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Papua New Guinea

PAPUA NEW GUINEA PROJECT NOTE DECEMBER 2023

The Impacts of Production and Price Shocks on the Coffee Industry in PNG

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Introduction

Coffee is one of Papua New Guinea's leading agricultural export in value terms, accounting for 156 million USD of export earnings in 2021 (FAOSTAT, 2023), 13 percent of agricultural export revenues and 1.4 percent of total export revenues. The coffee industry is a major source of income for some 2.5 million people, mainly in farm households, and is cultivated in 17 out of 22 provinces (ACIAR, 2021). Coffee exports and incomes are threatened, however, by a number of supply side factors such as ageing coffee trees, outbreaks of coffee berry borer, poor production practices and challenges in reaching markets (i.e. transport and post-harvest handling), as well as by demand-side fluctuations in the world price of coffee (World Bank, 2022; Dorum et al., 2023).

This research note first presents an overview of PNG's coffee sector, including a discussion of production trends and structure of the coffee value chain. We then utilize a simple partial equilibrium model of coffee supply and demand, along with data on coffee production and household consumption from the PNG Household Income and Expenditure Survey (HIES) of 2009/10, FAOSTAT and the World Bank, to simulate the impacts of potential production and price shocks on the coffee industry in Papua New Guinea (PNG). Finally, we present an analysis of price movements in recent years and the potential costs and benefits of a price stabilization policy for coffee producers.

Background: The History of Coffee in PNG

Coffee was introduced to British Papua (the southeastern part of the island of Guinea) in the 1890s, but substantial small plantings began in only 1952 in the Eastern Highlands.[1] In 1963, when the Coffee Marketing Board was established under the Department of Primary Industry (DPI), about half of coffee production came from plantations. Production by smallholders increased rapidly after 1964, rising from about 3000 tons in 1962/63 to 21,000 tons in 1969/70, about half of national production in that year.[2]

PNG's producers benefited from very high world prices resulting from frosts that damaged Brazil's coffee crops in the 1970s, but lower world prices and an outbreak of coffee rust in 1986 greatly reduced profitability of coffee in PNG, particularly in the plantation sector.[3] Subsequently, in 1991, the Coffee Industry Corporation Limited (CIC) was established through the merger of three coffee institutions: the Coffee Marketing Board (established in 1964), the Coffee Industry Board (established in 1976) and the Coffee Development Agency (established in 1987), and granted authority to issue licenses, collect levies and regulate the industry. The Coffee Industry Act 1991 also created a program of localization that transferred land to smallholders that helped smallholder production reach an average of about 55 thousand tons per year from the late 1990s to 2010.

Meanwhile, little new investment occurred in the plantation sector. In addition, after PNG independence in 1975, there was limited transfer of knowledge from large plantation owners to local smallholders, resulting in inadequate local technical skills to manage coffee production, its processing and marketing. Plantation sector production dropped from about 12 thousand tons per year from 1975 through 1995 to

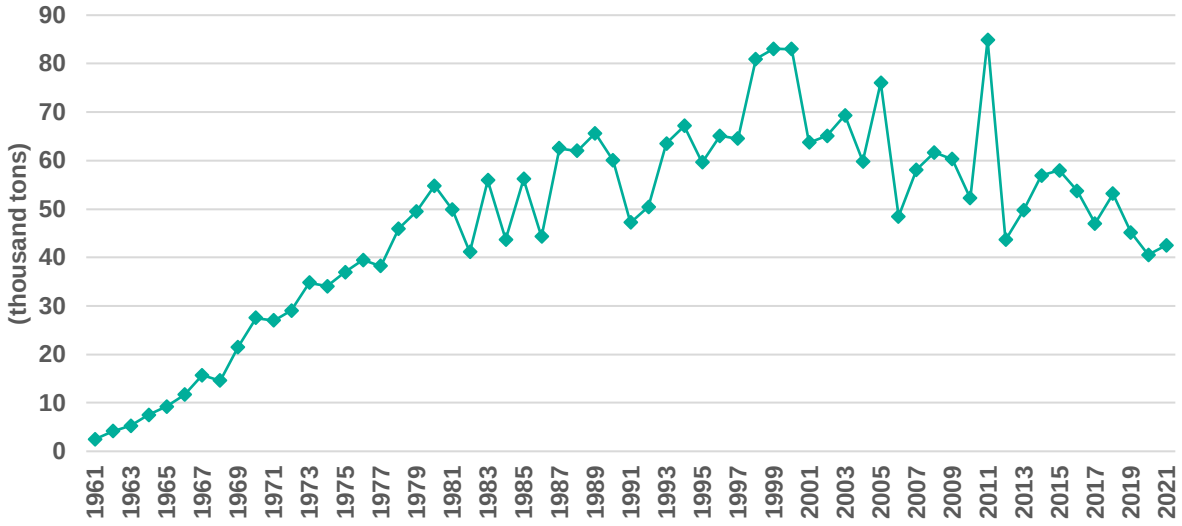
[1] https://web.archive.org/web/20090801072804/http://www.coffeecorp.org.pg/coffhist.html. Accessed December 4, 2023.

