Partial Equilibrium Analysis of Agricultural Price Policies

11

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Abstract

This chapter is designed to help policy analysts learn how a simple market model introduced in lessons on principles of economics can be used to analyse the effects of price policies. The chapter intends to describe the nature of price policies implemented by developing countries with special reference to the agricultural and food price policies implemented by the government of Sri Lanka. It demonstrates the theoretical effects of a floor price scheme, a price ceiling, and an input price subsidy when implemented in a perfectly competitive market and describes the steps to be undertaken in performing a simulation exercise to analyse a price policy using an econometrically estimated model and a synthetically calibrated model.

Keywords

Partial equilibrium · Price ceiling · Price floor · Estimation · Simulation

11.1 The Context

11.1.1 Intentions of the Policy and Global Context

The focus in this chapter is on domestic price policies affecting output and input markets. This section provides information on different agricultural pricing policies implemented by some notable developing countries.

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J. Weerahewa, A. Jacque (eds.), *Agricultural Policy Analysis*,
https://doi.org/10.1007/978-981-16-3284-6_11

11.1.1.1 Output Price Policies

Output price policies have been common policy instruments in many developing countries. A few examples can be cited from Bangladesh, Korea and Pakistan. Bangladesh operated a variable paddy rice tariff and an output price support. The level of the tariff varies on an ad hoc basis depending on the harvest. For example, when domestic production suffered substantial shortfalls as a result of the 'flood of the century' in 1998, import tariffs were eliminated and large private sector imports were allowed to flow into the country from India, thus stabilising domestic prices (Timmer and Dawe 2007). Output price support in Bangladesh has stimulated increasing investments in storage capacity to facilitate the increase of domestic grain production (Food and Agriculture Organisation 2016). Korea achieved self-sufficiency in rice paddy partially through output price controls. During the harvest period, the government purchased rice to support farm prices and released stocks to reduce consumer prices. Most of the time, the release price was less than the purchase price, plus storage and processing costs. The financial losses were borne by the government. Korea achieved self-sufficiency, well in advance of Bangladesh, where rates of population increase are much higher and lands limited (Krueger et al. 1991). In Pakistan, seasonal price stabilisation schemes, including government procurement and price ceilings, are common in wheat, which is the staple food (Krueger et al. 1991).

11.1.1.2 Input Subsidies

Input subsidies are incentives intended to increase productivity and production of farm outputs. Input subsidies include governmental support that reduces the cost of fertiliser, planting materials, and other farm inputs and technologies. Korea sought to circumvent the limitations on land for agriculture by increasing land productivity through measures such as increased application of fertilisers. Price subsidies and credits for fertilisers were provided. The government purchased fertilisers from producers and distributed them at a lower price to farmers while exporting the excess (Krueger et al. 1991). This led to a doubling of fertiliser usage between 1965 and 1986, and domestic fertiliser manufacturing plants were established. Thailand and the Philippines invested in irrigation, which facilitated two cultivations per year, and introduced an insurance scheme for rice farmers to address risks from natural disasters (Food and Agriculture Organisation 2018). Also, since 2016, Thailand has replaced its price stabilisation scheme with cash subsidies for rice farmers (Laiprakobsup 2019). Indonesia provided farmers with fertiliser at 50–75 per cent subsidised rates, along with an insurance scheme for rice farmers to cover natural calamities (Food and Agriculture Organisation 2017a). However, the effectiveness of these subsidies is highly context specific. For example, a study conducted on the fertiliser subsidy scheme in Bangladesh found that it was not as effective as expected because the supply of fertiliser was inelastic and the benefits accrued mainly to large-scale farmers. Small-scale farmers experienced a disadvantage as they purchased from large-scale farmers at unsubsidised rates. Further, limitations in irrigation facilities hampered the effectiveness of the introduced fertiliser subsidy scheme (Krueger et al. 1991). Malaysia implemented several assistance schemes, including a 100 per cent fertiliser subsidy and irrigation facilities for paddy farmers. Government distribution of fertilisers went through the main farmer organisations. Although the programme targeted mainly small-scale farmers, large-scale farmers also benefitted through multiple ownership, which is common in Malaysia (Krueger et al. 1991). Despite these incentives, production levels declined. As a remedy, the government introduced a land consolidation scheme called *estatization*, consolidating small lands into economically manageable land parcels, which successfully increased production through planting intensity and productivity improvements (Najim et al. 2007).

11.1.1.3 Food Subsidy

The majority of the world's poorest people depend on agriculture as their main source of income. The poor spend a relatively large portion of their income on food. Thus, food prices are major determinants of poverty level and income distribution (Anderson et al. 2010). Policies that raise the output price of food products hurt consumers, particularly those not engaged in farming. Food subsidies are one means of compensating consumers for real income decline, by effectively reducing expenditure on food consumption or increasing the level of food consumption by increasing affordability.

Since food subsidy schemes for the general population can be costly, implementation often includes aspects of targeting and rationing. For example, India provides food subsides through a minimum support price (MSP) scheme for which there was a threefold increase in cost between 2006 and 2012 (Sharma 2012). Indonesia implemented a subsidy scheme, a 'prosperity card', permitting the poor to purchase rice and sugar at concessionary rates. In addition, Indonesia provided cash transfers for children going to school and pregnant women attending regular clinics, targeting ten million households (Food and Agriculture Organisation 2017b).

11.1.2 Policy Milestones of Sri Lanka

11.1.2.1 Guaranteed Prices and Government Procurement

Since its independence in 1948, the government of Sri Lanka has been heavily involved in procuring paddy under a guaranteed price scheme. Between 1948 and 1971, paddy procurement was done through the Department of Agrarian Services. The Paddy Marketing Board (PMB) was established under the Paddy Marketing Board Act (No. 14 of 1971) primarily to (a) carry on the business of purchasing, selling, supplying, and distributing paddy and rice and (b) carry on the business and process of milling of paddy (Government of Sri Lanka 1971).

