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 1: Monday, November 6:

Morning: Introductions; Partial Equilibrium Model 1a (1 comm; 1 hh);

Afternoon: Partial Equilibrium Model 1b (1 comm, 4 hhs); Poultry sims

Day 2: Tuesday, November 7:

Morning: PE Model 1c (2 comm; 4 hhs);

Sweet potato sims (closed v. open economy)

Afternoon: PE Model 1d (multiple commodities);

Coffee w/ non-traded crops sims

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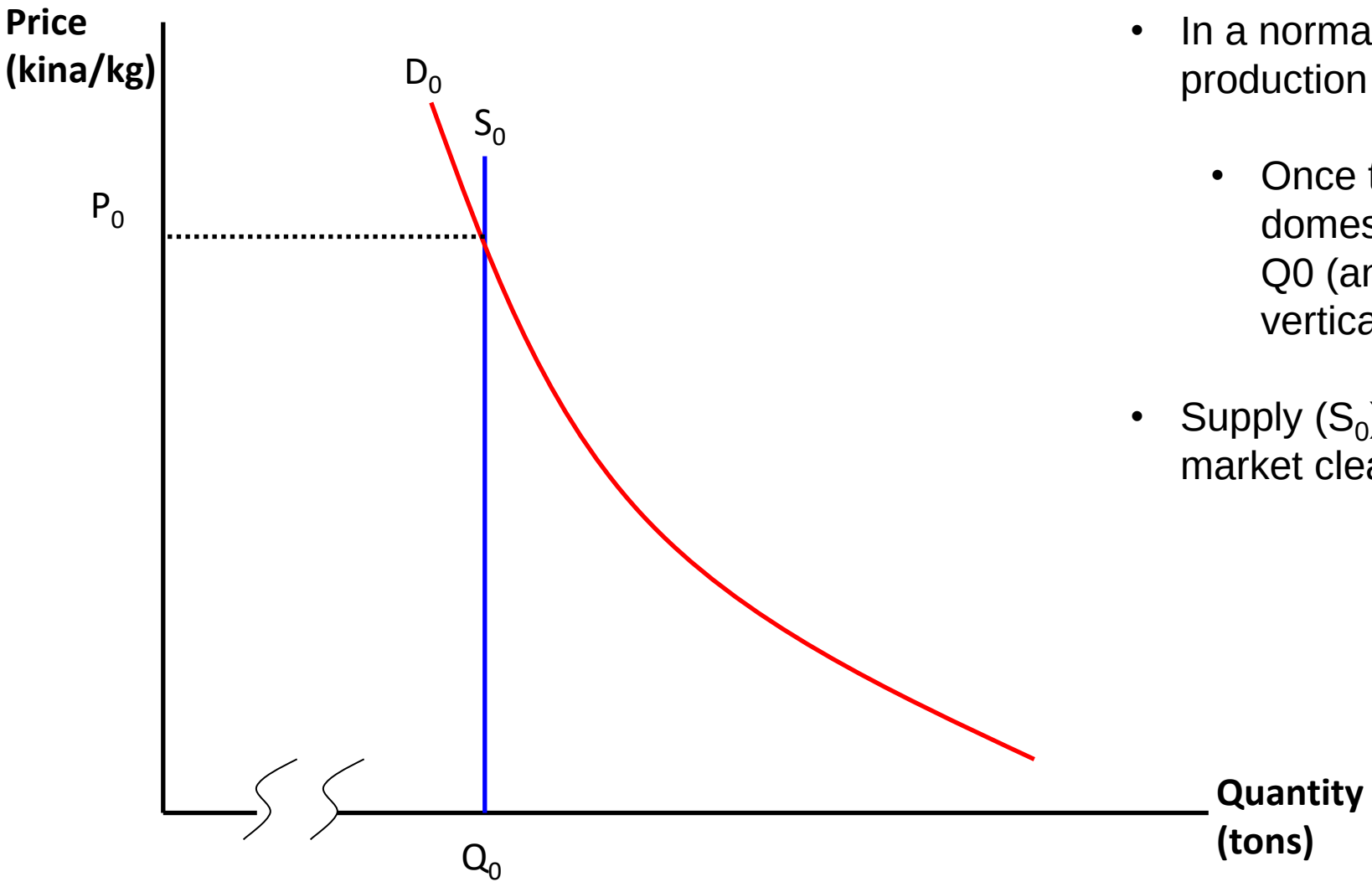
Short-run Impact of a Supply Shock (with Fixed Production)



