Papua New Guinea
Country Strategy Support Program

Workshop on
Price and Trade Policy Analysis

Monday, 6 November to Friday, 17 November, 2023

International Food Policy Research Institute
Washington, D.C.

The PNG Country Program
is funded by Australia DFAT

PNG Workshop:
Agricultural Policy Analysis with Partial Equilibrium Models

Day 2: Tuesday, November 7:

Morning: PE Model 1c (1 comm; 8 hhs);

Sweet potato sims (closed economy)

Afternoon: PE Model 1d (1 comm; multiple hhs);

Coffee sims (open economy)

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A Basic Partial Equilibrium Model:

Simulation Analysis of Supply, Demand and Prices

- Supply, demand and international trade
- Import parity, prices and imports
- Spreadsheet analysis of shocks with and without private imports (Model 1)

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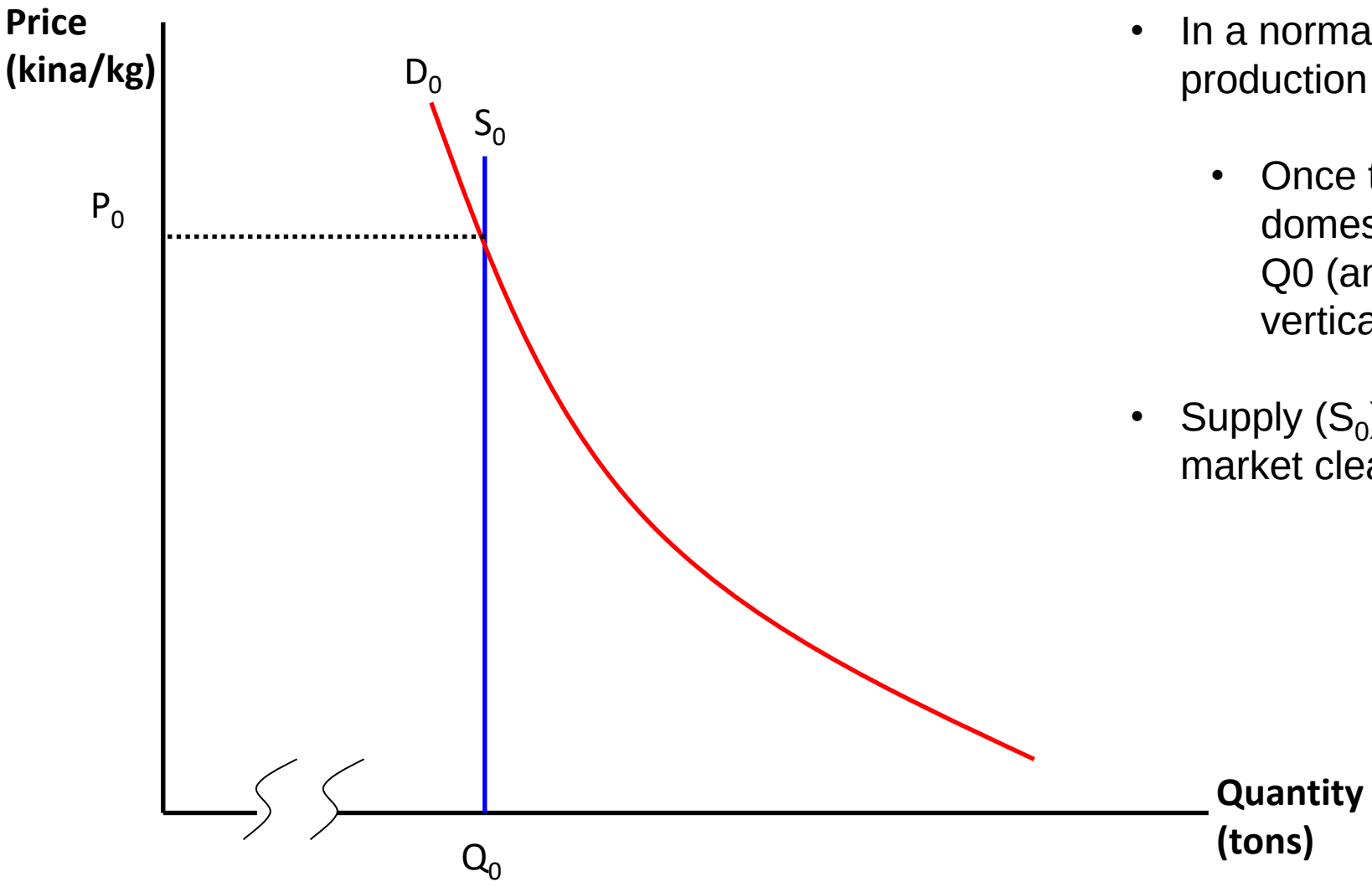
Short-run Impact of a Supply Shock (with Fixed Production)



