Appendix C
Models

The Computable Partial Equilibrium Model

To facilitate international comparison, the same computable partial equilibrium model that was used to compute the costs of protection in the United States, Japan, South Korea, and China is used in this book.[1] Compared with the computable general equilibrium approach, this partial equilibrium model is simple and easy to use. However, the methodology has several limitations (see chapter 2). The four key assumptions of the computable partial equilibrium model are:

- Domestic and imported goods are not perfect substitutes.
- The supply schedule for imported goods is flat (perfectly elastic).
- The supply schedule for domestic goods slopes upward (less than perfectly elastic).
- All markets are perfectly competitive.

The static effects of removing a trade barrier (either a tariff or a quota) are illustrated in figures C.1 and C.2. In figure C.1, the supply curve for imports (*Sm*) is flat, corresponding to a "small country" with an open economy. According to a fundamental assumption of this model, a small country is a "taker" of world market prices and does not influence them

1. The computable partial equilibrium model was devised by Peter Uimonen (see Hufbauer and Elliot 1994).

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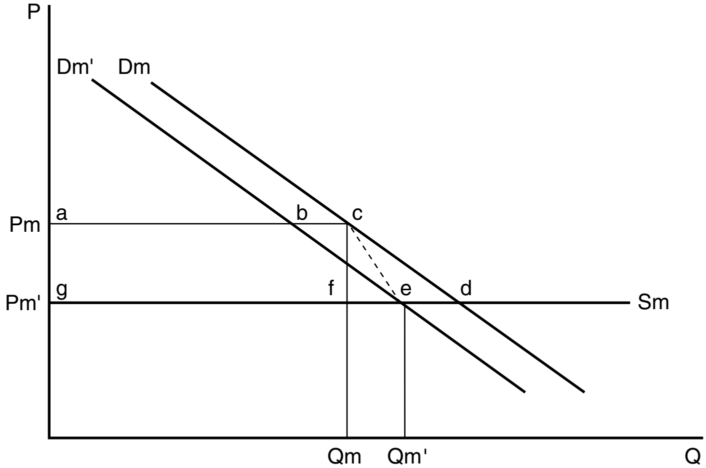
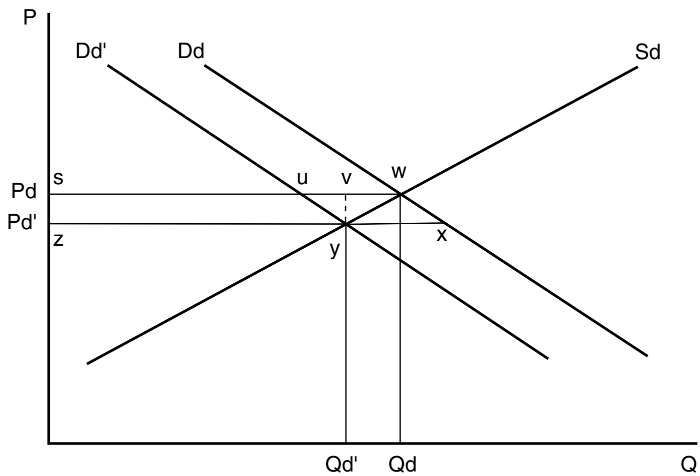
Figure C.1 Effects in the import market of removing a trade barrier



With the trade barrier in place, the price of the import in the protected market is *Pm,* and the quantity imported is *Qm.* Following liberalization, the price falls to *Pm'*, the world price. Then, responding to a lower price in the domestic market (see figure C.2), the demand schedule for the import shifts from *Dm* to *Dm'*, and the quantity imported settles at *Qm'.*

Figure C.2 Effects in the domestic market of removing a trade barrier



With the trade barrier in place, the price of the import-competing domestic product is *Pd,* and the quantity demanded is *Qd.* Following liberalization and the decline in the import price (see figure C.1), demand for the domestic substitute falls, shifting the demand curve from *Dd* to *Dd',* the quantity consumed falls to *Qd',* and the price drops to *Pd'.*

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(see the last section of chapter 3, which examines the case of the EC as a "large" country). *Pm′* is the world market c.i.f. price (expressed in euros); with the trade barrier in place, the landed price of imported goods in the protected home market is *Pm* (expressed in euros):

$$Pm = Pm' \,(1 + t + n), \tag{1}$$

where t is the tariff rate (percent ad valorem) and n is the tariff equivalent of nontariff barriers (percent ad valorem).

After liberalization (assuming the removal of all trade barriers), the landed price falls to *Pm′*. Then, responding to the lower price in the domestic market (see figure C.2), the demand curve for imports shifts from *Dm* to *Dm′*, and the quantity imported settles at *Qm′*, which is higher than the initial quantity imported, *Qm*. Trade liberalization will have a series of welfare effects. The consumer surplus gain from liberalization in the import market is approximated by the area *aceg* (figure C.1). Area *acfg* represents transfers to consumers from the government in the form of lost tariff revenues and transfers to consumers from those who controlled quotas in the form of lost quota rent. The import market will also experience an efficiency gain because resources will be better utilized.

Before liberalization, the wedge between the landed price of imports and the world market price lured resources toward the production of import substitutes and away from other sectors that could have made more efficient use of those resources. After liberalization, the process is reversed. The efficiency gain following liberalization is represented by the area *cef*. Areas *acfg* plus *cef* add up to area *aceg*, the total gains realized by consumers.

