MODELING THE FINANCIAL IMPACT OF TARIFFS IN CONCENTRATED PRODUCT MARKETS

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Abstract

We develop an industry-specific model of trade policy with an emphasis on the financial impact of new import tariffs. The imperfect competition model is applicable to highly concentrated industries in which imports are an important source of competition and profits are at stake. The paper demonstrates how the model works in a series of simulations of the impact of new tariffs.

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1 Introduction

Trade policy assessments often use industry-specific Armington models of trade, with constant elasticity of substitution (CES) demands for products that are differentiated by country of origin. The models assume perfect competition in product markets. Hallren and Riker (2017) is a recent example of this type of model. Perfect competition models are less applicable to industries with highly concentrated product markets. Perfect competition models are also not well-suited for analyzing whether a new tariff on imports can restore profitability to a struggling domestic industry, since perfect competition models assume that firms always earn zero economic profits, with or without the tariff.[1]

To better represent concentrated markets and address the impact of tariffs on profitability, we develop an industry-specific trade model with differentiated products and imperfect competition. The Bertrand model maintains the CES demand structure of the Armington model.[2] The impact on profits can be addressed in the Bertrand model, since the firms in the concentrated industry can earn profits, at least in the short run while the number of firms in the industry is fixed.

This paper demonstrates how the model works – and the importance of imperfect competition to the impact on profitability – in a series of model simulations based on illustrative data. The simulations indicate that the new tariffs increase the prices, sales volumes, and net profits of domestic producers. The impact on net profits is greater if imports are more interchangeable for domestic product, if the initial share of subject imports is larger, and if total industry demand is less price elastic.

Section 2 describes the assumptions of the imperfect competition model. Section 3 analyzes the effects of tariff changes on the prices, sales volumes, and profits of domestic

[1] Monopolistic competition models of trade also assume that there are zero economic profits in the industry.

[2] Helpman and Krugman (1989) is an early analysis of trade policy using different types of imperfect competition, including Bertrand models.

producers. Section 4 discusses data requirements for model calibration and practical methods for running model simulations. Section 5 reports the initial set of model simulations for a market with three firms. Section 6 reports additional simulations that illustrate the importance of market concentration. Section 7 compares simulation results for the Bertrand model and a perfect competition Armington model. Section 8 concludes.

2 Modeling Framework

The demand for the products of firm j in the market, q_j, is determined by CES preferences for products within the industry, with an elasticity of substitution σ.

$$q_j = b_j \; Q \; \left(\frac{p_j \; t_j}{P} \right)^{-\sigma} \tag{1}$$

Q is total demand for the products of the industry. p_j is the price of the products of firm j, P is the CES price index for the industry, and b_j is a preference asymmetry parameter for the products of firm j.[3] The tariff factor t_j is equal to one plus the ad valorem tariff rate on the products of firm j.

$$Q = Y \; P^{\,\theta} \tag{2}$$

Y is total nominal expenditures on the products of the industry in the market. θ is the price elasticity of total industry demand. P has the following CES functional form:

$$P = \left(\sum_k b_k \, (p_k \; t_k)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{3}$$

Each firm j has a fixed cost of production f_j and constant marginal costs of production c_j.

[3] For example, b_j could reflect differences in quality compared to the products of other firms in the industry.

Equation (4) represents the net profits of firm j.

$$\pi_j\left(p_j\right)=\left(p_j-c_j\right)\ q_j-f_j \tag{4}$$

In the Nash equilibrium in prices, each firm chooses its price to maximize its net profits in the market, taking the prices of competing firms as given. Equation (5) is the first order condition for firm j.[4]

$$p_j=\left(p_j-c_j\right)\left(\sigma-(\sigma+\theta)\ \frac{b_j\ \left(p_j\ t_j\right)^{1-\sigma}}{\sum_k b_k\ \left(p_k\ t_k\right)^{1-\sigma}}\right) \tag{5}$$

The model focuses on the short run, when there is no entry or exit from the market.

