UNANTICIPATED TARIFF CHANGES WITH TIME-TO-BUILD PRODUCTS

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Abstract

We develop a sector-specific partial equilibrium model that quantifies the reaction of trade to an unanticipated tariff increase in industries where production takes time to build or grow. Unanticipated tariff shocks that occur after products have been built can lead to large producer price effects as supply is difficult to adjust in the short-run. Producers can store production to future periods, subject to a storage cost, to mitigate large short-run price changes. We illustrate how the model works in a series of simulations.

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1 Introduction

For products that take time to build or grow, an unanticipated temporary tariff shock that occurs after goods have been built can lead to large producer price effects as supply is difficult to adjust in the short-run. Producers of imports can store products to future periods to relax the supply inelasticity, allowing both quantity and price to adjust, but must pay a storage cost. Absent storage capability, the temporary tariff shock leads to no adjustment in quantity and complete adjustment in producer prices. This is particularly relevant for time-to-grow industries like agriculture, where the more perishable the good, the higher cost to store. We capture these trade dynamics in a sector-specific partial equilibrium model of trade policy. Section 2 describes the modeling framework and identifies data requirements. Section 3 illustrates how the model works in a series of simulations, and Section 4 concludes.

2 Model Equations and Mechanics

The model has two sources of supply to the market: domestic producers (labeled d) and foreign producers (labeled f). There are three periods in the model. In period 0, suppliers make period 1 production decisions absent any tariff announcement. In period 1, there is an unanticipated one-time tariff shock on subject imports. Producers react to the temporary tariff shock by choosing how much production to sell in period 1 and how much, if any, to save for period 2. Producers also choose period 2 production. Then in period 2, tariffs on imported goods are removed and period 2 production is sold along with any period 1 production carried forward.

Products are imperfect substitutes, differentiated by source country (Armington (1969)). Consumers have CES preferences for foreign and domestic products and there is perfect competition in the product market in every period. The CES price index used to make period 0 production decisions about period 1 is:

$$\bar{P_1} = \left(\bar{p_{d1}}^{1-\sigma} + b\ \bar{p_{f1}}^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{1}$$

We use bar notation to emphasize that these equations represent the production decision assuming no tariff in period 1. The parameter b is calibrated to capture preference asymmetries and any differences in the quality of the products, and σ is the substitution elasticity. Equations (2) and (3) are the associated demand functions:

$$\bar{q_{d1}} = k\ \bar{P_1}^{\eta}\ (\frac{\bar{p_{d1}}}{\bar{P_1}})^{-\sigma} \tag{2}$$

$$\bar{q_{f1}} = k\ \bar{P_1}^{\eta}\ (\frac{\bar{p_{f1}}}{\bar{P_1}})^{-\sigma}\ b \tag{3}$$

k is a demand parameter that is calibrated to the size of the market. η is the price elasticity of total demand in the sector. Equations (4) and (5) are the supply functions in period 0, with constant price elasticity of supply parameters θ_d and θ_f:

$$\bar{q_{d1}} = \alpha_d\ (\bar{p_{d1}})^{\theta_d} \tag{4}$$

$$\bar{q_{f1}} = \alpha_f\ (\bar{p_{f1}})^{\theta_f} \tag{5}$$

$(\bar{q_{d1}}, \bar{q_{f1}})$ represent the planned production level in period 0 to sell in period 1. In period 1, an unexpected one-time tariff on foreign subject imports is announced and enters into force. The suppliers must decide how much of $(\bar{q_{d1}}, \bar{q_{f1}})$ to sell in period 1 and how much to store for period 2. Equations (6) through (10) represent the market equilibrium equations in period 1 when the unanticipated tariff enters into force.

