STRUCTURAL EQUATIONS FOR PE MODELS

IN GROUP 4

(NEW ENTRY, INTELLECTUAL PROPERTY AND OFFSHORING)

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Abstract

This paper presents the structural equations for the fourth group of industry-specific simulation models of changes in trade policy that are available for download on the USITC's PE Modeling Portal at https://www.usitc.gov/data/pe_modeling/index.htm.

The models described in this paper are the result of ongoing professional research of USITC staff and are solely meant to represent the professional research of individual authors. These papers are not meant to represent in any way the views of the U.S. International Trade Commission or any of its individual Commissioners. Please address correspondence to david.riker@usitc.gov.

1 Introduction

One of the spreadsheet models allows for the entry of imports from a new source. The second values the monopoly profits created by the protection of intellectual property rights. The third examines global incentives to innovate. The fourth addresses the impact of offshoring on domestic employment.

2 Model with Entry of a New Source of Imports

The first model addresses the entry of new sources of imports.[1] There are initially three sources of supply to the market, one domestic source (x) and two foreign sources (y and z). Consumers have CES preferences, with elasticity of substitution σ and a price elasticity of total industry demand equal to η. There is perfect competition in the market, and the supply from all three sources is perfectly elastic (i.e., there are no capacity constraints on production), so $p_j = c_j$ for $j \in \{x, y, z\}$.

Equation (1) is the original CES price index for the market, and (2) is the initial equilibrium demand for the product from source $j \in \{x, y, z\}$.

$$P_0 = \left((p_{x0})^{1-\sigma} + b_y \ (p_{y0} \ \tau_{y0})^{1-\sigma} + b_z \ (p_{z0} \ \tau_{z0})^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{1}$$

$$q_{j0} = k \ (P_0)^{\sigma+\eta} \ (p_{j0} \ \tau_{j0})^{-\sigma} \ b_j \tag{2}$$

Equations (3) through (5) calibrate the three demand parameters to initial expenditures and tariff rates, normalizing initial prices to one without loss of generality.

[1] Riker (2019) presents an extended version of this model.

$$b_y = \left(\frac{v_{y0}}{v_{x0}}\right) (\tau_{y0})^{\sigma-1} \tag{3}$$

$$b_z = \left(\frac{v_{z0}}{v_{x0}}\right) (\tau_{z0})^{\sigma-1} \tag{4}$$

$$k = v_{x0} \ \left(1 + b_y \ (\tau_{y0})^{1-\sigma} + b_z \ (\tau_{z0})^{1-\sigma}\right)^{\frac{-\sigma-\eta}{1-\sigma}} \tag{5}$$

Entry leads to a fourth source of supply, entrant e. The model assumes that source z is an appropriate reference group, meaning that the production costs and perceived quality of the products of the new entrant (c_e and b_e) are the same as those of the reference group (c_z and b_z). This is not a model of endogenous entry; it is modeling the economic impact conditional on entry.[2]

Equation (6) is the new equilibrium CES price index that includes source e.

$$P = \left((p_x)^{1-\sigma} + b_y \ (p_y \ \tau_y)^{1-\sigma} + b_z \ (p_z \ \tau_z)^{1-\sigma} + b_e \ (p_e \ \tau_e)^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{6}$$

Since supply from each source is perfectly elastic, $p_j = p_{j0} = c_j$ for $j \in \{x, y, z, e\}$. Equation (7) is the new equilibrium quantity from source j.

$$q_j = k \ (P)^{\sigma+\eta} \ (p_j \ \tau_j)^{-\sigma} \ b_j \tag{7}$$

Finally, (8) is the new equilibrium market share of source j.

$$m_j = \frac{b_j \ (p_j \ \tau_j)^{1-\sigma}}{(p_x)^{1-\sigma} + b_y \ (p_y \ \tau_y)^{1-\sigma} + b_z \ (p_z \ \tau_z)^{1-\sigma} + b_e \ (p_e \ \tau_e)^{1-\sigma}} \tag{8}$$

The model can be used to simulate the entry of a new source of imports, for example due to the reduction or removal of a prohibitive tariff on imports from the new source.

[2]The issue of conditional entry is discussed in detail in Riker (2019).

3 Model of the Value of a Monopoly Created by Protecting Intellectual Property Rights

In the second model, there is a linear demand curve for the products of the market.[3]

$$Q = a - b\ P \tag{9}$$

Equation (10) is the initial price elasticity of total industry demand.

$$\eta_0 = \frac{\partial Q_0}{\partial P_0}\ \frac{P_0}{Q_0}\ = -b\ \left(\frac{P_0}{Q_0}\right) \tag{10}$$

There is initially perfect competition, because intellectual property rights (IPRs) are not protected, so price is equal to marginal cost. Profits are competed to zero by infringing or imitating firms. Equations (11) through (13) calibrate marginal costs and the two parameters of the demand curve based on the initial equilibrium price and quantity, P_0 and Q_0.

$$c = P_0 \tag{11}$$

$$b = \eta_0 \left(\frac{Q_0}{P_0}\right) \tag{12}$$

$$a = Q_0\ \ (1 + \eta_0) \tag{13}$$

The protection of IPRs creates a monopoly in the market, and there is a new market equilibrium. Equation (14) is monopoly profits, in terms of the new monopoly price P_m and

[3]It can be problematic to assume a constant elasticity demand curve in a monopoly model, since the profit-maximizing price will be infinite for an elasticity of one or below in absolute value. For this reason, monopoly models often assume a linear demand curve.

quantity Q_m.

$$\pi_m = (P_m - c) \; Q_m \tag{14}$$

Equation (15) is the first order condition for monopoly pricing.