During the period 1972–1978, co-operatives collected paddy from farmers on behalf of the PMB, which hired private millers to process the paddy. The millers handed over the rice to the Food Commissioner's Department, which in turn issued it to the co-operatives for distribution to the consumers on ration. Also, the PMB was involved in maintaining a buffer-stock scheme for rice, using its regional warehouses.

With the opening up of the economy in 1977, the PMB Act was amended to permit the private sector to market rice. With this policy change, the share of PMB in purchasing paddy declined, and by 1990, the PMB became inactive.

In 2006, the Sri Lanka Agricultural Products Marketing Authority was established under the Companies Registration Act to purchase paddy through Co-operative Wholesale Establishments, the Co-operative Network, and farmer organisations. The PMB was re-established in 2007 and recommenced paddy purchasing in the 2008 *Yala* season. In 2018, the guaranteed price for Samba and Nadu rice were LKR 41 and LKR 38 per kg, respectively.

Proposals to introduce guaranteed prices for other food crops, specifically for potato, maize, raw milk, etc. have been made on a number of occasions. Such programmes, however, have not proved as long lasting as programmes for rice paddy.

11.1.2.2 Fertiliser Subsidy Programme

The government established a price subsidy for fertilisers in 1962, at the onset of the green revolution: the goal was to make fertiliser available to rice farmers at a low cost in order to maximise the benefits from high-yielding varieties introduced with the green revolution. It was expected that low fertiliser prices would increase the rate of adoption of high-yielding varieties, enhance land productivity, and reduce the cost of production, resulting in more profitable paddy farming. The increased paddy production was then expected to lower the prices of paddy and rice, thereby making rice affordable to the urban poor. Box 11.1 provides a timeline of important events in the fertiliser subsidy programmes in Sri Lanka.

Box 11.1 Timeline of fertiliser policy interventions

1962:	A fertiliser subsidy programme for paddy was introduced with a fixed subsidy rate.
1971:	Importation of fertiliser became a monopoly of the Ceylon Fertiliser corporation; importation of fertiliser by the private sector was banned.
1975:	The fertiliser subsidy programme was expanded to cover all crops.
1977:	Private sector companies were allowed to import fertiliser.
1978:	A uniform subsidy rate was introduced; the responsibility for administering the subsidy programme was given to the National Fertiliser Secretariat.
1979:	Subsidy rates were revised to 85 per cent for urea and 75 per cent for other fertilisers.
1988:	Subsidy rates were reduced, and the subsidy for sulphate of ammonia and rock phosphate was eliminated.
1990:	The subsidy was completely removed.
1994:	The subsidy for urea, sulphate of ammonia, muriate of potash, and triple super phosphate was reintroduced with a fixed fertiliser price.
1996:	The subsidy for sulphate of ammonia was eliminated.

(continued)

Box 11.1 (continued)

1997:	The subsidy was limited to urea.
2005:	The subsidy was limited to the main fertilisers for paddy (nitrogen, phosphate, and phosphorus) in their straight form but not as mixtures.
2006:	Tea, rubber, and coconut smallholder farmers (with less than five acres of land) became eligible for the fertiliser subsidy.
2009:	The fertiliser subsidy policy was coupled with a paddy procurement policy that required famers to supply a fixed portion of paddy to the government at a pre-specified price below the market price.
2016:	A programme, *A Wholesome Agriculture – A Healthy Populace – A Toxin-Free Nation* (2016 to 2019), was introduced under which it was suggested that the use of chemical fertilisers be phased out and organic agriculture be promoted. Tea smallholders continued to receive the subsidy of LKR15,000 per ha for fertilisers, which was implemented by the Tea Smallholder Development Authority.
2020:	Fertilisers were provided free of charge
2021:	Importation of chemical fertilisers was banned

Sources: Ekanayake (2009), Wickramasinghe et al. (2009), National Fertiliser Secretariat (2010–2020), Ministry of Finance (2010–2021)

11.1.2.3 Food Subsidy Programme

Interventions in Sri Lanka to increase the availability and accessibility of food date back to 1942, when a universal food subsidy scheme was implemented. Along with the introduction of more open trade and economic policies, a targeted food stamp programme was introduced in 1977 (refer to Table 11.1). While such programmes enhanced the availability and accessibility of energy and protein overall, successive governments improved food utilisation by targeting the specific nutritional needs of vulnerable segments of the populations, such as pregnant and lactating mothers and preschool children, through direct food provision, including school meal programmes, the Thriposha programme, and the nutrition bag programme.

The political objectives of the governing parties largely shaped the design of food policies in the early years after independence. Compared to policies in the present era, the policies implemented in the past had some profound effects on food price levels (Weerahewa et al. 2018).

11.2 Theoretical Model to Assess the Effects of Price Policies

The theoretical models presented in this section focus on closed markets (i.e. absence of international trade).

Table 11.1 Evolution of food assistance programmes 1942–2019

Period	Name of the programme	Objective of the programme	Approximate number of beneficiaries
1942–1979	Food subsidy programme	To protect consumers from rising prices and ensure equitable distribution of basic food items	Entire population of the country until 1970 From 1978, entire population except for income tax payers
1977–2002	Food stamp programme	To minimise hardships faced by communities in the country	In 1977, 50 per cent of the population In 1996, 10 per cent of the population
1989–1994	*Janasaviya* programme	To alleviate poverty in the country	1994: 265,000 families
1995–2019	*Samurdhi* programme	To improve the socioeconomic conditions of youth, women, and disadvantaged groups	1995: 2.2 million families 2006: 1.9 million families 2012: 1.5 million families 2015: 1.4 million families

Source: Adopted from Weerahewa et al. (2017)

11.2.1 Baseline Equilibrium: Competitive Market

The effects of price policies can easily be demonstrated using a market model developed using a partial equilibrium framework. The basic partial equilibrium model is comprised of a demand curve, a supply curve and a market closure condition.