- In a normal year, domestic production = supply = S_0
  - Once the crop is harvested, domestic production is fixed at Q0 (and the supply curve is vertical)
- Supply (S_0) equals demand (D_0) at market clearing price (P_0)

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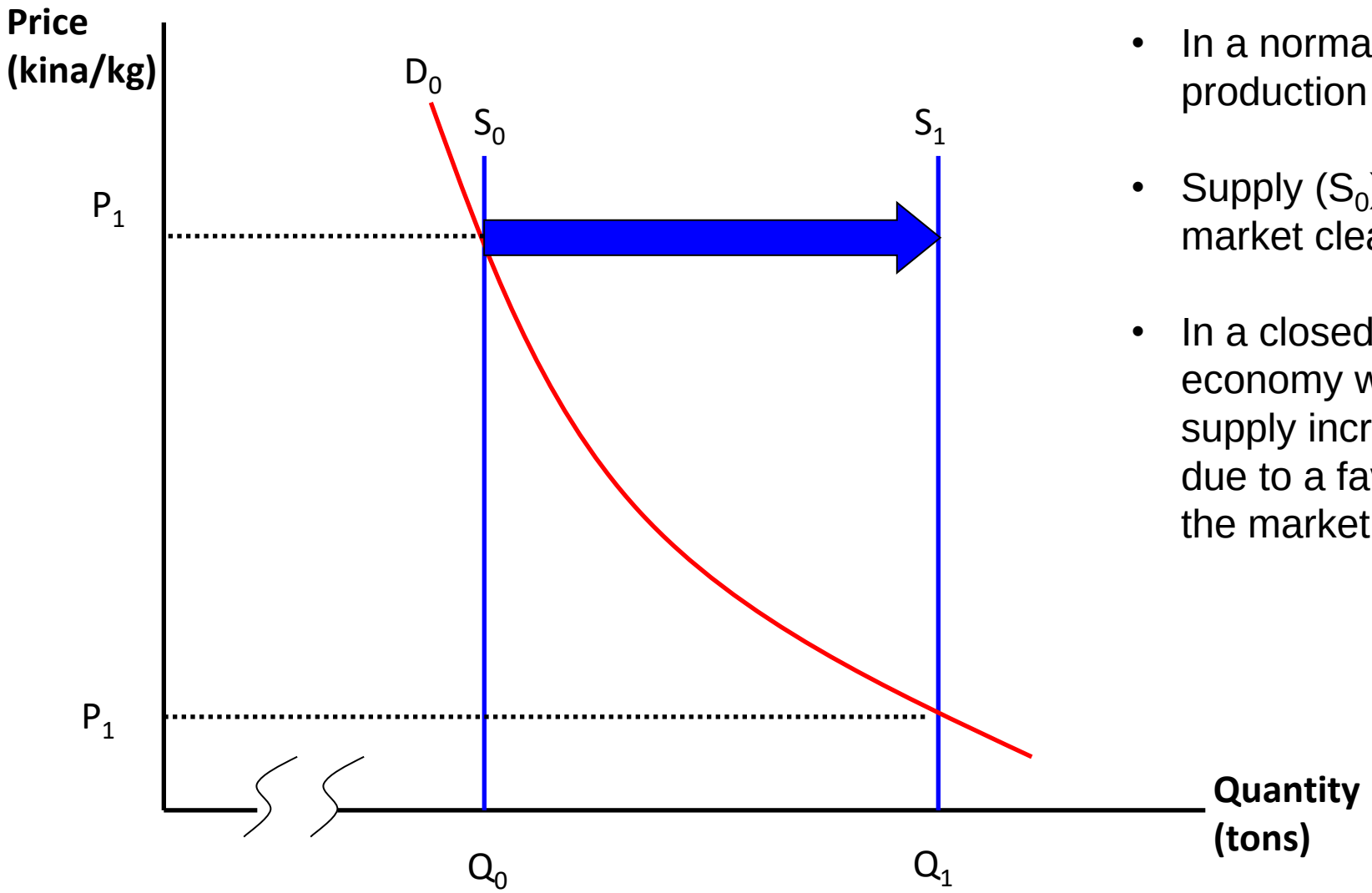
Short-run Impact of a Supply Shock



- In a normal year, domestic production = S_0
- Supply (S_0) equals demand (D_0) at market clearing price (P_0)
- In a closed economy (i.e. an economy with no foreign trade), if supply increases from S_0 to S_1 (e.g. due to a favorable weather shock), the market price falls to P_1.