[2] Sengere (2016), p. 83, citing CIC data.

[3] The Coffee Industry Corporation stated that "… over the past 10 years, PNG coffee production performance levels have been dismal compared to our Asian neighbors. This declining trend in production is attributed to low prices, law and order problems, decline of plantation sector, abnormal weather patterns, and low yields due to ageing tree stock, inappropriate research and extension delivery mechanisms, deteriorating road infrastructure resulting in more than 40% of coffee produced not reaching market." CIC (2009) quoting data from late 1990s. http://coffeereviewaustralia.com/2009/02/22/papua-new-guinea-land-of-opportunity/ (accessed December 4, 2023).

only about 6 thousand tons per year in the early 2000s and less than 1000 tons per year after 2013, i.e. 1 to 2 percent of total production.[4] Moreover, total coffee production has trended downwards since 2000, from 83 thousand tons in that year to just half that total (41 thousand tons) in 2020 (Figure 1).

Figure 1: Coffee production in PNG, 1961-2021



Source: FAO (2023) data.

The Coffee Value Chain and Domestic Coffee Consumption

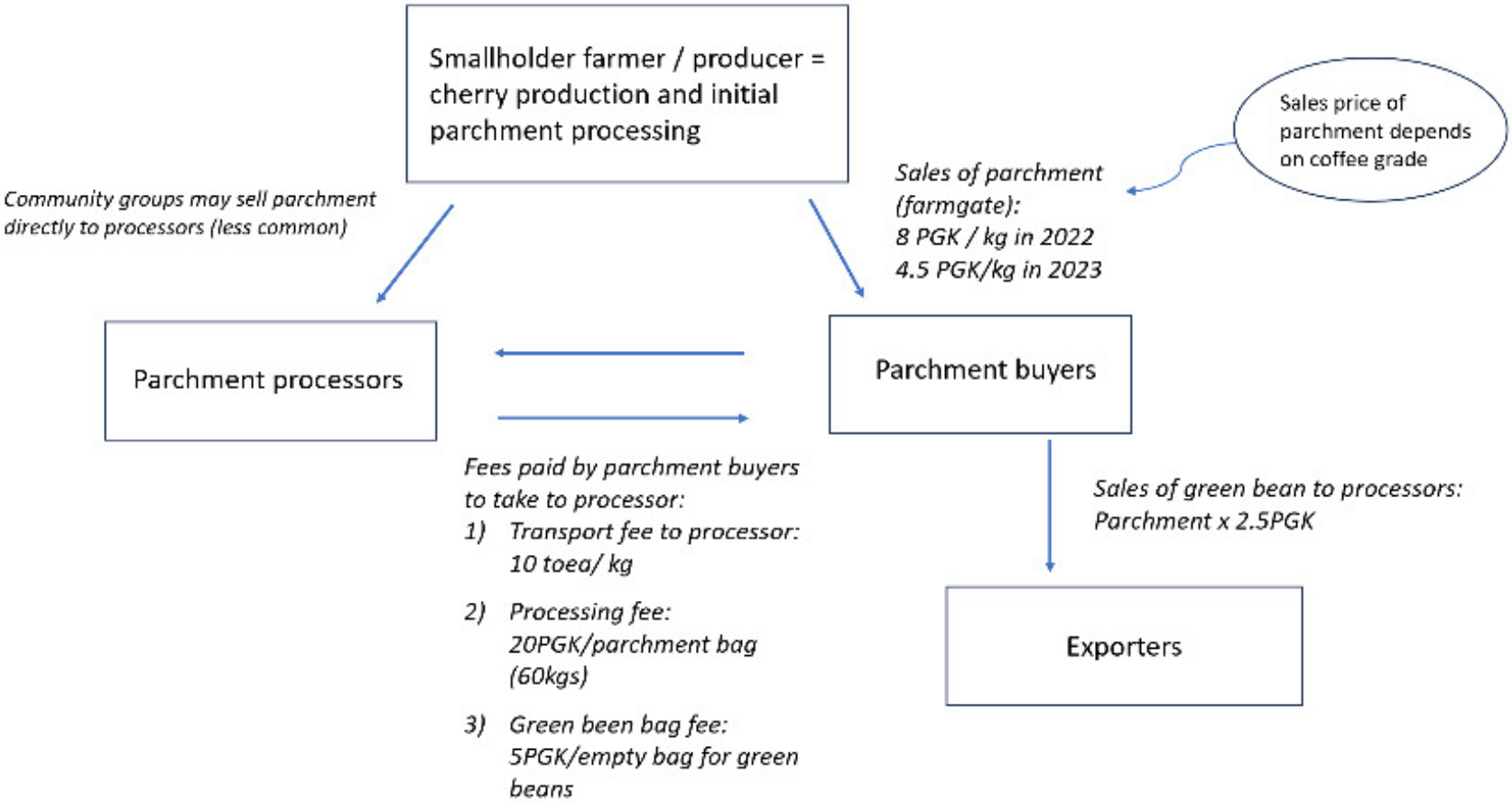
Coffee processing and marketing involves a series of steps and includes several actors (Figure 2). Coffee "cherries" are harvested by farmers in their coffee plots. The harvested cherries are then pulped (removing the outer soft layer), leaving the parchment (inner beans), which are washed and then dried for three to five days (depending on weather) by the farmers before sale to processors / exporters who mill the parchment to produce green beans.[5] (Note that typically, 5 kgs of cherries are required to yield 1 kg of parchment; and 1.25 kgs of parchment yields 1 kg of green beans.) Green beans are roasted in a factory by a processor or exporter who also then packages the coffee and sells the coffee at a retail level.