Consider the demand curve, the supply curve, and the equilibrium condition given below:

$$D = D(P, M)$$

$$S = S(P, W)$$

$$D = S$$

where:

D = quantity demanded
S = quantity supplied
P = price
M = vector of demand shifters
W = vector of supply shifters

The above model can be extended to assess the well-being of consumers and producers, as well as the expenditures to be incurred by the government with the implementation of a price policy.

Figure 11.1 depicts the equilibrium in a closed market. The supply curve slopes upwards, the demand curve slopes downwards, and the intersection of the supply and demand curves determines the equilibrium price ($P*$) and the equilibrium

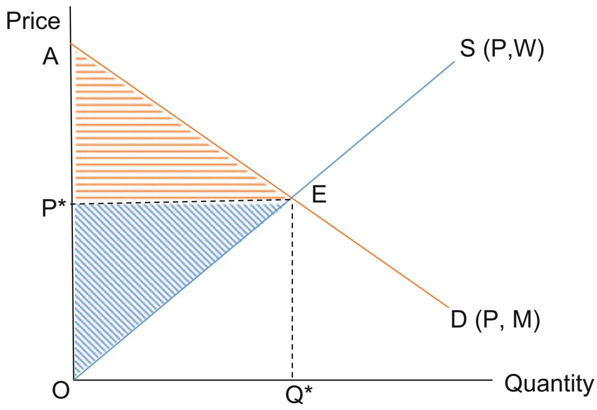

Fig. 11.1 Baseline equilibrium

quantity (Q^*) in this market. The area below the demand curve and above the price level, i.e. triangle AEP*, represents the consumer surplus (CS); the area above the supply curve and below the price level, i.e. triangle OEP*, represents the producer surplus (PS).

11.2.2 Application of the PE Model: Counterfactual Equilibrium with a Producer Price Subsidy

The equilibrium in this market after the imposition of a price floor, i.e. the minimum price that can prevail in this market, is depicted in Fig. 11.2. The quantity demanded under the controlled price (P_F) is given by (D_F), and in the absence of a government procurement scheme, the quantity demanded becomes the limiting factor and hence the equilibrium quantity supplied. This creates a deadweight efficiency loss in the market (BCE). PS increases from OEP* to OCBP$_F$. CS decreases from AEP* to ABP$_F$. Producers gain at the expense of the consumers, and society as a whole will lose as the gain in PS is not adequate to cover the loss in CS.

If the government has a parastatal to purchase the harvest at this given minimum price (P_F), then there will be a divergence in the quantity demanded (D_F) and the quantity supplied (S_F). Figure 11.3 shows the impacts of such a policy. In this situation, the PS would be much larger (shown by area OFP$_F$). CS will remain at ABP$_F$. However, the government will have to incur expenditure on procurement equivalent in value to the area P$_F$FS$_F$O (if the entire stock is purchased). Local consumers will purchase a value equivalent to the area P$_F$BD$_F$O if the retail price is the same as the guaranteed price; hence, the government has to bear the remaining cost, which is equivalent to D$_F$BFS$_F$.

In practice, parastatals tend to dispose of the stock at a lower price in another industry in the same country or to a foreign country to recover at least a part of the loss. The parastatal has the choice of selling the produce at a lower price in the same

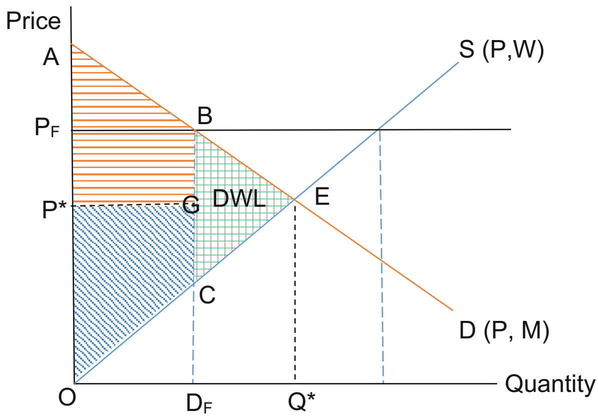

Fig. 11.2 Counterfactual equilibrium: a producer price subsidy with no government procurement

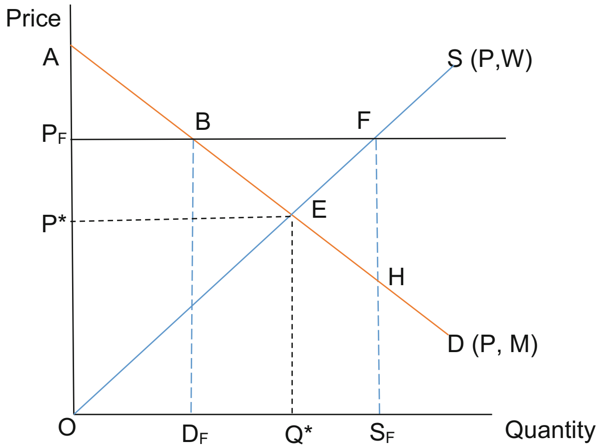

Fig. 11.3 Counterfactual equilibrium: a producer price subsidy with government procurement programme

market too. The local consumers would purchase the entire stock at the intersection of the local demand curve and S_F, which occurs at H. When this happens, consumers gain, the government incurs losses, and society will have to incur a deadweight loss of EFH.