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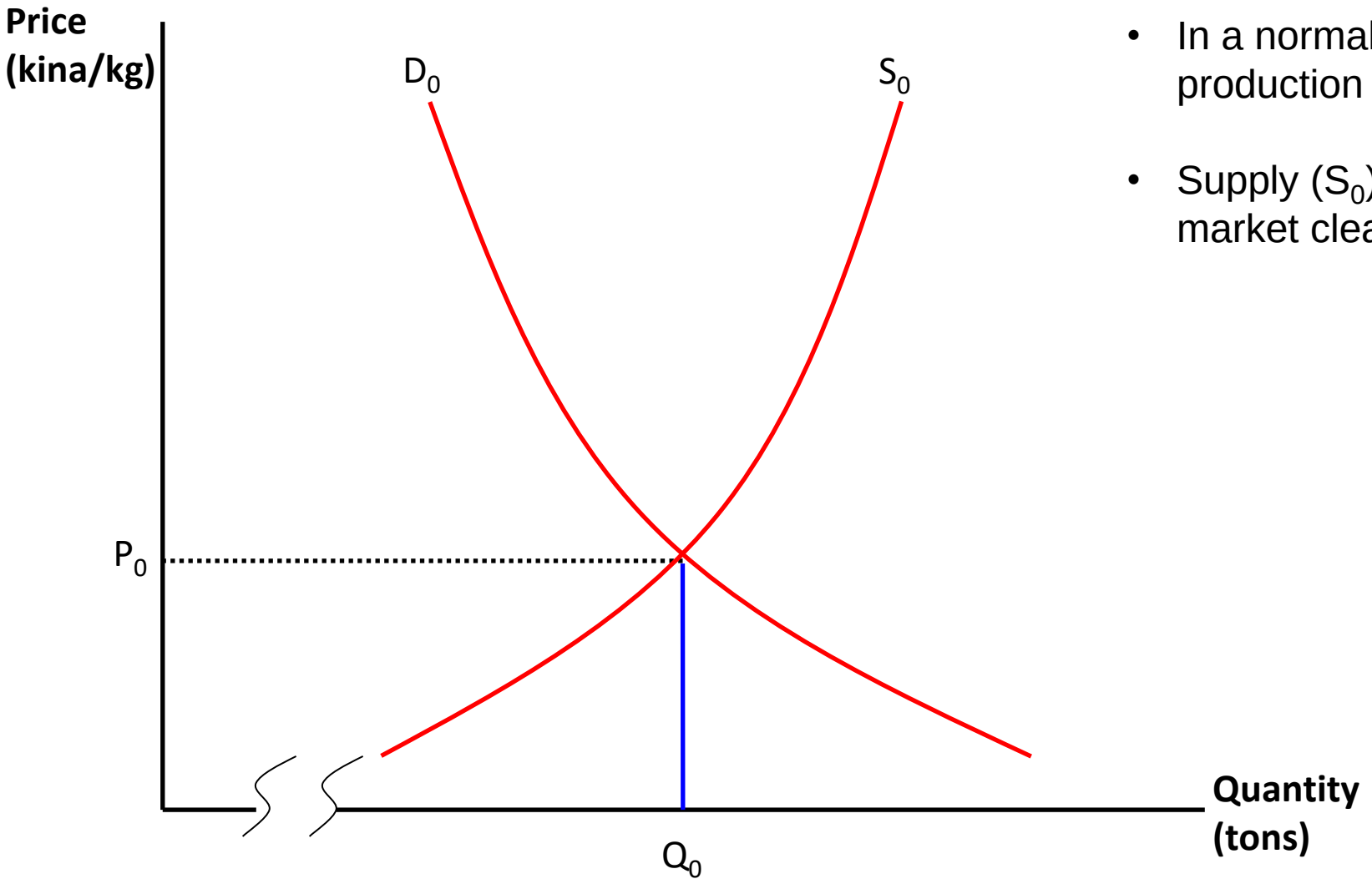
Impact of a Supply Shock (with Endogenous Production)



- In a normal year, domestic production = S_0
- Supply (S_0) equals demand (D_0) at market clearing price (P_0)