$$P_1 = \left(p_{d1}^{1-\sigma} + b\ (p_{f1}(1+t))^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{6}$$

$$q_{d1} = k\ P_1^{\eta}\ (\frac{p_{d1}}{P_1})^{-\sigma} \tag{7}$$

$$q_{f1} = k\ P_1^{\eta}\ (\frac{p_{f1}(1+t)}{P_1})^{-\sigma}\ b \tag{8}$$

$$q_{d1} = \alpha_d\ (\bar{p}_{d1})^{\theta_d} - z_{d1} \tag{9}$$

$$q_{f1} = \alpha_f\ (\bar{p}_{f1})^{\theta_f} - z_{f1} \tag{10}$$

z_{d1} and z_{f1} represents the period 1 planned production that is stored to period 2. Equations (11) through (15) represent the market equilibrium for planned period 2 production.

$$P_2 = \left(p_{d2}^{1-\sigma} + b\ (p_{f2})^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{11}$$

$$q_{d2} = k\ P_2^{\eta}\ (\frac{p_{d2}}{P_2})^{-\sigma} \tag{12}$$

$$q_{f2} = k\ b\ P_2^{\eta}\ (\frac{p_{f2}}{P_2})^{-\sigma} \tag{13}$$

$$q_{d2} = \alpha_d\ (p_{d2})^{\theta_d} + z_{d1} \tag{14}$$

$$q_{f2} = \alpha_f\ (p_{f1})^{\theta_f} + z_{f1} \tag{15}$$

Finally, (16) and (17) represent the arbitrage conditions that bind in equilibrium if there is storage from period 1 to period 2[1]. The left hand side is the return for selling the good in period 1 and the right hand side is the return when storing the good to period 2. The tariff will lower the import producer price on the left hand side and raise the domestic producer price. c_f and c_d are the ad valorem costs of storing the good one period, and r is the rate of return. If the left hand side is bigger than the right hand side, the supplier will not store the product.

$$p_{f1} = \frac{p_{f2}\,(1 - c_f)}{1 + r} \tag{16}$$

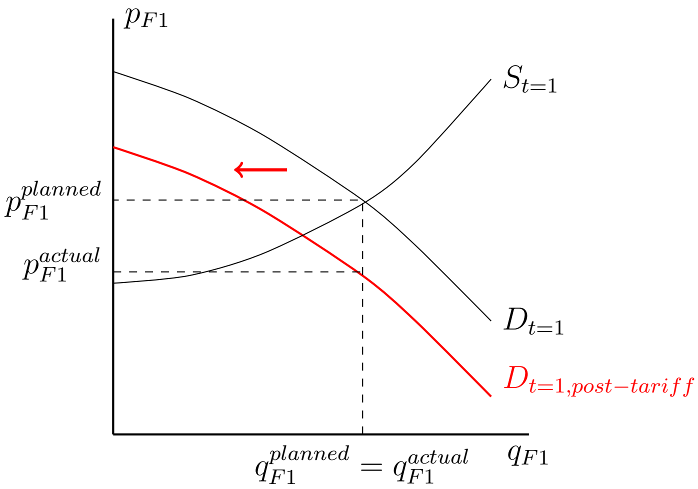
$$p_{d1} = \frac{p_{d2}\,(1 - c_d)}{1 + r} \tag{17}$$

c_f and c_d are industry-specific user inputs that will be large when the warehouse cost of storing a good is high. The storage costs are also large when the goods stored are highly perishable. The other data requirements for the model are the initial expenditures on the foreign and domestic products in the initial period, the unanticipated tariff rate t, the demand elasticity parameters (σ and η), and the supply elasticity parameters (θ_d and θ_f).