- 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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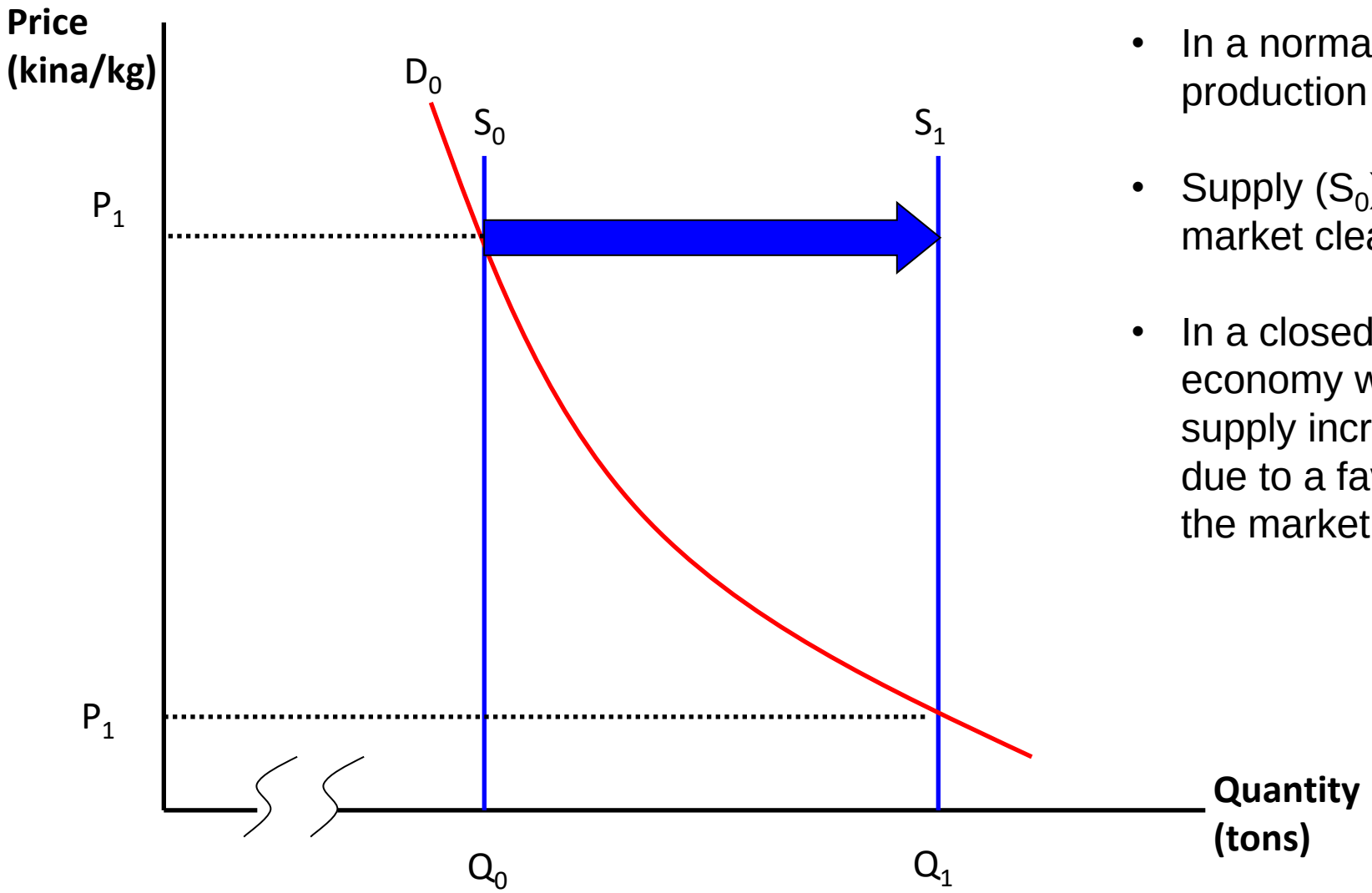
Short-run Impact of a Supply Shock