11.2.3 Counterfactual Equilibrium: An Input Price Subsidy

The equilibrium in the market depicted in Fig. 11.1 after imposition of an input price subsidy is depicted in Fig. 11.4. This causes a shift in supply, which leads to an increase in equilibrium quantity demanded and supplied (Q_S) and a lowering of equilibrium price from P^* to P_S. This increases CS by P^*EIP$_s$, but the effects on PS are uncertain. The PS will change from OEP* to OIP$_s$. This change can either be beneficial or harmful to the producers. The size and direction of change in PS depend on the slope of the demand curve and the size and nature of the shift in the supply curve.

It is important to note that in the case of an input subsidy, the cost of the subsidy is not marked in Fig. 11.4, and it has to be shown in the respective input market. Figure 11.5 shows the equilibrium changes in the input market due to the imposition of the subsidy, assuming that there is no local supply and the entire requirement of the input is imported. The world market price is shown by *W**, and the quantity imported is *X** in absence of an input subsidy. When a subsidy is provided, the price of the input is lowered to *W*′, and *X*’ will be imported into the country. The cost of the subsidy to the government will be *W**KLW’, and there will be a deadweight efficiency loss equivalent to JKL.

The gain in CS in the input market, equivalent to *W**JLW’, should be interpreted with caution. The consumers in the input market are the producers in the market

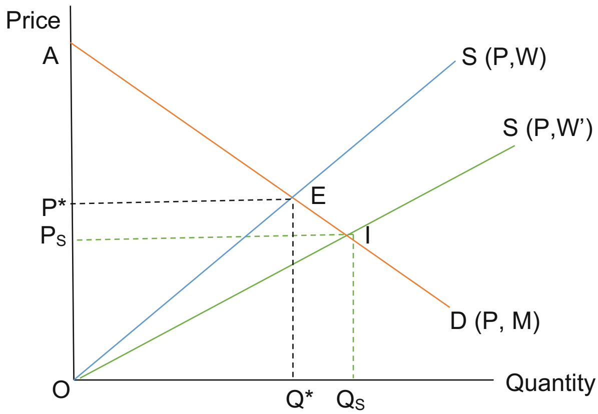

Fig. 11.4 Counterfactual equilibrium: input subsidy

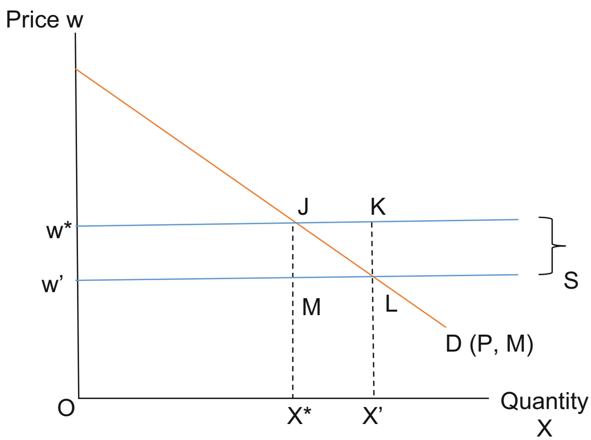

Fig. 11.5 Baseline and counterfactual equilibrium of an input market with and without price subsidy on input

shown in Fig. 11.4. The benefits will be double-counted if the change in CS in the input market and change in PS in the vertically related market are summed.

11.2.4 Counterfactual Equilibrium: A Food Price Subsidy

The equilibrium in the market depicted in Fig. 11.1 after the imposition of a price ceiling, i.e. the maximum price that can prevail in this market, is depicted in Fig. 11.6. The quantity supplied under the price ceiling (P_C) is given by (S_C), and in the absence of a government distribution scheme, this quantity becomes the equilibrium demand. This creates a deadweight efficiency loss (REN) in the market, along with a loss in PS (P^*ENP_C), and a gain in CS (from AEP* to ARNP$_C$).

The imposition of price ceilings, in economies with large informal sectors, can generate black markets. Generally, the product is sold in limited quantities through the government distribution channel, along with a price ceiling. If the beneficiaries are not properly targeted and/or the product is sold at the concessionary price on a first-come-first-served basis, intermediaries purchase the product from the government agency for sale in the informal market at the highest willingness to pay, as determined by the demand curve. In an extreme case, the entire CS marked by the area ARNP$_C$ will be reaped by the intermediaries.

If the government opens up trade, and the world market price happens to be P_C, then the economy will enjoy trade gains. Consumers would demand D_C, the excess demand would be imported (D_C–S_C), consumers would enjoy a surplus of AUP$_C$, and gains from trade will be EUN.

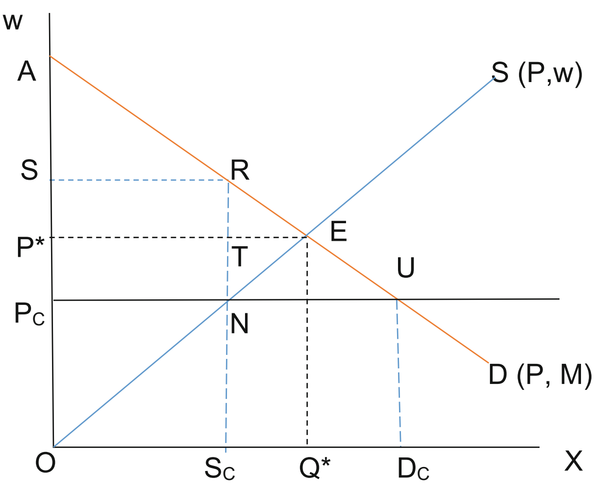

Fig. 11.6 Counterfactual equilibrium: a consumer subsidy with no government intervention

11.3 An Application Using an Econometrically Estimated Structural Model

11.3.1 A Price Ceiling for a Non-tradable Food Commodity

Suppose that you are interested in estimating the effects of a price ceiling imposed on chicken meat. The first step would be to understand the regulations imposed. Given below is an example of a gazette notification imposing the maximum ceiling price for chicken Sri Lanka.