3 Impact on Prices, Sales Volumes, and Net Profits

Equation (5) can be used to derive the changes in the prices, sales volumes, and net profits of a domestic producer due to the new tariff on imports. To simplify the notation, we assume that there are only three firms in the market: a domestic firm (d), a foreign firm whose products are subject to the new tariff (s), and a foreign firm whose products are not subject to the new tariff (n). In this case, there are three versions of the first order condition (FOC) in equation (5), with $j \in \{d, s, n\}$. The reduced form percent changes in the three prices ($\hat{p}_d$, $\hat{p}_s$, and $\hat{p}_n$) are derived by totally differentiating the FOC equations with respect to the three prices and the tariff factor for subject imports.[5] These reduced form percent changes in prices determine the percent change in the quantity of domestic shipments, $\hat{q}_d$, according to (6).

[4] Equation (5) is derived by substituting q_j from (1) into (4) and then taking the derivative with respect to p_j, holding all other prices fixed.

[5] These steps and the derivation of equation (6) are explained in the Technical Appendix. $\hat{p_j}$ is defined as $\frac{dp_j}{p_j}$.

$$\hat{q}_d = (\sigma + \theta)(m_d\,\hat{p}_d + m_s\,(\hat{p}_s + \hat{t}_s) + m_n\,\hat{p}_n) - \sigma\,\hat{p}_d \tag{6}$$

m_k is the share of firm k in the initial equilibrium in the market, and $\hat{t}_s$ is the percent change in the tariff factor for subject imports. The new equilibrium prices are calculated from the following updating equations:

$$p_j = p_{j0}\,(1 + \hat{p}_j) \tag{7}$$

$$q_d = q_{d0}\,(1 + \hat{q}_d) \tag{8}$$

p_{j0} is the initial price of the product of firm $j \in \{d, s, n\}$, and q_{d0} is the initial output of the domestic firm.

Equation (9) is the change in the net profits of the domestic firm due to the tariff changes.[6]

$$\Delta\pi_d = (p_{d0}\,(1 + \hat{p}_d) - c_d)\;q_{d0}\,(1 + \hat{q}_d) - (p_{d0} - c_d)\;q_{d0} \tag{9}$$

In general, an increase in the tariff on subject imports increases the consumer price of the imports and shifts demand toward non-subject imports and the products of the domestic firm. This leads to an increase in the price and quantity of the sales of the domestic firm and an increase in its net profits. The magnitudes of these effects depend on the data inputs specific to the industry.

4 Data Requirements and Simulation Methods

The data requirements of the model are the initial revenues of each firm in the market, the initial and new tariff rates on their sales in the market, the elasticity of substitution between

[6] Equation (9) assumes that $t_d = 0$, since the domestic producer will not face a tariff in its own market.

the domestic and foreign products, and the price elasticity of total industry demand in the market. Equation (10) uses the FOC in (5) and these data inputs to calibrate firm j's marginal cost c_j as a share of its initial price p_{j0}.

$$\frac{c_j}{p_{j0}} = \left(1 - \frac{1}{\sigma - (\sigma + \theta)\, m_{j0}}\right) \tag{10}$$

m_{j0} and p_{j0} are the initial market share and price of firm j, and t_{j0} is the initial tariff factor on product j in the market. The calibrated value of c_j should be positive for all j.[7]

The FOC equations of the model are non-linear, and the reduced form percent changes are only linear approximations. These approximations will be reasonably accurate for estimating the impact of very small changes in the tariff rate on subject imports but are less accurate for estimating the impact of a large change in the rate. To significantly reduce this approximation error when estimating the impact of a large change in the tariff rate, the model uses the multi-step Euler method approach to simulating partial equilibrium models in Riker (2018).

5 Illustrative Simulations

This section reports model simulations for a range of data inputs for the hypothetical three-firm market.[8] Imports from firm s face a new 25% tariff.

Table 1 reports three different simulations with alternative assumptions about the elasticity of substitution σ. In all three simulations, the new tariff increases the price, sales volume, and net profits of the domestic producer. The magnitudes of all of these percent changes are increasing in σ: there is a greater increase in the demand for the domestic products when

[7] Otherwise, the model is not consistent with the data inputs for the specific industry.