Very little coffee is actually consumed by households in PNG, however. According to the survey data from HIES (2009/10), average coffee consumption was only 1.2 kilograms (kg) per person per year (Table 1). Coffee consumption of rural non-poor households is about six times higher, however (7.2 kg per capita per year). In total, rural non-poor households in the highlands in PNG consumed about three quarters of the national total coffee consumption. Non-poor households in areas other than highlands account for 11 percent of the total coffee consumption within PNG.

[4] Data on production by source is from Sengere (2016) citing CIC data.

[5] Coffee cherries are also sold in small quantities to local cherry coffee buyers, who then process the cherries to parchment. These sales are more common among small output farmers or households that need quick cash income.

Figure 2. The Coffee Value Chain in PNG, 2023



Source: PNG Coffee Handbook (2016) and authors.

Table 1: PNG Coffee Consumption and Demand Parameters

	Highlands				Other PNG				All PNG
	Rural		Urban		Rural		Urban		
	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor	
Consumption (kgs/person)	0.19	7.17	0.07	0.87	0.19	0.39	0.15	0.41	1.15
Consumption (kina/person)	1.55	25.86	3.94	19.31	1.22	8.22	4.40	14.00	9.86
Total expenditures (kina/person)	794	2,700	1,670	5,275	710	3,059	1,649	6,011	3,025
Share of total expenditure	0.2%	1.0%	0.2%	0.4%	0.2%	0.3%	0.3%	0.2%	0.3%
Consumption (tons)	0.49	13.90	0.06	0.28	0.48	1.03	0.64	2.04	18.91
Consumption (share of total)	2.6%	73.5%	0.3%	1.5%	2.5%	5.4%	3.4%	10.8%	100.0%
Income elasticity	0.96	0.92	0.80	0.73	1.03	0.96	0.66	0.62	0.89
Own-price elasticity	-0.70	-0.85	-0.63	-0.70	-0.70	-0.86	-0.52	-0.60	-0.80

Source: HIES 2009/10 and Diao et al. (2021). Calculated by authors.

Implications of Coffee Berry Borer Productivity Shocks

To estimate the potential effects of production and price shocks on PNG's coffee sector, we use a simple partial equilibrium model of supply and demand of coffee in PNG. The model, based on estimates for production, exports and consumption from the FAO Food Balance Sheets for 2021 (FAO, 2023), calculates production and the volume of coffee exports given changes in world prices, productivity and model parameters (e.g. price responsiveness of supply and demand).

In Simulation 1, we model the potential impacts of a negative 10 percent productivity shock arising from infestation of coffee berry borer (*Hypothenemus hampei*). This simulation follows previous coffee berry borer impacts measured on the coffee sector in Indonesia, which caused an estimated 10 percent loss in coffee output (See Durham, 2004; Wiryadiputra et al., 2008). Simulation 1 assumes a more localized negative productivity shock to coffee, which does not change the world price. In this case, coffee production and the value of PNG's exports both decline by 10 percent (Table 2 and Figure 3). If, however, the outbreak of coffee berry borer or other supply side shocks have a major effect on world coffee production so that the world price of coffee rises 20 percent, production in PNG falls only 3.2%. Under this scenario, following economic theory of supply and demand, PNG coffee producers would respond to higher prices with increased production. Producer responses could include, in the short run, increased chemical inputs such as fertilizer or pesticides and labor input for coffee plot and tree maintenance. In the medium run, producers could respond with investments to improve coffee tree stock and output quality (whether at production or processing level) (Simulation 2).