- 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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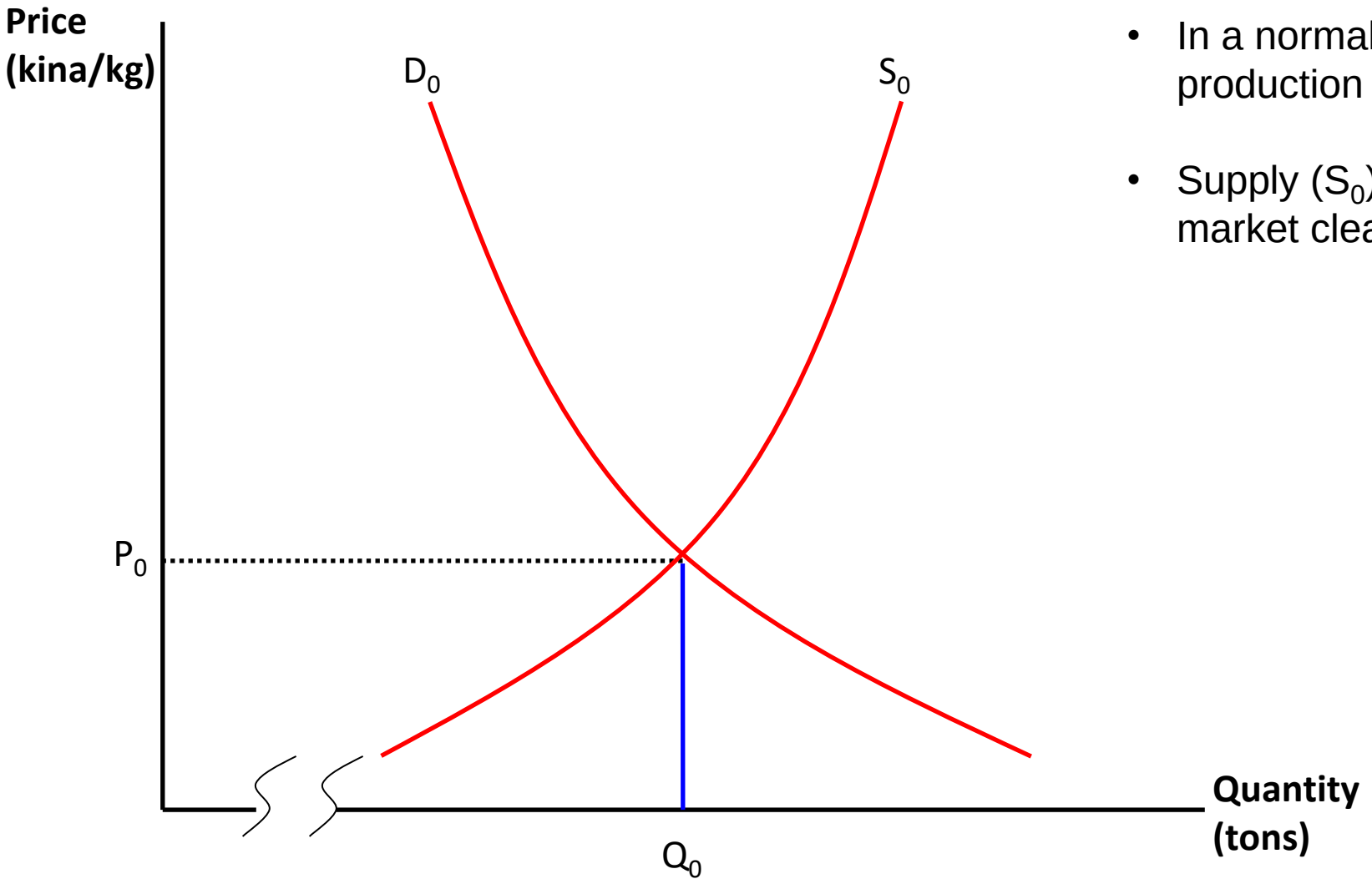
Impact of a Supply Shock (with Endogenous Production)