$$\frac{\partial \pi_m}{\partial P_m} = a - 2 \; b \; P_m + b \; c = 0 \tag{15}$$

This first order condition implies the monopoly price in (16), the percent change in price in (17), and the percentage change in quantity in (18).

$$P_m = P_0 \; \left(\frac{1 + 2 \; \eta_0}{2 \; \eta_0} \right) \tag{16}$$

$$\frac{P_m - P_0}{P_0} = \frac{1}{2} \left(\frac{1}{\eta_0} \right) \tag{17}$$

$$\frac{Q_m - Q_0}{Q_0} = - \left(\frac{1}{2} \right) \tag{18}$$

Finally, (19) is the value of monopoly profits at the new equilibrium, as a function of total industry revenues in the initial equilibrium, $R_0 = P_0 \; Q_0$.

$$\pi_m = \left(\frac{1}{4 \; \eta_0} \right) \; R_0 \tag{19}$$

4 Model of Trade and Innovation

The third model addresses how the protection of IPRs affects incentives to innovate. It is based on models of trade, product diversity, and monopolistic competition in Krugman (1980). It is a simpler, static, partial equilibrium version of the model with innovation and horizontal differentiation in Grossman and Helpman (1989). As we note below, the same model can be applied – with specific modifications to the model inputs – to address innovation that creates vertical differentiation, by reducing production costs or increasing product quality.

Within each industry, consumers have symmetric CES preferences with elasticity of substitution σ. There are Cobb-Douglas preferences between industries, which implies that the price elasticity of total industry demand is equal to -1.

There is a fixed cost to invent a new variety, f, and constant marginal costs of production c. The "blueprint" for each variety is non-rival in its use in different countries, so there are global scale economies to innovation, as long as the returns to innovation are ensured by the protection of IPRs.

There are a number of national markets, indexed by j, in which IPRs are protected in the initial equilibrium. In each market, there is a continuum of varieties. Each firm prices at a constant mark-up over marginal cost. Equation (20) are initial profits in market j.

$$\pi_j = \frac{1}{\sigma} R_j \tag{20}$$

R_j are initial revenues in country j. The model assumes that laws that protect IPRs create a monopoly in the variety that would otherwise not exist. Unrestricted imitation and infringement would drive the mark-up to zero and eliminate the incentive to develop the additional variety. Equation (21) is the initial number of varieties, N_0.

$$N_0 = \frac{1}{\sigma f} \sum_j R_j \tag{21}$$

With the additional protection of IPRs in country k, the equilibrium number of varieties will increase to N.

$$N = N_0 + \frac{R_k}{\sigma f} = \frac{1}{\sigma f}\left(\sum_j R_j + R_k\right) \tag{22}$$

Equation (23) is the percent change in the total number of product varieties developed. This measure of innovation increases in proportion to the size of the global sum of the IPR-protected national markets.

$$\frac{N - N_0}{N_0} = \frac{R_k}{\sum_j R_j} \tag{23}$$

Equation (24) is the simulated change in the value of innovations from protecting IPRs in the additional markets.

$$f\ \Delta N = \frac{1}{\sigma} R_k \tag{24}$$

If innovation leads to cost reductions then the IPR-protected mark-up is determined by the cost advantage of the technology leader over non-infringing imitators, rather than the reciprocal of the elasticity of substitution. The model can be applied to this alternative scenario by changing the model inputs. If innovation leads to quality reductions, then the mark-up would be based on the quality step.[4]

5 Model of Offshoring

In the fourth model, a partial equilibrium version of Grossman and Rossi-Hansberg (2008), there are two countries (d and f) and two types of workers (low-skilled workers L and high-skilled workers H). There is a continuum of tasks indexed by j. The model assumes that the cost of offshoring the two types of tasks, $1 + j$, are both uniformly distributed between

[4]Examples of models with vertical differentiation include Grossman and Helpman (1990), Grossman and Helpman (1991a), and Grossman and Helpman (1991b).

zero and one.[5] The model calculates changes in the share of tasks offshored by skill level (J_H and J_L) and domestic employment by skill level (E_H and E_L), as well as the change in the product price (p). The model quantify the economic effects of exogenous changes in wage rates in the two countries (w_d and w_f) and the relative productivity of foreign workers within each skill type (λ_L and λ_H). The relative productivity of low-skilled workers overall (γ) is calibrated within the model.

$$J_L = \frac{w_d}{w_f \ \lambda_L} - 1 \tag{25}$$

$$J_H = \frac{w_d}{w_f \ \lambda_H} - 1 \tag{26}$$

$$p^{1-\theta} = \left(w_d \ (1 - J_H) + \lambda_H w_f \left(\frac{1}{2} J_H^2 + J_H\right)\right)^{1-\theta} + \gamma \left(w_d \ (1 - J_L) + \lambda_L w_f \left(\frac{1}{2} J_L^2 + J_L\right)\right)^{1-\theta} \tag{27}$$

$$E_L = a_L \ k \ p^{\eta} \left(\frac{\gamma \left(w_d \ (1 - J_L) + \lambda_L \ w_f \ \left(\frac{1}{2} J_L^2 + J_L\right)^{1-\theta}\right)}{p^{1-\theta}}\right)^{-\theta} J_L \tag{28}$$

$$E_H = a_H \ k \ p^{\eta} \left(\frac{\left(w_d \ (1 - J_H) + \lambda_H \ w_f \ \left(\frac{1}{2} J_H^2 + J_H\right)^{1-\theta}\right)}{p^{1-\theta}}\right)^{-\theta} J_H \tag{29}$$

[5] Grossman and Rossi-Hansberg (2008) do not assume a specific form for this distribution, but it is necessary to specify a distribution to generate a quantitative estimates in the model.

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