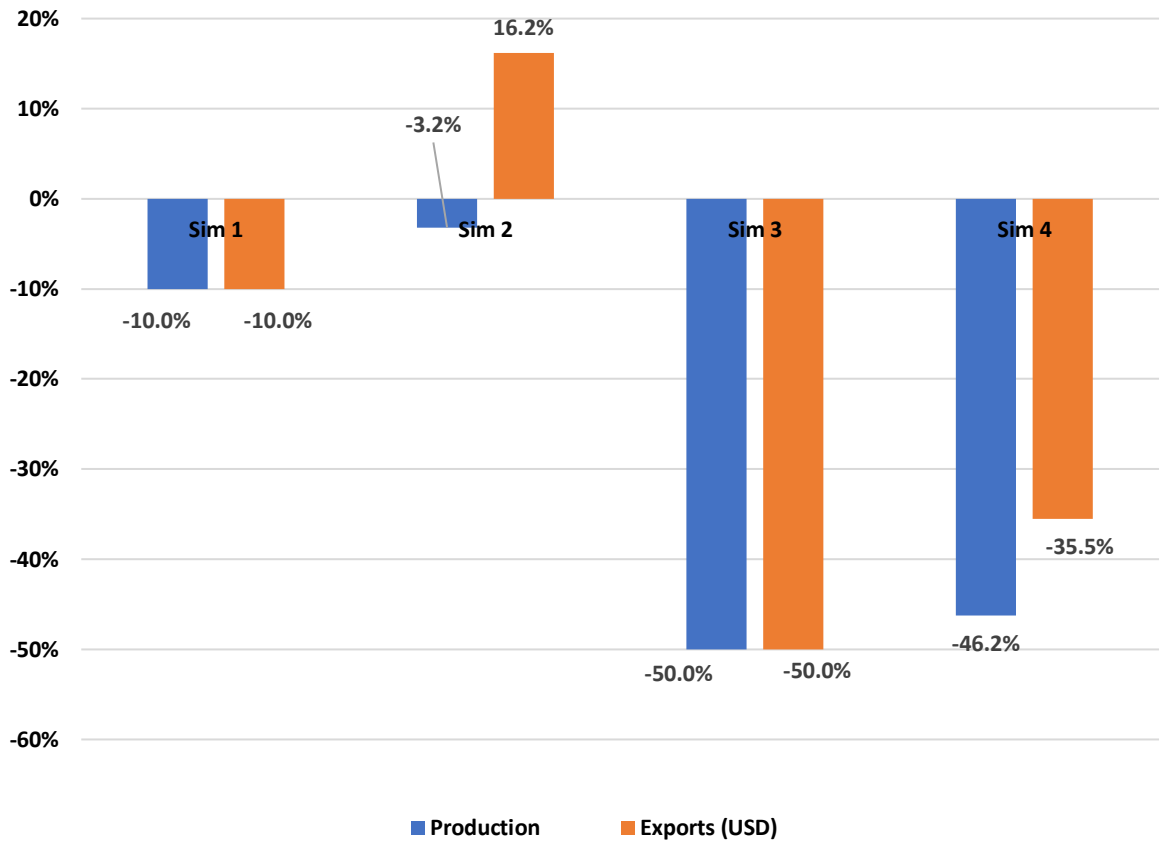
In this case, although the volume of coffee exports also drops by 3.2%, because of the world price increase, the value of PNG's exports increases by 16.2%.

Table 2: Effects of Negative Shocks to PNG Coffee Production (Model Simulations)

		Sim 1 (-10%Prod) (+0% PW)	Sim 2 (-10%Prod) (+20% PW)	Sim 3 (-50%Prod) (+0% PW)	Sim 4 (-50%Prod) (+20% PW)
	2021	**2023**	**2028**	**2028**	**2028**
	Base	**Short-run**	**Medium-run**	**Medium-run**	**Medium-run**
Production ('000 tons)	46.0	41.4	44.5	23.0	24.7
(% change)	---	-10.0%	-3.2%	-50.0%	-46.2%
Market Price	---	0.0%	20.0%	0.0%	20.0%
Exports ('000 tons)	44.0	39.6	42.6	22.0	23.6
(% change)	---	-10.0%	-3.2%	-50.0%	-46.2%
Exports (mn USD)	156.1	140.5	163.2	81.5	52.6
(% change)	---	-10.0%	16.2%	-50.0%	-35.5%

Source: Model simulations.

Figure 3: Effects of Negative Shocks to Coffee Production (Model Simulations)



Source: Model simulations.

If the negative productivity shock is 50 percent instead of only 10 percent, PNG's coffee production and exports fall by 50 percent, as well (Simulation 3). Combined with a 20% increase in the coffee price, the 50 percent productivity shock results in a 46.2 percent fall in PNG's production and export volume, and a 35.5% decline in the USD value of PNG's coffee exports (Simulation 4).

