STRUCTURAL EQUATIONS FOR PE MODELS IN GROUP 4 (INTELLECTUAL PROPERTY RIGHTS)

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March 2020

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`.

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1 Introduction

This group includes a series of spreadsheet models of intellectual property rights.

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

In the first model, there is a linear demand curve for the products of the market.[1]

$$Q = a - b\ P \tag{1}$$

Equation (2) is the initial price elasticity of total industry demand.

$$\eta_0 = \frac{\partial Q_0}{\partial P_0}\ \frac{P_0}{Q_0}\ = -b\ \left(\frac{P_0}{Q_0}\right) \tag{2}$$

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 (3) through (5) calibrate marginal costs and the two parameters of the demand curve based on the initial equilibrium price and quantity, P_0 and Q_0.

$$c = P_0 \tag{3}$$

$$b = \eta_0 \left(\frac{Q_0}{P_0}\right) \tag{4}$$

[1]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.

$$a = Q_0 \ (1 + \eta_0) \tag{5}$$

The protection of IPRs creates a monopoly in the market and there is a new market equilibrium. Equation (6) is monopoly profits, in terms of the new monopoly price P_m and quantity Q_m.

$$\pi_m = (P_m - c) \ Q_m \tag{6}$$

Equation (7) is the first order condition for monopoly pricing.

$$\frac{\partial \pi_m}{\partial P_m} = a - 2 \ b \ P_m + b \ c = 0 \tag{7}$$

This first order condition implies the monopoly price in (8), the percent change in price in (9), and the percentage change in quantity in (10).

$$P_m = P_0 \ \left(\frac{1 + 2 \ \eta_0}{2 \ \eta_0} \right) \tag{8}$$

$$\frac{P_m - P_0}{P_0} = \frac{1}{2} \left(\frac{1}{\eta_0} \right) \tag{9}$$

$$\frac{Q_m - Q_0}{Q_0} = - \left(\frac{1}{2} \right) \tag{10}$$

Finally, (11) is the value of monopoly profits at the new equilibrium, as a function of total industry revenues in the initial equilibrium, $R_0 = P_0 \ Q_0$.

$$\pi_m = \left(\frac{1}{4 \ \eta_0} \right) \ R_0 \tag{11}$$

3 Model of Trade and Innovation

The second 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 (12) are initial profits in market j.

$$\pi_j = \frac{1}{\sigma} R_j \tag{12}$$

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 (13) is the initial number of varieties, N_0.

$$N_0 = \frac{1}{\sigma f} \sum_j \ R_j \tag{13}$$

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

$$N = N_0 + \frac{R_k}{\sigma f} = \frac{1}{\sigma f} \left(\sum_j \ R_j + R_k \right) \tag{14}$$

Equation (15) 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.

$$\frac{N - N_0}{N_0} = \frac{R_k}{\sum_j \ R_j} \tag{15}$$

Equation (16) is the simulated change in the value of innovations from protecting IPRs in the additional markets.

$$f \ \Delta N = \frac{1}{\sigma} R_k \tag{16}$$

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.[2]

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

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