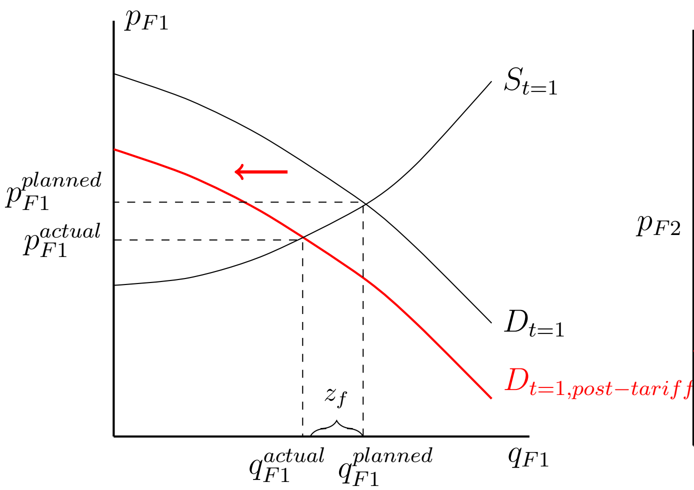
Figure (1) illustrates the model mechanics in a series of graphs. Without any storage capability, there are no adjustments in quantity and full adjustment in producer prices (graph (1a)). Adding storage to the model allows for more short-run elastic supply as both quantity and price adjust to the tariff shock (graph (1b) and (1c)). Following the one-time tariff shock in period 1, suppliers plan for period 2 production when prices return to normal levels. The model implicitly assumes that goods take time to ship, meaning there is no possibility of diverting imports to other markets or foregoing exports from the home market and selling

[1] When there is no storage of imports in equilibrium, potentially due to high storage costs or low tariff rates, the arbitrage conditions do not bind.

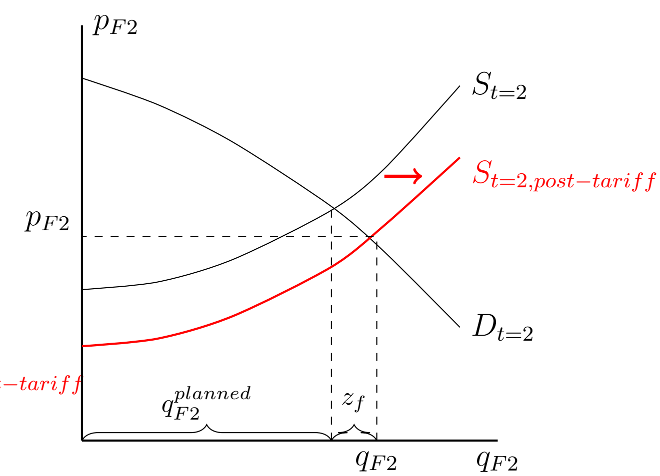
Figure 1: Comparing Storage and No Storage following an Unanticipated Tariff Shock



(a) No Storage



(b) Storage: Period 1



(c) Storage: Period 2

them at inflated domestic prices within the same period. Storage is the only mechanism for short-run supply elasticity in the model.

3 Illustrative Simulations

In this section, we run illustrative simulations of the model. It may be helpful when analyzing the model to consider the foreign source subject to tariffs as the product that is exported to a foreign market. This source of supply exports goods to a country that has its own domestic supply. The decision to store goods happens after production but before exporting to the foreign country, so the exports are not subject to a tariff. For consistency, the source subject to the tariff will be called the producers of imports in the rest of this section. Prices are normalized to one without loss of generality[2].

Table 1 reports three model simulations with varying storage costs, keeping all other variables constant. In the first simulation with low storage costs, more of period 1 planned production is shifted to period 2. In the second simulation, the higher storage costs lower the period 1 production stored to period 2 and show bigger price effects on the producer of imports. The third simulation is an example where storage costs are so high, that no storage is occurs in equilibrium. Table 1 also shows the loss (in the same units as the domestic shipments) to the importing supplier as the amount stored changes. This is calculated as the revenues of the goods sold in period 1 less the costs of those goods, with the amount of loss growing as supply is more inelastic. As the storage cost increases, less goods are stored, price impacts are more negative, the producer faces higher losses.

Table 2 adjusts the rate of return, tariff values, and market shares to show how the new equilibrium varies changes in the data inputs. When the producers of imports have a higher

[2]Note that in all simulations described below, only the import source subject to the tariff stores goods. Given the model inputs, it is optimal for the domestic producer to sell all planned production. There may be cases where the domestic source also optimally stores some of the goods, so we included a domestic storage option in the modeling equations.

initial market share, they can shift more incidence of the tariff onto the consumers. As the tariff increases, the amount of imports stored to period 2 increases as it becomes more costly to sell goods in the tariff period. When the rate of return is large, the amount stored for period 2 falls. This is because the marginal unit stored that sets the left hand side of equation (16) equal to the right now occurs earlier than the arbitrage condition with lower interest rates. In words, the rate of return for storing the product is lower.