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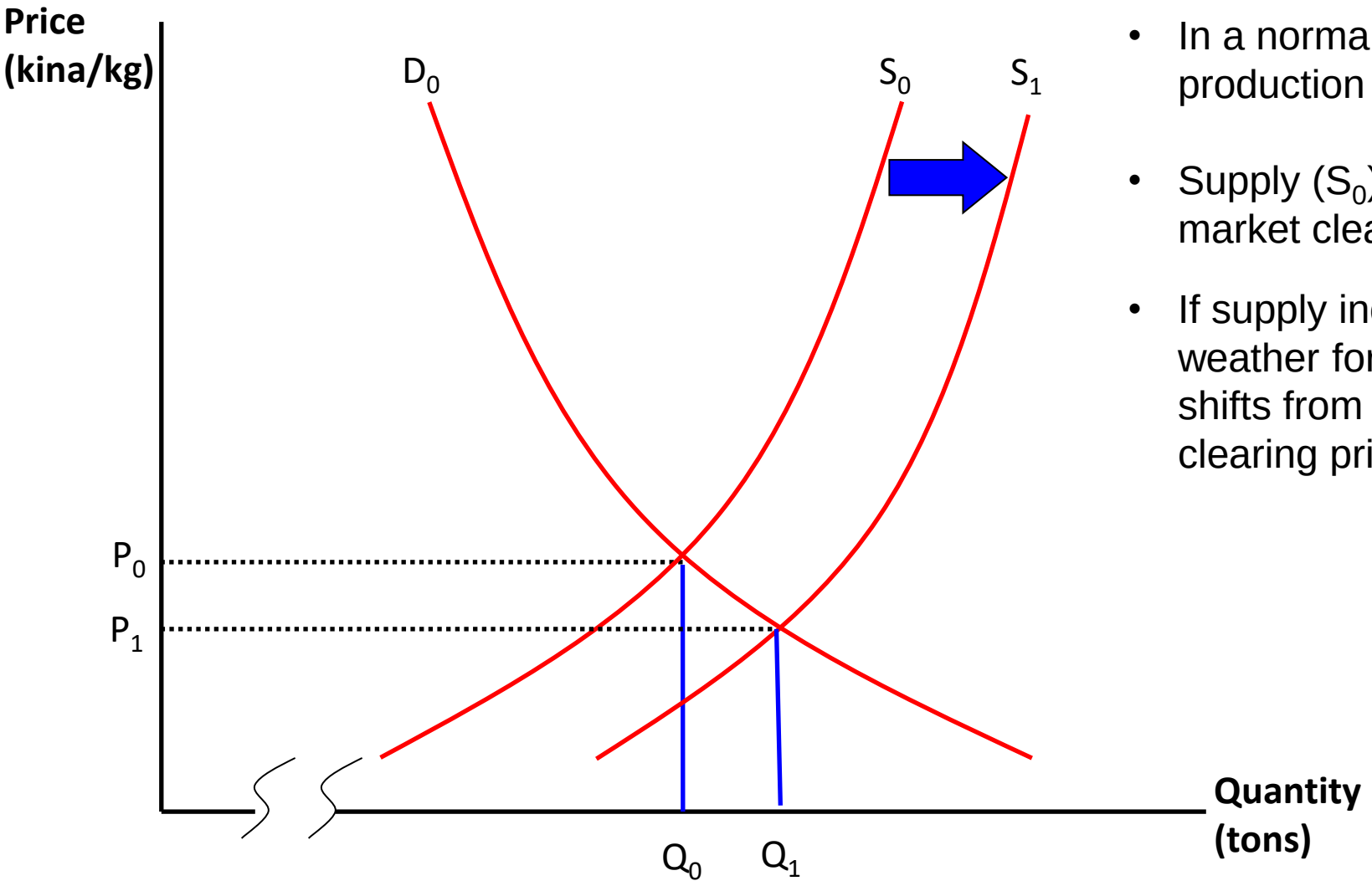
Short-run Impact of a Supply Shock



- In a normal year, domestic production = S_0
- Supply (S_0) equals demand (D_0) at market clearing price (P_0)
- If supply increases due to favorable weather for crops, the supply curve shifts from S_0 to S_1 and the market clearing price falls to (P_1)

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A Basic Partial Equilibrium Model

(1) $S_1 = S_0 * (P_1/P_0)^{\gamma 1}$

$\gamma 1$ = own-price elasticity of supply

(2) $D_1 = D_0 * (P_1/P_0)^{\beta 1} * (Y_1/Y_0)^{\beta 2}$

$\beta 1$ = own-price elasticity of demand
$\beta 2$ = income elasticity of supply

(3) $S_1 = D_1$

Equilibrium Condition

S = Supply;
D = Demand; P = Price
Y = Income

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Some Mathematics of Elasticities

(1) $S = a * P^{\gamma 1}$

Taking the derivative with respect to P:

(2) $dS / dP = a * \gamma 1 * P^{(\gamma 1 - 1)}$

$= a * \gamma 1 * P^{\gamma 1} / P$

$= \gamma 1 * (a * P^{\gamma 1}) / P$

$= \gamma 1 * S / P$ (using the definition of S from equation 1)

==> $(dS/S) / (dP/P) = \gamma 1$

Or in discrete terms, $(\Delta S/S) / (\Delta P/P) = \gamma 1$

S = Supply; P = Price

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Elasticity Formulas (with Logarithms)

(1) $S_1 = S_0 * (P_1/P_0)^{\gamma 1}$

$\ln(S_1) = \ln(S_0) + \gamma 1 * \ln(P_1/P_0)$

$\ln(S_1 / S_0) = \gamma 1 * \ln(P_1/P_0)$

$d \ln(S_1 / S_0) / d \ln(P_1/P_0) = \gamma 1$

$\gamma 1$ = own-price elasticity of supply

(2) $D_1 = D_0 * (P_1/P_0)^{\beta 1} * (Y_1/Y_0)^{\beta 2}$

$\ln(D_1) = \ln(D_0) + \beta 1 * \ln(P_1/P_0) + \beta 2 * \ln(Y_1/Y_0)$

$\ln(D_1 / D_0) = \beta 1 * \ln(P_1/P_0) + \beta 2 * \ln(Y_1/Y_0)$

$d \ln(S_1 / S_0) / d \ln(P_1/P_0) = \beta 1$

$\beta 2$ = own-price elasticity of demand

S = Supply;
D = Demand; P = Price
Y = Income

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PNG Sweet Potato Market Simulations (Model 1)

Endogenous Price w/ Zero Imports

(1) $S_1 = XS_0 * shock * (P_1/P_0)^{\gamma 1}$

$\gamma 1$ = own-price elasticity of supply

(1) $D_1 = D_0 * (P_1/P_0)^{\beta 1} * (Y_1/Y_0)^{\beta 2}$

$\beta 1$ = own-price elasticity of demand
$\beta 2$ = income elasticity of supply

(2) $S_1 = D_1$

Equilibrium Condition

S = Supply; X = Production,
D = Demand; P = Price

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PNG Sweet Potato Simulations

Price change		13.0%	8.1%	3.2%	-2.4%
Residual		0.0	0.0	0.0	0.0
	2021	**2021**	**2021**	**2021**	**2021**
	Base	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**
		(-10% Prod)	**(-10% Prod)**	**(-10%Q,Y)**	**(+20%Q;10%Y)**
		es=0.4;ed=-0.5	**es=0.9;ed=-0.5**	**es=0.9;ed=-0.5**	**es=0.9;ed=-0.5**
Production ('000 tons)	699.0	660.6	675.0	647.0	752.1
Losses (10 percent)	97.0	91.7	93.7	89.8	104.4
Net Production ('000 tons)	602.0	568.9	581.3	557.2	647.7
Private imports ('000 tons)	0.0	0.0	0.0	0.0	0.0
Subtotal ('000 tons)	602.0	568.9	581.3	557.2	647.7
Private stock change ('000 tons)	0.0	0.0	0.0	0.0	0.0
Supply	602.0	568.9	581.3	557.2	647.7
Demand ('000 tons)	602.0	568.9	581.3	557.2	647.7
Per Capita Demand (kg/person/month)	59.4	56.1	57.3	54.9	63.9
Per Capita Supply (% change)	0.0%	-5.5%	-3.4%	-7.4%	7.6%
Per Capita Income (2021/22 = 100)	1.00	1.00	1.00	0.90	1.10
Productivity	1.00	0.90	0.90	0.90	1.10
Elasticity of Supply		0.40	0.90	0.90	0.90
Income Elasticity of Demand		0.50	0.50	0.50	0.50
Own Price Elasticity of Demand		-0.50	-0.50	-0.50	-0.50

Endogenous Price w/ Fixed Imports

(1) $S_1 = QS_0 * shock * (P_1/P_0)^{\gamma 1}$

(2) $D_1 = D_0 * (P_1/P_0)^{\beta 1} * (Y_1/Y_0)^{\beta 2}$

(3) $S_1 = D_1$

S = Supply; QS = Production,
D = Demand; P = Price

To solve the Excel model:

Data / "What-If Analysis / Goal Seek

Set Cell: D2 (residual = S-D)
To Value: 0
By changing cell: G1 (price)

OR

Data / Solver

Set Objective: D2 (residual = S-D)
To: Value Of: 0
By Changing Cell: D1 (price)

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* Assumes no change in stocks.