Effects of World Price Increases in the Short- and Long-Run

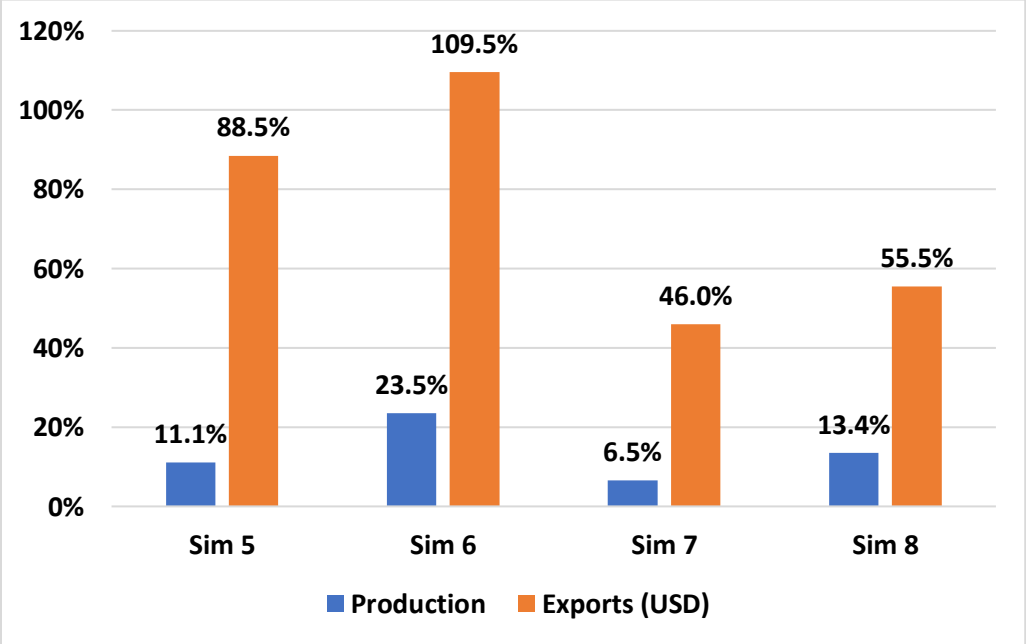
World coffee prices have risen sharply in recent years, increasing incomes from coffee and incentives for coffee production. In Simulation 5, we model the effects of a 70 percent increase in the world price of coffee, (equal to the actual percentage change in the USD price of Arabica coffee in world markets between 2020 and 2022). Using the base parameters as in the above simulations, PNG coffee production increases by 11.1 percent and the USD value of exports increases by 89 percent (Simulation 5, (Table 3 and Figure 4). If this higher world price persists in the medium run, the positive supply response of coffee producers in PNG would be larger: PNG coffee production increases by 23.5 percent and the USD value of exports increases by 110 percent (Simulation 6).

Table 3: Effects of World Price Shocks on PNG Coffee Production (Model Simulations)

		Sim 5 (+70% PW) (+0% Prod)	Sim 6 (+70% PW) (+0% Prod)	Sim 7 (+37% PW) (+10%Prod)	Sim 8 (+37% PW) (+10%Prod)
	2021	**2023**	**2028**	**2028**	**2028**
	Base	**Short-run**	**Medium-run**	**Short-run**	**Medium-run**
Production ('000 tons)	46.0	51.1	56.8	49.0	52.2
(% change)	---	11.1%	23.5%	6.5%	13.4%
Market Price	---	69.6%	69.6%	37.0%	37.0%
Exports ('000 tons)	44.0	48.9	54.3	46.8	49.9
(% change)	---	11.2%	23.6%	6.5%	13.5%
Exports (mn USD)	156.1	294.2	616.5	900.1	1399.5
(% change)		88.5%	109.5%	46.0%	55.5%
Consumption ('000 tons)	0.0	0.0	0.0	0.0	0.0
(% change)	---	-23.2%	-23.2%	-14.6%	-14.6%

Source: Model simulations.

Figure 4: Effects of World Price Shocks on PNG's Coffee Sector (Model Simulations)