Table 1: Simulations of the tariff shock with varying storage costs

Model Inputs	**1**	**2**	**3**
Elasticity of Substitution	4	4	4
Price Elasticity of Total Industry Demand	-1	-1	-1
Domestic Supply Elasticity	2	2	2
Import Supply Elasticity	5	5	5
Initial Market Share of Imports	50%	50%	50%
Tariff Rate on Period 1 Imports	25%	25%	25%
Rate of Return	5%	5%	5%
Storage Costs as Share of initial Price	5%	10%	50%
Period 1 Planned Production Level (Foreign, Domestic)	(50, 50)	(50, 50)	(50, 50)
Fraction of Period 1 Production Stored to Period 2	15.1%	8.7%	0%
Period 1 Actual, Foreign Source (quantity consumed, price)	(42.4, 0.9)	(45.6, 0.85)	(50, 0.8)
Period 1 Actual, Domestic Source (quantity consumed, price)	(50, 1.06)	(50, 1.03)	(50, 1)
Period 2 Actual, Foreign Source (quantity produced, price)	(51.3, 0.99)	(52, 0.98)	(50, 1)
Period 2 Actual, Domestic Source (quantity produced, price)	(49.3, 0.98)	(49.6, 0.99)	(50, 1)
Loss due to storage costs in Period 1, Foreign Source	-11.5%	-15.4%	-20%

Table 2: Simulations of the tariff shock under a variety of data changes

Model Inputs	**1**	**2**	**3**	**4**
Elasticity of Substitution	4	4	4	4
Price Elasticity of Total Industry Demand	-1	-1	-1	-1
Domestic Supply Elasticity	2	2	2	2
Import Supply Elasticity	5	5	5	5
Initial Market Share of Imports	50%	90%	50%	50%
Tariff Rate on Period 1 Imports	25%	25%	100%	25%
Rate of Return	5%	5%	5%	10%
Storage Costs as Share of initial Price	5%	5%	5%	5%
Period 1 Planned Production Level (Foreign, Domestic)	(50,50)	(90,10)	(50,50)	(50,50)
Fraction of Period 1 Production Stored to Period 2	15.1%	10.8%	58.6%	9.6%
Period 1 Actual, Foreign Source (quantity consumed, price)	(42.4, 0.9)	(80.3, 0.89)	(20.7, 0.82)	(45.2,0.85)
Period 1 Actual, Domestic Source (quantity consumed, price)	(50, 1.06)	(10, 1.08)	(50, 1.32)	(50, 1.04)
Period 2 Actual, Foreign Source (quantity consumed, price)	(51.3, 0.99)	(91.9, 0.98)	(60.2, 0.9)	(51.4, 0.99)
Period 2 Actual, Domestic Source (quantity consumed, price)	(49.3, 0.98)	(9.83, 0.99)	(46.8, 0.97)	(49.5, 0.99)
Loss in period 1, supplier of imports	-11.5%	-11.1%	-17.8%	-14.8%

4 Conclusion

This paper presents a simple dynamic industry-specific model of trade policy applicable to products that take time to build or grow. For these types of products, unanticipated tariff changes can lead to large producer price effects as supply is difficult to adjust in the short-run. Producers of imports can store products to future periods when the tariff increase is reversed to relax this supply inelasticity, allowing both quantity and price to adjust, but must pay a storage cost. The negative price impacts are largest for highly perishable products or products with higher physical storage costs. The decision to store and the magnitude of storage is endogenously determined in the model.

This model can be applied to sectors like agriculture where production decisions are made ahead of time and crops are planted, grown and harvested long before reaching the market.

The model could be extended to include hedging instruments like option contracts, signed ex-ante to sell the goods at a specified unit price, that would further insure exporters against the negative impact of an unanticipated tariff increase. The model could also be extended to include tariff policy uncertainty and tariffs that last several periods.

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