[8] The model assumes that there are only three firms in the market, but the modeling framework can be easily extended to apply to the actual number of firms and actual price and market share data for a specific industry.

imports are more interchangeable with the domestic product.

Table 1: Simulations with Alternative Values of σ

Simulation number	1	2	3
Armington elasticity	2	4	6
Price elasticity of total industry demand	-1.0	-1.0	-1.0
Expenditure on domestic products	50	50	50
Expenditure on subject imports	25	25	25
Expenditure on non-subject imports	25	25	25
Percent change in domestic price	2.58	3.67	3.89
Percent change in domestic quantity	1.12	4.57	7.80
Change in the value of domestic profits	1.68	2.83	3.21

Table 2 reports three additional simulations with alternative market shares of subject, fixing σ at 4. Again, the new tariff increases the price, sales volume, and net profits of the domestic producer in these three additional model runs. The magnitudes of these changes are all increasing in the initial shares of subject imports in the market: there is a greater increase in the demand for the domestic product when a larger share of the market is subject to the new tariff.

Table 2: Simulations with Alternative Import Shares

Simulation number	4	5	6
Armington elasticity	4	4	4
Price elasticity of total industry demand	-1.0	-1.0	-1.0
Expenditure on domestic products	50	50	50
Expenditure on subject imports	10	25	40
Expenditure on non-subject imports	40	25	10
Percent change in domestic price	1.71	3.67	5.47
Percent change in domestic quantity	2.35	4.57	6.22
Change in the value of domestic profits	1.34	2.83	4.15

Table 3 reports three simulations with alternative assumptions about the price elasticity of total industry demand, fixing the import market shares and the value of σ. Again, the new tariff increases the price, sales volume, and net profits of the domestic producer in all three model runs. These changes are all smaller when total industry demand is more price elastic.

Table 3: Simulations with Alternative Price Elasticity of Total Industry Demand

Simulation number	7	8	9
Armington elasticity	4	4	4
Price elasticity of total industry demand	-0.5	-1.0	-2.0
Expenditure on domestic products	50	50	50
Expenditure on subject imports	25	10	40
Expenditure on non-subject imports	25	40	10
Percent change in domestic price	4.77	3.67	1.92
Percent change in domestic quantity	5.63	4.57	3.13
Change in the value of domestic profits	3.77	2.83	1.51

6 Simulations with Two Domestic Producers

Table 4 adds a second domestic firm to the market. For ease of reference, Simulation 10 repeats Simulation 2 from Table 1, in which a single domestic firm has 50% of the market. Simulation 11 splits this 50% market share between two symmetric domestic producers. Simulation 12 splits the 50% unevenly between two domestic producers. The increase in the net profits of domestic producers is smaller when there are two rather than one domestic producer. When the two domestic producers have asymmetric initial market shares, the increase in net profits due to the tariff is larger for the larger domestic producer.

7 Comparison to a Perfect Competition Model

The Bertrand model has different predictions for the magnitude of changes in the price and quantity of subject imports and the price and quantity of domestic producers. The

Table 4: Simulations with Different Numbers of Domestic Producers

Simulation number	10	11	12
Armington elasticity	4	4	4
Price elasticity of total industry demand	-1.0	-1.0	-1.0
Number of domestic producers	1	2	2
Expenditure on first domestic producer	50	25	30
Expenditure on second domestic producer		25	20
Expenditure on subject imports	25	25	25
Expenditure on non-subject imports	25	25	25
Percent change in price of first domestic producer	2.83	1.22	1.53
Percent change in price of second domestic producer		1.22	0.95
Percent change in quantity of first domestic producer	3.67	10.10	8.88
Percent change in quantity of second domestic producer		10.10	11.40
Change in the profits of first domestic producer	4.57	1.11	1.36
Change in the profits of second domestic producer		1.11	0.88

comparable perfect competition model (one that assumes constant marginal costs but no profit margins) predicts greater pass-through of changes in tariffs into changes in prices, leading to a larger reduction in the quantity of subject imports and a larger increase in the quantity of domestic producers. To illustrate this point, Table 5 compares Simulation 2 (based on the Bertrand model) to a simulation using a perfect competition model with the same data inputs and parameter values. The perfect competition model overstates the import and domestic quantity effects of the new tariff relative to the Bertrand model.