PNG Sweet Potato Simulations

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Simulation 1: Short Term (inelastic parameters)

- With es = 0.4 and ed = -0.5, a 10% reduction in productivity leads to 5.5% decrease in output and a 13% price increase.
- The total decline in production (5.5%) is the combined effect of the price effect on supply
  (εs * Δ% Price = 0.4 * 13% = +5.2%)
  and the 10% decrease in productivity

Simulation 2: Medium Term (more elastic parameters)

- With es = 0.9 and ed = -0.5, a smaller price increase is required to increase production and balance domestic supply and demand.
- The poultry price increases by only 8.1% in Simulation 2, compared to 13% in Simulation 1.

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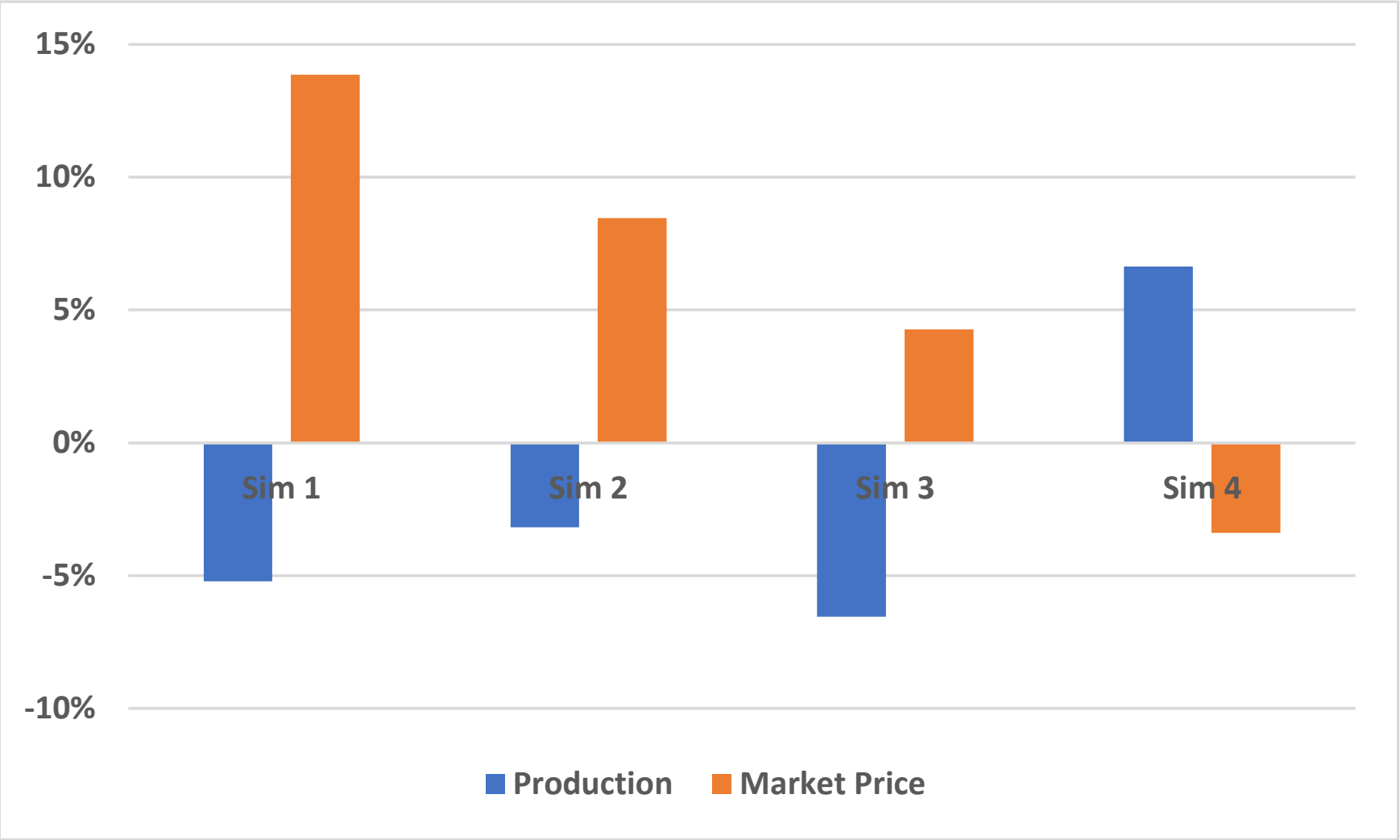
* Assumes no change in stocks.

PNG Sweet Potato Simulation Results



- Sim 1: 10% reduction in productivity reduces the supply, leads to 13% increase in the market price and lowers production (and consumption) by 5.5%.
- Sim 3: 10% decrease in productivity with 10% decrease in incomes leads to a 3% increase in the market price and a 7% increase in production and consumption.