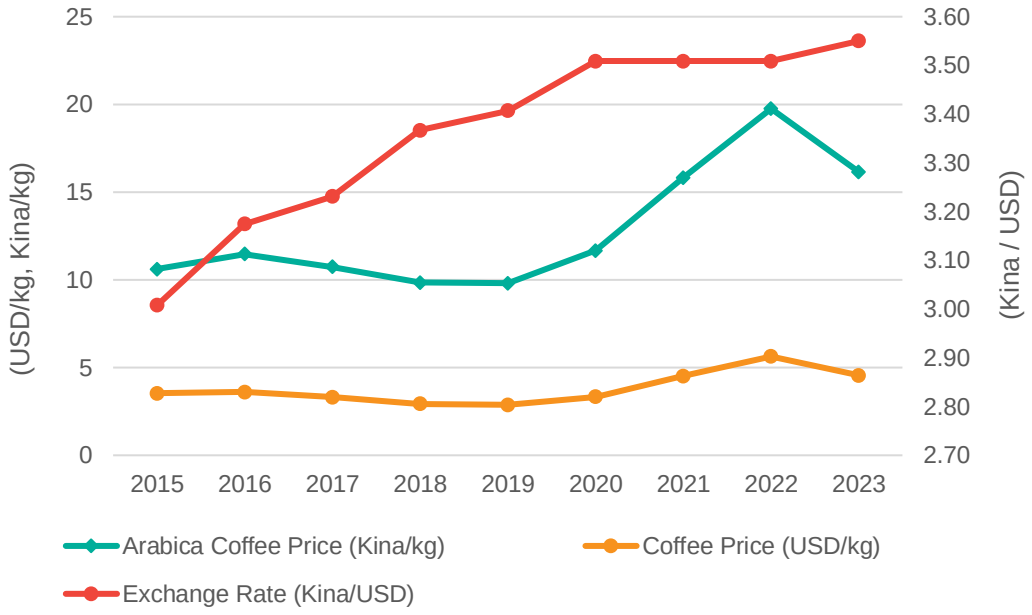
Source: Model simulations.

World prices of Arabica coffee declined somewhat in 2023, so the percentage change in price between 2020 and 2023 was only 37 percent (compared to 70 percent between 2020 and 2022). A 37 percent increase in the coffee export price has smaller effects than in Simulation 5: PNG coffee production increases by 7 percent and the USD value of exports increases by 46 percent (Simulation 7). If the 37 percent increase in export prices persists in the medium term, the positive supply response of producers would be larger. In this case, PNG coffee production increases by 13 percent and the USD value of exports increases by 56 percent (Simulation 8).

Costs of a Hypothetical Price Stabilization Policy

As discussed above, world price changes have major effects on PNG's coffee production and exports. The actual impacts on domestic producers and consumers depend not only on the world price, but the exchange rate, as well. As shown in Figure 5, the price of Arabica coffee in world markets ranged from 2.88 USD/ton to 5.63 USD/ton between 2015 and 2023. During this same period, PNG's nominal exchange rate depreciated from 3.01 Kina/USD to 5.63 Kina/USD. Thus, the kina price of coffee rose from 5.84 to 11.66 kina/kg. Considering only the period between 2020 and 2023, however, the world price of Arabica coffee in domestic currency terms rose 70 percent, before dropping to 16.2 Kina/kg in 2023 (only 37% higher than the 2020 price).

Figure 5: The Price of Arabica Coffee (USD/kg and Kina/kg), 2015 to 2023



Source: World Bank (2023), IMF (2023) and authors' calculations.

These large fluctuations in Arabica coffee prices also result in significant variations in incomes for coffee producers. However, stabilizing incomes by eliminating these changes in prices could be very costly. As shown in Figure 6, the actual coffee export price in PNG was below a hypothetical target price of 12 Kina/kg every year from 2015 through 2020. A price stabilization program that kept prices at this hypothetical target price would have entailed a subsidy each of these years equal to the gap between the target price and the actual export price times the quantity of coffee production, an amount ranging from 14 to 114 million Kina per year (Figure 7 and Table 4).

Figure 6: Export Prices and Hypothetical Target Prices of Coffee (Kina/kg), 2005 to 2023