- 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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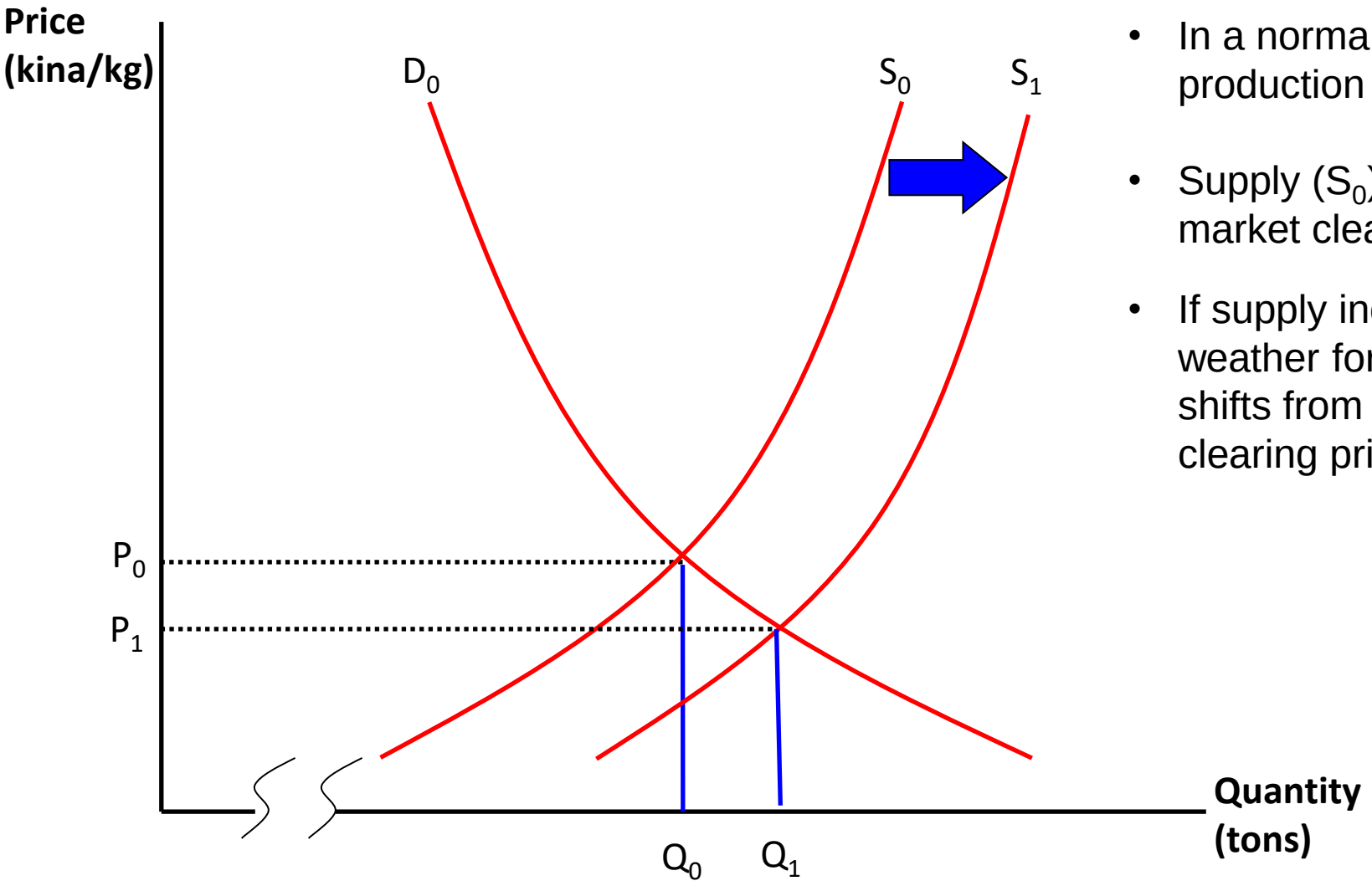
Short-run Impact of a Supply Shock