Sim 1: -10% productivity (S-Run)
Sim 2: -10% productivity (L-Run)
Sim 3: Sim 2 w/ -10% Incomes
Sim 4: +20% productivity; +10% Incomes

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PNG Sweet Potato Simulations

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Residual		0.0	0.0	0.0	0.0
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Subtotal ('000 tons)	602.0	568.9	581.3	557.2	647.7
Private stock change ('000 tons)	0.0	0.0	0.0	0.0	0.0
Supply	602.0	568.9	581.3	557.2	647.7
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Productivity	1.00	0.90	0.90	0.90	1.10
Elasticity of Supply		0.40	0.90	0.90	0.90
Income Elasticity of Demand		0.50	0.50	0.50	0.50
Own Price Elasticity of Demand		-0.50	-0.50	-0.50	-0.50

* Assumes no change in stocks.

Simulation 3:

- With es = 0.9 and ed = -0.5, a 10% reduction in productivity along with 10% reduction in incomes leads to 7.4% decrease in output and a 3.2% price increase.

- The total decline in production (7.4%) is the combined effect of the price effect on supply
  ($\varepsilon s * \Delta\%$ Price = 0.9 * 3.2% = +2.88%)
  and the 10% decrease in productivity

Simulation 2: Medium Term (more elastic parameters)

- With es = 0.9 and ed = -0.5, a smaller price increase is required to increase production and balance domestic supply and demand.

- The poultry price increases by only 8.1% in Simulation 2, compared to 13.0% in Simulation 1.

PNG Sweet Potato Model: Multiple Household Groups

	Sim 1	Sim 2	Sim 3	Sim 4
	-10% Prod	-10% Prod	-10% Q, Y	20%Q;10%Y
	Short-run	Medium-run	Medium-run	Medium-run
Urb Hi Poor	-1.9%	-1.2%	-2.6%	2.3%
Urb Hi NPoor	-2.1%	-1.3%	-2.4%	2.2%
Oth Urb Poor	-2.2%	-1.4%	-2.4%	2.2%
Oth Urb NPoor	-1.9%	-1.2%	-2.2%	1.9%
Rur Hi Poor	-3.7%	-1.9%	-6.9%	7.4%
Rur Hi NPoor	-5.3%	-3.4%	-7.4%	7.5%
Oth Rur Poor	-7.5%	-4.8%	-8.6%	8.6%
Oth Rur NPoor	-6.8%	-4.3%	-8.1%	8.2%

Demand Parameters (expenditure elasticity, own-price elasticity)

Urban Highlands Poor	(0.20, -0.1533)
Urban Highlands Non-poor	(0.18, -0.1728)
Other Urban Poor	(0.18, -0.18)
Other Urban Non-poor	(0.16, -0.16)
Rural Highlands Poor	(0.63, -0.4879)
Rural Highlands Non-poor	(0.62, -0.5626)
Other Rural Poor	(0.68, -0.68)
Other Rural Non-poor	(0.65, -0.65)

Diao et al. (2021)

Household Demand

(1) $D_{h,1} = D_{h,0} * (P_1/P_0)^{\beta 1,h} * (Y_{h,1}/Y_{h,0})^{\beta 2,h}$

D = Demand; P = Price, Y=Income

- Each household group faces the same market price of sweet potatoes (P)
- Household incomes (Y_h) are exogenous

(2) $D = \sum_h D_h$

- Total demand = the sum of demands by each household type

- Higher prices of sweet potatoes associated with the productivity shocks (Sims 1 and 2) result in steep declines in household consumption of sweet potatoes.