Maximum retail prices of chicken

Details	Price (Rs.)
Frozen refrigerated broiler chicken meat with skin 1 kg	380.00

Let's pose a policy question related to this regulation: *what will be the effects of a price ceiling on chicken on the chicken market of Sri Lanka?*

A slight rewording of the above policy question enables us to make the above researchable and formulate a policy research question. Here is a potential policy research question: *what equilibrium would have prevailed in the chicken market if the retail price had not been regulated by the Consumer Affairs Authority of Sri Lanka?*

11.3.2 Empirical Model

In order to assess a policy research question of this sort, we need to rely on a theoretical framework. The partial equilibrium model explained in Sect. 11.2.4 provides an appropriate framework for this analysis.

The model consists of three equations and three endogenous variables, namely demand, supply, and price. We could extend this model to accommodate the specific characteristics of the chicken market.

If we plan to study the price ceiling on chicken meat, first we need to identify the exact product and limit our analysis to the product that matches the description stated in the regulation: 'Frozen, Refrigerated Broiler Chicken with Skin' bought and sold at the retail level as per the above regulation. Value-added products of chicken (sausages, meatballs, etc.) are excluded.

This also requires a specification of the demand for chicken at the retail level. We could specify a function that treats per capita consumption of chicken as the dependent variable and chicken price, prices of chicken substitutes, per capita income, and a proxy for tastes and preferences as independent variables. To complete the demand side of the model, another equation needs to be added to the model to connect the per capita consumption of chicken with the total demand for chicken. An identity can be used for this purpose.

It would be better to capture chicken supply at the farm level rather than at the retail level. Farm-level supply of chicken can be specified as a function of the farm-gate price of chicken. An equation is required to connect the farm-gate price of chicken with the retail price of chicken.

An equilibrium condition needs to accommodate the structure of the market. The whole chicken market can generally be considered as a closed market, yet the demand in a given year is not exactly equal to the supply in that year – stocks, wastage, and some unexplained issues need to be taken into account. A residual in each year can be identified and added to the equilibrium condition to capture such differences.

Box 11.2 specifies an empirical model that can be used to estimate the effect of a ceiling price imposed on chickens. Please note that all price and income terms are expressed in real terms in this model.

Box 11.2 An empirical model to estimate the effects of a price ceiling on chicken in Sri Lanka—equilibrium without price ceiling

Demand side:

1. PCD = a + b RRP + c RPCM, where PCD = per capita *demand*, RRP = *real retail price*, and RPCM = *real* per capita *income.*
2. D = PCD * POP, where D = *total demand* and POP = *population.*

Supply side:

3. RMM = RRP – RFGP, where RMM = *real marketing margin* and RFGP = *real farm-gate price.*
4. S = d + e RFGP + f RW, where S = *supply* and RW = *real wage rate.*

Market-clearing conditions:

5. S = D + INV, where INV = *residual including inventories.*

Exogenous variables:
RPCM, POP, RW, RMM, INV
Endogenous variables:
RRP, D, PCD, RFGP, S
Parameters:
a, b, c, d, e, f

The values of five endogenous variables may be expressed in terms of exogenous variables and parameters by simultaneously solving the above equations. The values of the endogenous variables can be obtained in a sequential manner using the equations given below:

RRP = [d − e RMM + f RW − a POP − c POP * RPCM − INV]/(b POP − e)
RFGP = RRP − RMM

$S = d + e$ RFGP $+ f$ RW
PCD $= a + b$ RRP $+ c$ RPCM
$D =$ PCD * POP
Once the price ceiling is imposed, the closure of the above model changes. Box 11.3 specifies the model after the imposition of the price ceiling.

Box 11.3 An empirical model to estimate the effects of a price ceiling on chicken in Sri Lanka—equilibrium with price ceiling
Demand side:

1. $D =$ PCD * POP

   Supply side:

2. RMM = RRP − RFGP
3. $S = d + e$ RFGP $+ f$ RW

   Market-clearing conditions:

4. $S = D +$ INV

   Exogenous variables:
   POP, RW, RMM, INV, RRP
   Endogenous variables:
   D, PCD, RFGP, S
   Parameters:
   a, b, c, d, e, f

Note that RRP in the above model is exogenous and hence the values of four endogenous variables of this model can be directly obtained by sequentially solving the equations in the following order:

RFGP = RRP − RMM.
$S = d + e$ RFGP + f RW.
$D = S -$ INV.
PCD $= D$/POP.

The models depicted in Boxes 11.2 and 11.3 can be extended to include the equations for CS, PS, and deadweight efficiency loss.

11.3.3 Data, Data Sources, and Econometrics

In the model depicted in Box 11.2, Eqs. (11.1) and (11.4) are stochastic equations to be estimated econometrically. To estimate these two equations, a data set to capture variability in all the exogenous and endogenous variables is required. Variability in prices can only be captured, in a small country like Sri Lanka, in a time series. Therefore, in order to estimate demand and supply equations, a time series data set is required. The prices and income levels are to be deflated using appropriate price indices to obtain a time-varying data set.

The data set can be compiled using the statistics reported in various government publications. Per capita consumption data are available in the food balance sheets of the Department of Census and Statistics; price data are available from the Hector Kobbekaduwa Agrarian Research and Training Institute; per capita income and price indices are available in Central Bank annual reports.

The longer the time series is, the higher the variability and the lower the standard errors are. Suppose that the following data set has been gathered (Table 11.2).

The first step is to obtain a plot of data. Figure 11.7 provides some sample plots. These plots help in identifying missing values, typographical errors, and inconsistencies in data.