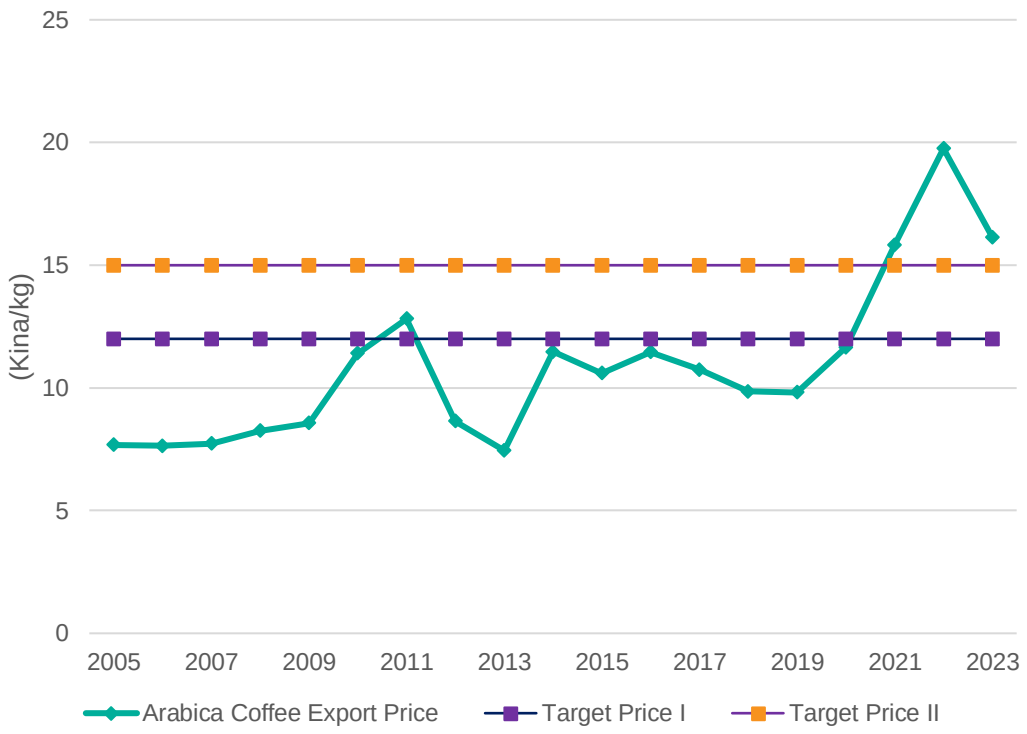
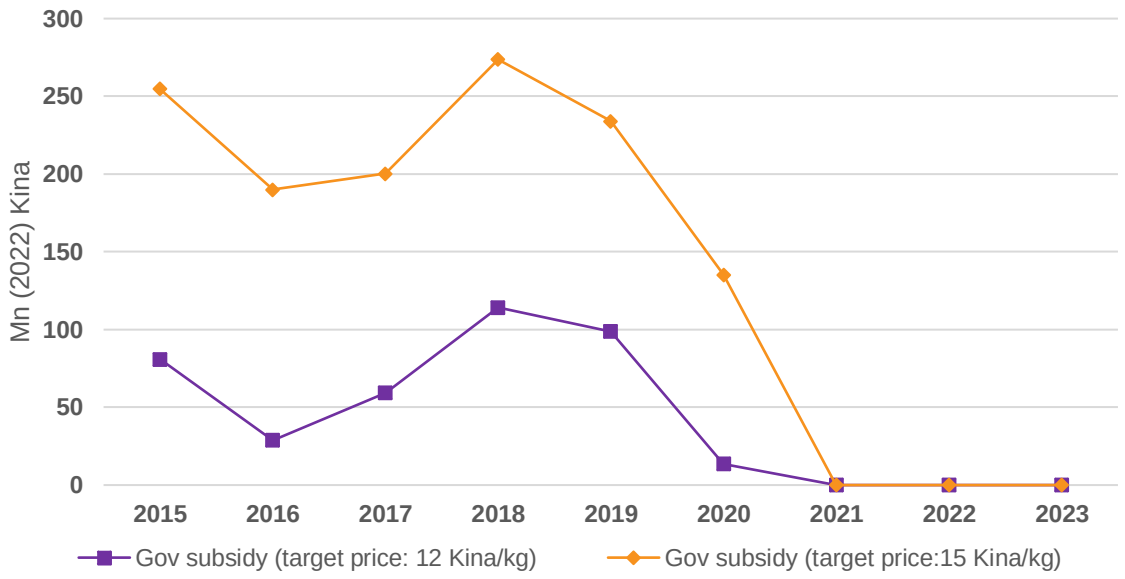


Figure 7: Estimated cost of hypothetical price stabilization policies, 2005 to 2023



Source: World Bank (2023) and IMF (2023) data; authors' calculations.

Table 4: Estimated Cost of a PNG Coffee Price Stabilization Policy (2015-2023)

	2015	2016	2017	2018	2019	2020	2021	2022	2023
World Coffee Price (USD/kg)	3.53	3.61	3.32	2.93	2.88	3.32	4.51	5.63	4.55
Exchange Rate (Kina/USD)	3.01	3.17	3.23	3.37	3.41	3.51	3.51	3.51	3.55
World Coffee Price (Kina/kg)	10.60	11.46	10.74	9.85	9.81	11.66	15.83	19.76	16.15
Gap to Target Price: 12 Kina/kg	1.4	0.5	1.3	2.1	2.2	0.3	0.0	0.0	0.0
Gap to Target Price: 15 Kina/kg	4.4	3.5	4.3	5.1	5.2	3.3	0.0	0.0	0.0
Production ('000 tons)	58.0	53.7	47.0	53.2	45.1	40.5	42.5	42.5	42.5
Subsidy 1 (12 Kina/kg)	80.9	28.8	59.3	114.2	98.8	13.7	0.0	0.0	0.0
Subsidy 2 (15 Kina/kg)	254.9	190.0	200.3	273.7	234.1	135.2	0.0	0.0	0.0

Notes: The government subsidy = the gap between target price and actual export price * production quantity.
No data is available for production in 2022 and 2023; the figures used here are the production level in 2021.