- 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 Poultry Market Simulations (Model 1)

Endogenous Price w/ Fixed Imports

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

γ1 = own-price elasticity of supply
$\underline{M}$ = exogenous imports

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

β1 = own-price elasticity of demand
β2 = income elasticity of supply

(2) $S_1 = D_1$

Equilibrium Condition

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

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PNG Poultry Simulations (Model 1)

Price change		154.4%	85.4%	30.0%	72.3%
Residual		0.00	0.00	0.00	0.00
	2020	**2020**	**2020**	**2020**	**2020**
	Base	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**
		(0 Imps S-Run)	**(0 Imps L-Run)**	**(Imp Tariff)**	**(+20% Prod)**
		es=.6;ed=-.79	**es=0.9;ed=-1.2**	**es=0.9;ed=-1.2**	**es=0.9;ed=-1.2**
Production ('000 tons)	7.00	12.26	12.20	8.86	13.70
Losses (10 percent)	0.00	0.00	0.00	0.00	0.00
Net Production	7.00	12.26	12.20	8.86	13.70
Private imports	23.00	0.00	0.00	11.95	0.00
Subtotal	30.00	12.26	12.20	20.82	13.70
Private stock change	-4.00	-4.00	-4.00	-4.00	-4.00
Supply	34.00	16.26	16.20	24.82	17.70
Demand	34.00	16.26	16.20	24.82	17.70
Per Capita Demand (kg/person/month)	3.35	1.60	1.60	2.45	1.75
Per Capita Supply (% change)	0.0%	-52.2%	-52.3%	-27.0%	-47.9%
Per Capita Income (2021/22 = 100)	1.00	1.00	1.00	1.00	1.00
Productivity	1.00	1.00	1.00	1.00	1.20
Elasticity of Supply		0.60	0.90	0.90	0.90
Income Elasticity of Demand		0.70	1.10	1.10	1.10
Own Price Elasticity of Demand		-0.79	-1.20	-1.20	-1.20

* Assumes no change in stocks.

Endogenous Price w/ Fixed Imports

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

(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,
M = Imports; 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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Simulation 1: Short Term (inelastic parameters)

- With es = 0.6 and ed = -0.79, setting imports to zero (instead of 23K in the base) leads to a large 154.4% increase in price to balance domestic supply and demand.
- Production increases sharply from 7K to 12.26K tons. Demand falls from 34K to 16.26K tons.

Simulation 2: Medium Term (more elastic parameters)

- With es = 0.9 and ed = -1.20, a smaller price increase is required to balance domestic supply and demand with zero imports.
- The poultry price increases by only 85.4% in Simulation 2, compared to 154.4% in Simulation 1.

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PNG Poultry Simulation Results: Import Bans and Tariffs

- Sim 1: 500K (23%) reduction in imports reduces supply, leads to 28% increase in the market price and lowers consumption by 18%.
- Sim 3: 20% increase in productivity with no change in imports leads to a 8% reduction in the market price and a 4% increase in consumption.

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PNG Poultry Simulations (Model 1)

Price change		154.4%	85.4%	30.0%	72.3%
Residual		0.00	0.00	0.00	0.00
	2020	**2020**	**2020**	**2020**	**2020**
	Base	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**
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Per Capita Income (2021/22 = 100)	1.00	1.00	1.00	1.00	1.00
Productivity	1.00	1.00	1.00	1.00	1.20
Elasticity of Supply		0.60	0.90	0.90	0.90
Income Elasticity of Demand		0.70	1.10	1.10	1.10
Own Price Elasticity of Demand		-0.79	-1.20	-1.20	-1.20

* Assumes no change in stocks.