The second step is checking the stationarity properties of the data to avoid spurious regressions. A detailed discussion on this aspect is beyond the scope of this chapter; hence, the analysis is carried out without this test.

The two equations can be estimated using ordinary least squares (OLS) if the assumptions for OLS have not been violated.

Tables 11.3 and 11.4 show the results of econometric estimation using the above hypothetical data set and considering the relationships to be linear. Alternatively, a log-log, linear-log, or log-linear functional form can be employed. The nominal price and income variables were deflated using the price indices to obtain the real values of the same.

The above coefficient estimates can be used to obtain elasticities of demand and supply with respect to own prices and other factors affecting demand (income) and supply (wage rate). Table 11.5 shows the elasticities of demand and supply computed at the mean of the sample.

In order to complete the model, exogenous variables in identities (2) and (3) are to be used. Table 11.6 provides the values of MM and INV, which would be consistent with the data set given in Table 11.2. The value of MM is obtained by deducting FP from RP, and the value of INV is obtained by deducting S from D. Price index was used to obtain the real value of market margins.

11.3.4 Validation of the Model

The next step is to test the degree to which the above model captures the actual values. This can be achieved by predicting the values of endogenous variables using values of the exogenous variables and the parameters of the model. If the predictions

Table 11.2 A hypothetical data set

Year	Demand	Supply	Nominal retail price	Nominal farm gate price	Nominal wage	Nominal income	Price index	Population
2005	144.76	154.76	462.36	452.36	514.80	1500.00	100.00	1.50
2006	151.02	171.02	490.10	479.89	505.29	2042.00	102.10	1.52
2007	166.90	166.90	476.53	466.14	509.25	2181.27	103.87	1.54
2008	162.15	166.15	504.09	493.61	554.42	2252.77	104.78	1.55
2009	162.70	172.70	511.83	501.18	516.46	2397.60	106.56	1.57
2010	168.58	172.58	535.67	524.71	529.60	2530.84	109.56	1.59
2011	177.88	173.88	516.49	505.49	506.81	2673.00	110.00	1.61
2012	177.06	193.06	547.12	535.93	470.12	2799.50	111.98	1.63
2013	180.21	178.21	567.84	556.53	561.89	2918.50	113.12	1.65
2014	178.14	183.14	582.97	571.39	588.65	3010.28	115.78	1.66
2015	184.98	185.98	565.80	554.08	515.79	3058.92	117.20	1.68
2016	183.67	193.67	585.94	574.10	500.36	3114.71	118.43	1.69
2017	164.71	172.71	650.68	638.69	722.30	3201.86	119.92	1.70
2018	191.98	182.98	609.54	597.54	573.62	3600.00	120.00	1.72
2019	186.78	201.78	684.82	672.55	714.57	4296.60	122.76	1.73

Source: Hypothetical data—constructed by the author

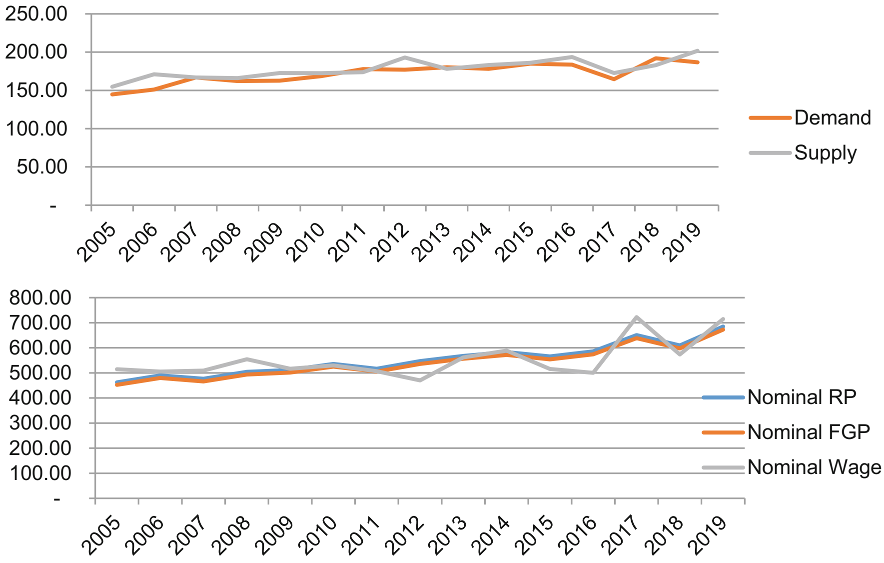

Fig. 11.7 Plots of the hypothetical data set

Table 11.3 Results of the econometric estimation of demand equation

Summary output					
Regression statistics					
Multiple R	0.94				
R square	0.89				
Adjusted R square	0.87				
Standard error	1.75				
Observations	15.00				
ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	2.00	292.31	146.15	47.71	0.00
Residual	12.00	36.76	3.06		
Total	14.00	329.07			
	Coefficients	*Standard error*	*t stat*	*P-value*	
Intercept	162.77	10.27	15.85	0.00	
RRP	−21.91	2.82	−7.77	0.00	
RPCM	3.41	0.35	9.77	0.00	

are close to actual values, we consider that the model is valid for policy analysis. The indicators to test the validity of the model include percentage error, mean square error, root mean square error, bias, etc.