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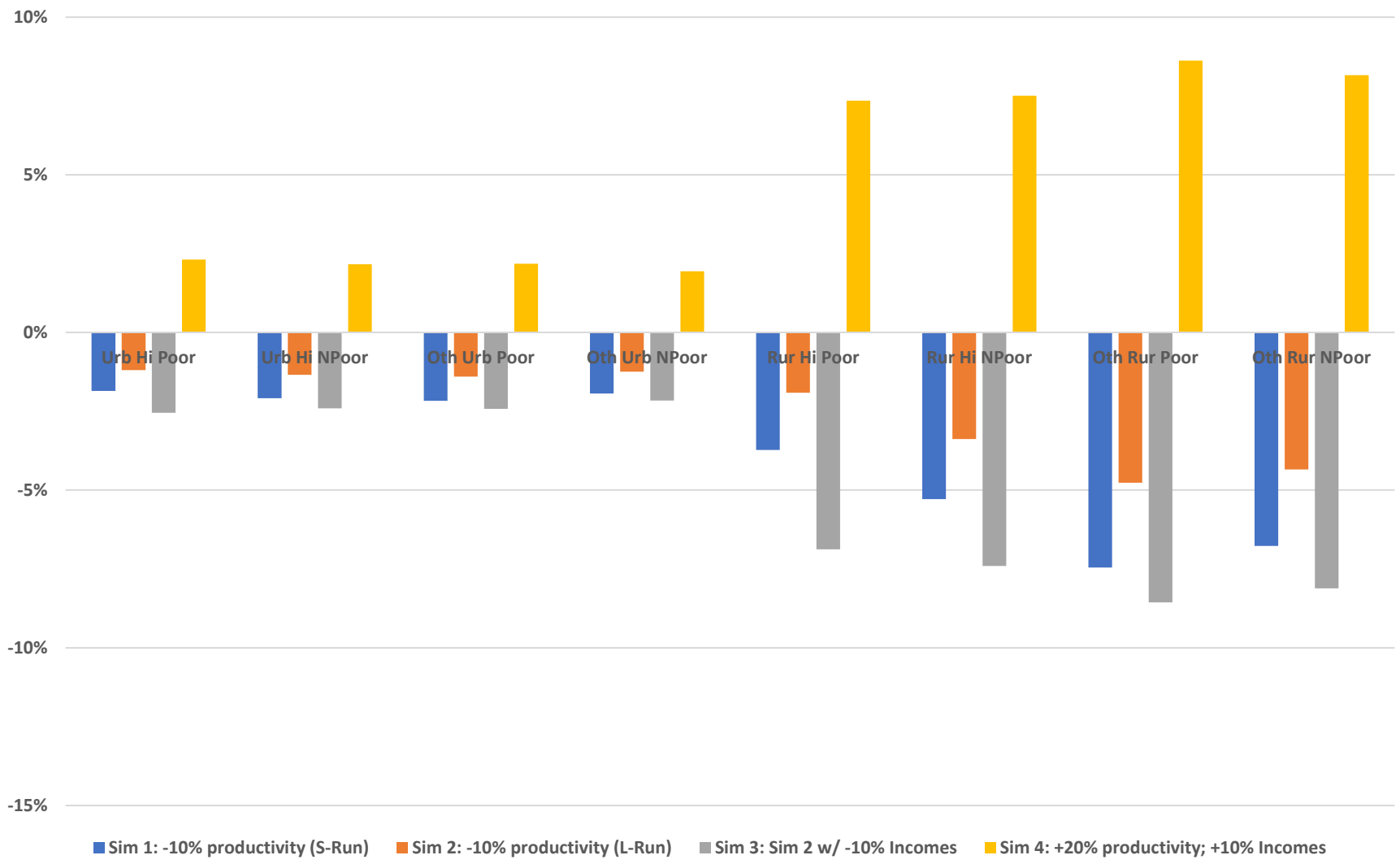
PNG Sweet Potato Simulation Results: Household Consumption



- Sim 1: A 10% reduction in productivity lowers consumption of sweet potatoes of urban highland poor households by 1.9%.
- Sim 4: 20% **increase** in productivity with a 10% increase in household incomes raises sweet potato consumption by 7.4% and 7.5% for rural highland poor and nonpoor households, respectively.

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Exercise 1: Sweet Potato Model Simulations

- Scenario 1: Household incomes increase by 20 percent. Consider two cases:
  a) own-price elasticity of supply (es) of sweet potato is 0.4.
  b) es = 0.9.

- Scenario 2: Losses in sweet potato are twice the expected loss.

- Scenario 3: Sweet potato productivity increases by 20 percent and household incomes rise by 10 percent.

For each scenario, explain why the percentage change in sweet potato consumption varies by income/household group.

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Caveats (Limitations of the Model Analysis)

- The model results depend on:
  - Base data on production, household consumption, trade and prices
  - Model parameters (elasticities of supply and demand)

- There is considerable uncertainty in the household consumption data and the assumptions used in creating the base data set for 2021.
  - The elasticities used are only rough approximations (based on cross-section state-level data!)

- High marketing costs, unofficial restrictions on trade, periodic conflicts, etc. inhibit market flows ==> there is no one national price and marketing margins across locations are not constant in percentage terms.
  - Periodic changes in government policy, production shocks and world price shocks may have greater effects on market outcomes than the shocks and policies modeled.

- **Sensitivity analysis is needed!**

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References

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Dorosh, Paul A. 2001. “Trade Liberalization and National Food Security: Rice Trade between Bangladesh and India”, *World Development*, 29(4): 673-689.

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