is achieved. Together, the above 11 equations simultaneously solve for the values of 11 endogenous variables (i.e., *C*, *X*, *L*, *D*, *Q*, *PX*, *Y*, *B*, *I*, *W* and *P*). The national consumer price index (CPI) is our numéraire.

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