In figure C.2, the supply curve for the import-competing domestic product (*Sd*) slopes upward. With the trade barrier in place, the price of the domestic product is *Pd* (expressed in euros), and the quantity demanded is *Qd*. Following liberalization and the decline in the import price (figure C.1), the demand curve for the domestic substitute shifts from *Dd* to *Dd′*, the quantity consumed falls to *Qd′*, and the price drops to *Pd′*. The consumer surplus gain from lower domestic prices may be approximated by the area *swyz*, which is just offset by the producer surplus loss.

To summarize the welfare effects on the two markets following liberalization, the efficiency gain is the area *cef*, and the total consumer surplus gain is the area *aceg* + *swyz*. Of this total, area *acfg* is the transfer to consumers from the government and quota rent collectors, and area *swyz* is the transfer to consumers from domestic producers.[2] Because the model

2. The tariff revenue plus quota rent (area *acfg*) may be estimated as $Qm(Pm - Pm')$. The efficiency loss due to protection (area *cef*) may be estimated as $(1/2)[(Pm - Pm')\,(Qm' - Qm)]$. The consumer surplus loss in the domestic market due to protection (area *swyz)* may be estimated as $Qd'(Pd - Pd') + (1/2)[(Pd - Pd')\,(Qd - Qd')]$.

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only calculates static welfare, it might substantially underestimate the contribution that trade expansion makes to economic growth.

To derive solutions for individual industries, a computable partial equilibrium model corresponding to figures C.1 and C.2 was devised. The model assumes that supply and demand relationships are not linear in their absolute terms, but rather that they are linear in their logarithmic terms. This assumption enables the parameters associated with the price terms to be interpreted as elasticities.

The underlying domestic supply and demand functions are specified according to the following equations:

$$Qd = aPd^{Edd}Pm^{Edm} \tag{2}$$

and

$$Qs = bPd^{Es}. \tag{3}$$

In equation 2, *Edd* is the own-price elasticity of demand for the domestic good, while *Edm* is the cross-price elasticity of demand for the domestic good with respect to the price of the imported good. In equation 3, *Es* is the own-price elasticity of supply of the domestic good. Because the domestic good and the imported good are imperfect substitutes in this model, equilibrium in the domestic market requires that domestic demand equal domestic supply (i.e., $Qd = Qs$).

Assuming that the supply of the import is perfectly elastic, the demand and supply equations in the import market are:

$$Qm = cPd^{Emd}Pm^{Emm} \tag{4}$$

and

$$Pm = Pm'(1 + t + n)(1 + Rv)/(1 - Rc) \tag{5}$$

In equation 4, *Emd* is the cross-price elasticity of demand for the imported commodity with respect to the price of the domestic commodity, while *Emm* is the own-price elasticity of demand for the imported commodity. Equation 5 represents the assumption that the supply of the imported commodity is perfectly elastic, and that the world market c.i.f. price, *Pm′*, is therefore the same regardless of import quantity. In equation 5, *Rv* represents the value-added tax rate for imports, and *Rc* represents the consumer tax rate.

This system of supply and demand functions may be converted into a system of linear relationships by taking the logarithms to the base *e* (shown by *ln*) of equations 2, 3, 4, and 5:

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$$\ln Qd = \ln a + Edd \ln Pd + Edm \ln Pm \quad (6)$$

$$\ln Qs = \ln b + Es \ln Pd \quad (7)$$

$$\ln Qm = \ln c + Emd \ln Pd + Emm \ln Pm \quad (8)$$

$$\ln Pm = \ln[Pm'(1 + t + n)(1 + Rv)/(1 - Rc)] \quad (9)$$

Equations 6, 7, 8, and 9 are used to calculate the welfare effects of liberalization.

A Generalized Armington Import Model

This note summarizes the nonlinear Armington model developed in Francois and Hall (1997). They define the demand system for product *X* as a CES, where the elasticity of demand is σ and the CES weights are designated as α. This gives equation (1) as follows.

$$(1) \qquad Q = \left[\sum_{i=1..n} \alpha_i X_i^{\rho} \right]^{1/\rho}$$

$$(2) \qquad \left[\frac{\alpha_j}{P_j} \right]^{\sigma} P^{\sigma-1} E - k_{si} \left[\frac{P_j}{(1+t_j)} \right]^{\varepsilon_{sj}} = 0 \quad j = 2..n$$

$$(3) \qquad \left[\frac{\alpha_i}{P_i} \right]^{\sigma} P^{\sigma-1} E - k_{si} \left[\frac{P_i}{(1+t_i)} \right]^{\varepsilon_{si}} = 0 \quad i = 1$$

$$(4) \qquad k_A P^{NA+1} - E = 0$$

$$(5) \qquad \left[\sum_{i=1}^{n} \alpha_i^{\sigma} P_i^{1-\sigma} \right]^{1-1/\rho} - P = 0$$

$n + 2$ *equations and unknowns*

P, E, P_i

From the first order conditions, they are then able to derive excess demand for a given national variety (indexed by *i*=1…*n*) as in equation (2) above for the case of imports. Note that they have assumed that import supply is subject to a constant supply elasticity of ε_s. In equation (2), the term *t* is an import tax. In equation (3), they then have excess demand for the competing domestic variety, where it is also potentially subject to an output/production tax or subsidy at rate t_i. Equation (5) then defines the prices for the CES composite good *Q*, while equation (4) relates this composite price to demand for the CES composite, subject to composite demand elasticity *NA*.

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Note that equations (2) through (5) define a system of n+2 equations, and n+2 unknowns. Working with a nonlinear solver (like that provided in Excel) they can use this system to solve explicitly for a calibrated version of the model, and to then apply the numeric model to examine the impact of changes in tariffs on prices, import volumes, and the implied welfare and consumer and producer surplus changes that follow from trade policy changes.

This model can be downloaded from http://www.intereconomics.com/handbook/.

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