Simulation 3: 30% World Price Increase with Endogenous Imports

- With a 30% increase in the domestic and world price and more elastic parameters, production is 8.86K tons, 26.6% higher than in the base.
- Demand (consumption) falls to 24.82K tons (27.0% below the base).
- Imports are 11.95K tons, compared to 23.0 mn tons in the base.

Simulation 4: +20% Productivity Increase (Zero Imports)

- With a 20% increase in productivity, production increases to 13.7 mn tons (compared to 12.2 mn tons in Sim 2).

- The poultry price increases by only 72.3% in Sim 4, compared to 85.4% in Sim 2.

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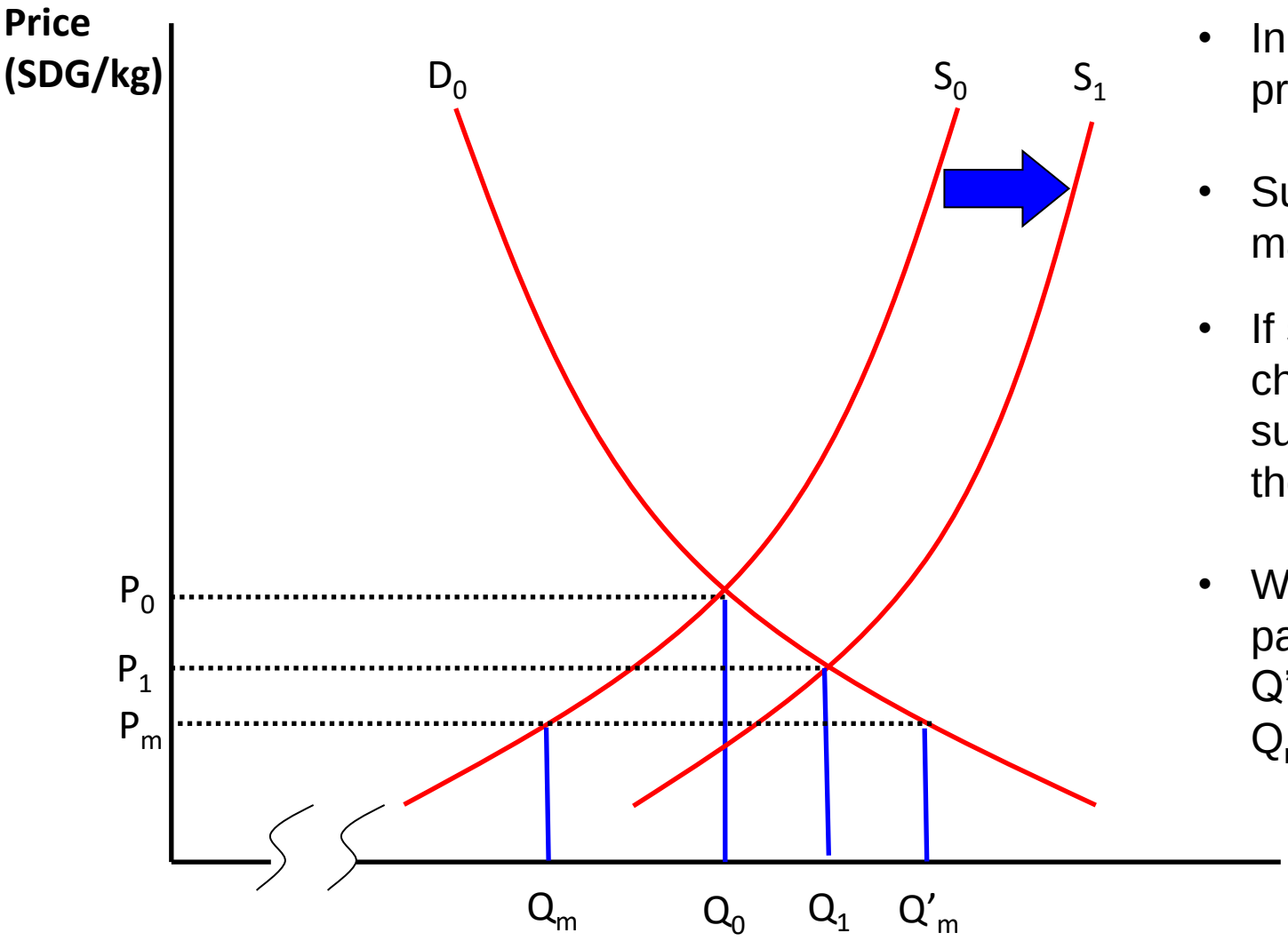
Short-run Impact of a Supply Shock with Private Imports