To begin the validation, the two stochastic equations should be validated as single equations first. Figure 11.8 provides the results of the validation of PCD and *S*,

Table 11.4 Results of the econometric estimation of supply equation

Summary output					
Regression statistics					
Multiple R	0.93				
R square	0.86				
Adjusted R square	0.84				
Standard error	4.88				
Observations	15.00				
ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	2.00	1821.33	910.67	38.20	0.00
Residual	12.00	286.09	23.84		
Total	14.00	2107.42			
	Coefficients	*Standard error*	*t stat*	*P-value*	
Intercept	35.26	23.30	1.51	0.16	
RFGP	51.47	6.03	8.53	0.00	
RW	−21.48	3.21	−6.68	0.00	

Table 11.5 Computation of elasticities

Equation	Variable	Mean	Coefficient	Elasticity
Demand	RRP	4.93	−21.91	−1.02
	RPCM	15.06	3.41	0.48
Supply	RFGP	4.83	51.47	1.40
	RW	4.94	−21.48	−0.60

Note: Mean of PCD = 105.96, and Mean of S = 177.97
Source: Author's calculations

Table 11.6 Values of the inventories and marketing margins

Year	Inventory (INV)	Nominal marketing margin (MM)	Real marketing margin (RMM)
2005	−1275.23	12,000.00	120.00
2006	349.03	11,231.00	110.00
2007	−638.46	12,983.75	125.00
2008	−1493.27	13,830.96	132.00
2009	2144.22	10,656.00	100.00
2010	1331.15	24,103.20	220.00
2011	3704.45	15,400.00	140.00
2012	−117.50	17,916.80	160.00
2013	1716.36	13,574.40	120.00
2014	−735.58	17,367.00	150.00
2015	1014.59	16,994.00	145.00
2016	2310.86	15,395.90	130.00
2017	−723.63	16,788.80	140.00
2018	3256.26	7200.00	60.00
2019	−2216.92	13,503.60	110.00

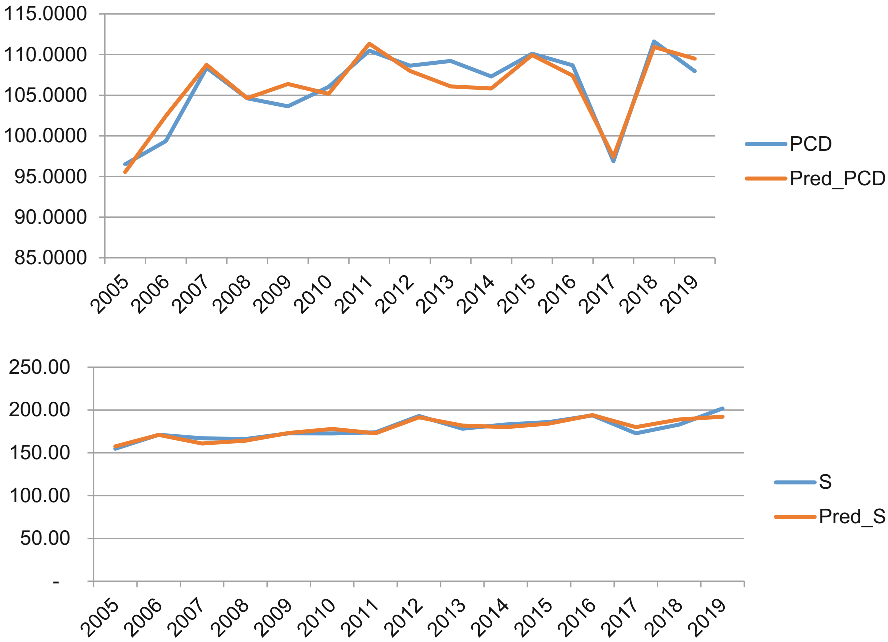

Fig. 11.8 Plots of actual values of PCD and *S*, together with their predicted values

Table 11.7 Percentage error in the predicting of the endogenous variables at the mean

Variable	Actual	Predicted	Percentage error
RRP	4.9340	4.8155	−2.4019
RFGP	4.8340	4.7155	−2.4516
PCD	105.9603	105.9603	0.0000
D	172.1010	172.0705	−0.0178
S	177.9677	177.9371	−0.0172

Source: Author's calculations

treating RRP and RPCM as the exogenous variables for the determination of PCD and RFGP and RW as the exogenous variables for the determination of *S*.

However, we are aware that RRP and RFGP are linked through RMM and that PCD and *S* are linked through INV. RRP was determined through the interaction of demand and supply; RRP, RFGP, PCD, *D*, and *S* are endogenously determined; and the values of the variables were determined by RPCM, RW, RMM, and INV, as depicted in Box 11.3.

The predictions of the endogenous variables are depicted in Table 11.7. The deviations of predictions from the actual levels show the validity of the model. The model is taken for policy analysis despite the deviations.

It should be noted that if we are to predict what will happen in 2020 using this model, we require predicted values for all the exogenous variables for 2020. The procedure adopted for validation in the example cited in Table 11.7 refer to predictions within the study period.

11.3.5 Policy Experiments and Policy Simulations

The above model can now be used to perform a few policy experiments. The nature of the policy to be experimented upon depends on the research questions raised at the beginning of the project. In the current example, the purpose is to examine the economic effects of the price ceiling.

Conducting this policy experiment is generally termed a simulation, and the values of endogenous variables generated through this process are termed as simulated values. Simulated values are different from the predictions made in the previous section, where the purpose was testing the validity of the model to make predictions within the study period. The simulation involves obtaining values for endogenous variables for each of the years by changing one or more of the exogenous variables (price of chicken meat in this example) to reflect the policy change using the model developed for the counterfactual scenario.

11.4 An Application Using a Synthetic Model

Despite the advantages of using an econometrically estimated system of equations for policy simulations, they are not popular among policy analysts. They perceive that the knowledge and skill requirements to perform a policy simulation using econometrically estimated behavioural functions are quite high. Developing a model to perform such an analysis requires a fair knowledge of microeconomic foundations and econometric techniques and numerical skills. Even for an experienced researcher with the necessary expertise, the exercise can be highly time-consuming.