8 Conclusion

Incorporating imperfect competition into an industry-specific trade model improves estimates of the economic impact of new tariffs in industries with concentrated product markets, and it provides a framework for analyzing the impact of the tariffs on the profitability of the domestic industry.

It is important to keep in mind, though, that changes in the profitability of the domestic

Table 5: Comparison to Perfect Competition Model

	Bertrand Model Simulation 2	Perfect Competition Model
Armington elasticity	4	4
Price elasticity of total industry demand	-1.0	-1.0
Expenditure on domestic products	50	50
Expenditure on subject imports	25	25
Expenditure on non-subject imports	25	25
Percent change in producer price of subject imports	-3.18	0.00
Percent change in quantity of subject imports	-43.71	-53.35
Percent change in producer price of domestic product	3.67	0.00
Percent change in quantity of domestic product	4.57	13.90
Change in the profits of domestic producers	2.83	0.00

industry are not the same the changes in overall economic welfare in the domestic economy. Tariffs that achieve a targeted increase in the profitability of domestic firms usually also increase the prices faced by consumers in the market.

9 Technical Appendix

This appendix explains the derivation of several of the key equations in the paper. Equation (11) repeats the first order condition in (5).

$$p_j = (p_j - c_j)\,(\sigma - (\theta + \sigma)\, m_j) \tag{11}$$

The reduced form percent changes in the three prices, $\hat{p_j}$ for $j \in \{d, s, n\}$, are derived by totally differentiating (11) with respect to all three prices and the tariff factor for subject imports.

$$(\sigma - (\theta + \sigma)\ m_j)\ dp_j - (p_j - c_j)\,(\theta + \sigma)\ dm_j = dp_j \tag{12}$$

$$dm_j = m_j \left((1-\sigma)\left(\frac{dp_j}{p_j} + \frac{dt_j}{t_j}\right) - (1-\sigma)\sum_k m_k \left(\frac{dp_k}{p_k} + \frac{dt_k}{t_k}\right)\right) \tag{13}$$

Substitute dm_j from (13) into (12):

$$\hat{p_j} = \frac{(p_j - c_j)(\theta+\sigma) m_j (1-\sigma)(1-m_j)}{(\sigma - (\theta+\sigma) m_j - 1) p_j}\left(\hat{p_j} + \hat{t_j}\right) + \sum_{k \neq j} \frac{(p_j - c_j)(\theta+\sigma) m_j (1-\sigma)(-m_k)}{(\sigma - (\theta+\sigma) m_j - 1) p_j}\left(\hat{p_k} + \hat{t_k}\right) \tag{14}$$

Then solve this three-equation system for $\hat{p_d}$, $\hat{p_s}$, and $\hat{p_n}$.

Equation (15) substitutes (2) and (3) into (1).

$$q_j = k_j Y \left(\sum_k b_k (p_k\ t_k)^{1-\sigma}\right)^{\frac{\theta+\sigma}{1-\sigma}} (p_j\ t_j)^{-\sigma} \tag{15}$$

Totally differentiating (15):

$$\frac{1}{q_j} dq_j = (\theta+\sigma) \sum_k \left(\frac{b_k (p_k\ t_k)^{1-\sigma}}{\sum_h b_h (p_h\ t_h)^{1-\sigma}}\right)\left(\frac{1}{p_k} dp_k + \frac{1}{t_k} dt_k\right) - \sigma \left(\frac{1}{p_j} dp_j + \frac{1}{t_j} dt_j\right) \tag{16}$$

Equation (16) implies (6) since m_k is defined as follows:

$$m_k = \frac{b_k (p_k\ t_k)^{1-\sigma}}{\sum_h b_h (p_h\ t_h)^{1-\sigma}} \tag{17}$$

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