- 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 technical change in poultry production, the supply curve shifts from S_0 to S_1 and the market clearing price falls to (P_1)
- With private imports and an import parity price of P_m, demand is equal to Q'_m and domestic supply is equal to Q_m with imports = ($Q'_m - Q_m$).

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Exercise 1: Base Model

- Scenario 1: Total poultry imports are restricted to only ten thousand tons per year. Consider two cases:
  a) the own-price elasticity of supply of poultry es = 0.0 (farmers do not have access to sufficient additional inputs to enable a significant supply response)
  b) es = 0.9.

- Scenario 2: Poultry productivity increases by 50 percent and household incomes rise by 10 percent.

- Scenario 3: The import price of poultry in the world market rises by 40 percent.

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PNG Poultry Model 2: Multiple Household Groups

			Sim 3	
	Sim 1	Sim 2	30% Import	Sim 4
	Import Ban	Import Ban	Tariff	-20% Prod.
	Short-run	Medium-run	Medium-run	Medium-run
Urban poor	-64.2%	-57.9%	-30.7%	-53.3%
Urban nonpoor	-42.9%	-42.6%	-21.0%	-38.7%
Rural poor	-67.4%	-60.4%	-32.5%	-55.8%
Rural nonpoor	-52.6%	-57.2%	-30.3%	-52.7%
Total	**-51.4%**	**-51.8%**	**-26.9%**	**-47.4%**
Price change	**154.4%**	**85.4%**	**30.0%**	**72.3%**

Demand Parameters (expenditure elasticity, own-price elasticity)

	Short-run	Medium-run
Urban poor	(0.80, -1.10)	(1.20, -1.40)
Urban nonpoor	(0.60, -0.60)	(0.90, -0.90)
Rural poor	(0.90, -1.10)	(1.30, -1.50)
Rural non-poor	(0.73, -0.80)	(1.23, -1.38)

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 poultry meat (P)
- Household incomes (Y_h) are exogenous

(2) $D = \sum_h D_h$

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

- The sharp increases in the price of rice under the import ban results (Sims 1 and 2) results in steep declines in household rice consumption
- Note that no income shocks are modeled in these simulations.