Synthetic models can retain the same structure as in the case of an econometric model, yet they are not demanding in terms of researchers' time. The equations in a synthetic model are deterministic, and they are synthesised using a baseline data set and elasticity estimates available in published articles. The equations are first calibrated to a given equilibrium, commonly known as baseline equilibrium, and then used for the simulation. When elasticity estimates are not available, guess estimates are used. The characteristic feature of the synthetic model is the non-reliance on stochastic equations. All the equations are considered as identities.

Synthetic models can either be static or dynamic. In static models, the baseline data set reflects a snapshot of the market under consideration at a given period. The temporal effects cannot be considered using a static model. In dynamic models, data over a few points in a given time period are used, and connection from a one-time point to another is captured.

Let's look at how a static synthetic model is developed to assess the effects of increasing an import tariff charged on vegetable seeds by the government of Sri Lanka.

11.4.1 Step 1: Gather Information to Depict the Baseline Equilibrium

Suppose that the baseline equilibrium of the market is characterised by a tariff of 25 per cent. Let's consider that 5000 tonnes of seed is produced locally and 10,000 tonnes were demanded by the country in 2019, with a wholesale price of seed in the local market of LKR 50 per kg. The tariff rate and wholesale price imply that the world market equivalent price – the price that would prevail in the wholesale market in the absence of import tariff – is 50/(1 + 0.25), which is equal to LKR 40 per kg. It should be noted that, unlike import price, the world market equivalent price accounts for market margins between the wholesale market and the point of imports. The gap between demand and supply, 5000 tonnes, could be attributed to imports, exports, differences in inventories, and wastages. If the import volume recorded by the official statistics is 4500 tonnes, we could assign the remaining 500 tonnes to the residual in the gap, i.e. exports, differences in inventories, and wastages.

11.4.2 Step 2: Identify the Structure of the Market

This requires some exploratory research to identify the trade dependency of the commodity, whether the specific commodity market in the country can be considered as small (not in a position to influence the world market price) or large (large player in the global market so that world market prices can be influenced) and any hidden taxes or subsidies or any other policy measures exist.

Consider a situation in which Sri Lanka is a small player in the global market and, therefore, world market prices are exogenous. Let's also consider that a tariff is the only policy instrument.

This allows us to depict the market in the following manner:

$$D = D(P, M)$$

$$S = S(P, W)$$

$$P = P^W \ (1 + \text{tariff})$$

11.4.3 Step 3: Calibrate the Market to the Baseline Equilibrium Using Some Elasticity Estimates

Suppose that the price elasticities of demand and supply are −1.0 and + 1.0, as per the previous estimates. If the functional forms of the demand and supply curves and the values that prevailed in the baseline equilibrium are known, then this would enable us to compute the parameters of the two equations.

Suppose that the two equations are in multiplicative form as below:

$$D = \alpha_1 P^{\alpha 2}$$

$$S = \beta_1 P^{\beta 2}$$

The elasticity estimates are the respective exponents. The two intercept terms, which capture all the prices affecting the dependent variable other than the price, can be set to reproduce the baseline equilibrium values:

$$\alpha_1 = D/P^{\alpha 2}$$

$$\beta_1 = S/P^{\beta 2}$$

Given the baseline values of variables and the elasticities, the values of α_1 and β_1 will be 10,000/50$^{(-1)}$ = 500,000 and 5000/50$^{(+1)}$ = 100.

11.4.4 Step 4: Reproduce the Baseline Equilibrium

Use the parameters of the two equations and the exogenous variables to obtain the values that prevailed under the baseline equilibrium:

$$D = 500,000 * 50^{(-1)} = 10,000$$

$$S = 100 * 50^{(+1)} = 5000$$

In the baseline equilibrium, an import volume of 4500 was reported, suggesting a residual of 500.

11.4.5 Step 5: Conduct the Policy Experiment by Changing the Level of a Policy Variable

The policy variable in this example is import tariff, and the policy level that prevailed in the baseline equilibrium was 25 per cent. Consider an increase in the level of policy variable up to 50 per cent.

This policy change will increase the price prevalent in the market from LKR 50 to LKR 60 per kg; lower the demand from 10,000 to 8333.33 tonnes; and increase the supply from 5000 to 6000 tonnes in the following manner:

$$P* = P^W\ (1 + \text{tariff}) = 40 * (1 + 0.5) = 60$$

$$D* = \alpha_1 P^{\alpha 2} = 500,000 * 60^{(-1)} = 8333.33$$

$$S* = \beta_1 P^{\beta 2} = 100 * 60^{(+1)} = 6000$$

The above computation indicates a gap of 2333.33 tonnes between quantity supplied and quantity demanded. Out of this volume, 1833.33 tonnes can be attributed to imports as 500 tonnes are to be left as the residual.

11.4.6 Step 6: Interpret Your Results

The above computation illustrates the equilibrium that would have prevailed in the market in 2019 if the import tariffs on seed had been 50 per cent instead of 25 per cent. In this scenario, the wholesale price of seed would have been LKR 60 per kg (an increase by 20 per cent), the demand for seed would have been 8333.33 (a reduction by 16.66 per cent), the supply of seed would have been 6000 (an increase by 20 per cent), and the import of seed would have been 2333.33 (a reduction of 53.34 per cent). The numbers generated do not provide predictions for the future – rather, they show the equilibrium that would have been in 2019 if there had been an import tariff of 50 per cent.

11.5 Assignment

Design a policy research study to address the following policy questions:

1. A guaranteed price scheme for paddy is implemented in Sri Lanka, together with a procurement programme performed through the PMB. Write a short essay describing how the activities of PMB helped in improving farmer well-being and stability of farm prices of Sri Lanka?
2. The government of Sri Lanka has decided to reduce the maximum retail price (MRP) of milk powder to LKR 325 per 400 g milk powder packet by lowering the price by LKR 61 per 400 g packet. How will this impact producer and consumer well-being?

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