Source: FAOSTAT and World Bank data; authors' calculations.

A higher target price would imply an even larger subsidy. With a target price of 15 kina/kg, the subsidy range would have amounted to 135 to 274 million Kina per year. Since the steep price rise of 2021, however, world coffee prices have exceeded 15 Kina/kg and the subsidy would have been zero at both target prices. In total, stabilizing PNG coffee export prices at a target price of 12 kina/kg would have required annual subsidies averaging an estimated 66 mn Kina/year in the years 2015 through 2020. Total costs of the subsidy with a target price of 15 kina/kg in these years would have been 215 mn kina (3.3 times larger than the subsidy with the lower 12 kina/kg target price).

Note that PNG's average coffee export price was about 90% of the average world price of Arabica coffee in US and European markets from 2015 to 2021. Prices for farmers would be lower than the export price given processing and marketing costs from rural areas to the port.

Summary and Policy Implications

Coffee is a major agricultural export for PNG and an important source of income for rural households in the highlands of PNG. However, coffee production, exports and producer incomes are susceptible to pest and weather shocks in PNG, as well as fluctuations of prices in international markets.

For example, a major outbreak of coffee berry borer in 2023-24 could reduce productivity of coffee in PNG, as well as in other countries. Model simulations indicate that a 10% loss in coffee productivity in PNG due to coffee berry borer (as in Indonesia in the early 2000s), in the absence of any changes in world prices, would result in a decline in coffee production and exports of a similar magnitude. However, if at the same time world prices rise by 20% due to productivity losses in major coffee exporting countries[6], coffee production in PNG would fall by only 3.2% and the value of PNG's coffee exports would actually increase by 16.2%.

In contrast, low world coffee prices (as in the years prior to 2021) imply substantial losses of income for coffee producers. Avoiding the negative effects of such low world market prices of coffee could be very expensive, however, particularly if target domestic coffee prices are set too high. For example, stabilizing PNG coffee export prices at a target price of 12 kina/kg would have required annual subsidies averaging an estimated 66 mn Kina/year in the years 2015 through 2020.Total costs of the subsidy with a target price of 15 kina/kg in these years would have amounted to 215 mn kina (3.3 times larger). Moreover, ensuring that farmers (and not just traders) receive the benefits of a stabilization policy would be very difficult without major changes in coffee marketing.

Further analysis is needed to explore other means of raising producer incomes, including reducing marketing costs, improving the quality of the coffee and raising yields.

[6] The impact on PNGs coffee sector would be the same if PNG's export price rose by 20% because of increased quality, attracting a higher price premium for PNG coffee.

Annex I: A Partial Equilibrium Model of PNG's Coffee Sector

The PNG Coffee Model estimates quantities of coffee production and exports, as well as export earnings based on FAOSTAT data on supply and demand for 2021 (FAO, 2023).

The domestic price of coffee received by producers plus marketing costs is equal to the world price multiplied by the kina/USD exchange rate. (The model takes the world price of coffee in US dollars as given (exogenous), since PNG exporters have little influence on the world market price.)

(1) Pd * (1+mktg) = PWE * ER

Pd	=	the domestic price of coffee (kina/kg)
PW	=	the world price of coffee, fob PNG (USD/kg
ER	=	the nominal exchange rate (kina / USD)
Mktg	=	marketing costs between farmgate and fob (percent)

Production is modeled as the product of a productivity shock (lambda) and the domestic market price raised to the power es (the elasticity of supply):

(2) QS1 = QS0 * λ * Pd es,

es	=	the elasticity of supply of coffee with respect to the price of coffee
Pd	=	the farmgate price of coffee
lambda	=	the productivity shock
QS0	=	the base level of supply
QS1	=	the simulated level of supply.

Demand for coffee is modeled in a similar way:

(3) $QD1 = QD0 * (Pd/P0d)^{ed} * (Y1/Y0)^{eY}$

ed	=	the elasticity of supply of coffee with respect to the price of coffee
Pd	=	the domestic price of coffee
Y0	=	the base level of household income
Y1	=	the simulated level of household income
QD0	=	the base level of demand
QD1	=	the simulated level of demand.

Exports are equal to supply less total demand (including household consumption):

(4) Exports = QS1 – QD1

Note that this model of Papua New Guinea, since domestic demand for coffee is such a small share (about 0.1 percent) of supply, domestic demand for coffee does not affect the results in a significant way.

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ACKNOWLEDGMENTS

Funding for this work output was provided by the Australia Department of Foreign Affairs and Trade (DFAT) through the Australia High Commission (AHC) in Port Moresby.

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