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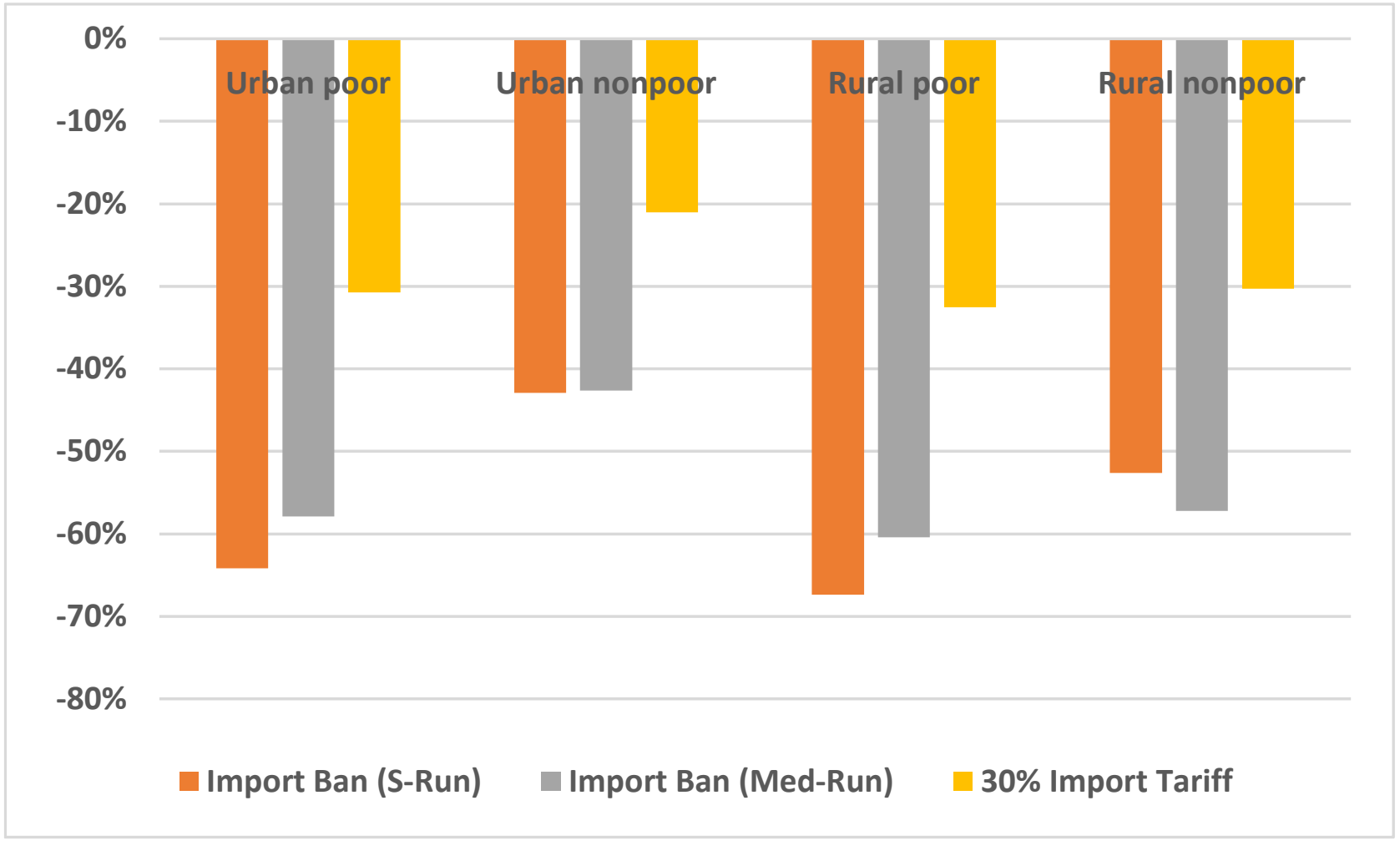
PNG Poultry Simulation Results: Import Bans and Tariffs Household Consumption



- Sim 1: An import ban lowers consumption of urban households by 43 to 58% in the medium run.
- A 30 percent import tariff has a smaller effect on consumption:
  - -21 to -31% for urban households
  - -30 to -33 percent for rural households

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Exercise 2: Multiple Household Groups

- Scenario 1: Total poultry imports are restricted to only 18k tons per year. Consider two cases:
  a) Urban incomes are unchanged.
  b) Urban incomes decline by 20 percent.

- Scenario 2: Poultry productivity increases by 20 percent and imports are reduced by 20 percent.

- Scenario 3: Private imports are liberalized, the import price of poultry in the world market rises by 40 percent and household incomes fall by 10 percent.

For each scenario, explain why the percentage change in poultry consumption varies by 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

Coady, David, Paul Dorosh and Bart Minten. 2009. “Evaluating Alternative Policy Responses to Higher World Food Prices: The Case of Increasing Rice Prices in Madagascar”, *American Journal of Agricultural Economics* 91(3) (August 2009): 711-722.

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