TARIFFS AND TRADE DIVERSION WITH MULTIPLE EXPORT MARKETS

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Abstract

We develop a partial equilibrium model that can estimate the impact of a change in access to an export market on the pattern of international trade and the prices paid to exporting agricultural producers in a country. The model includes barriers to shifting exports to other countries, limited flexibility in production levels, and stock management that can smooth price fluctuations over time.

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1 Introduction

Foreign market access restrictions on agricultural exports can put downward pressure on prices paid to agricultural producers engaged in export markets. This price pressure is mitigated if exporters can divert their shipments to their domestic market or other export destinations, reduce their production in the short run, and manage stocks to smooth price fluctuations over time.

In this research note, we develop a partial equilibrium (PE) model that can estimate the impact of a change in access to an export market on the pattern of international trade and the prices paid to exporting agricultural producers.[1] The model reflects important features of trade in agriculture, including barriers to shifting exports to other countries, limited flexibility in production levels, and storage, and it can be easily estimated using information on market shares.

The remainder of this research note is organized into four sections. Section 2 presents the basic PE model and derives a reduced-form expression for the price effects of tariff changes. Section 3 adds several types of impediments to trade diversion that modify this reduced-form expression. Section 4 adds a price elasticity of supply. Section 5 adds storage and inter-temporal price arbitrage.

2 Basic PE Model

A single homogeneous commodity product j is produced by one exporting country and sold across N markets, including a domestic market. Output can be redirected if market access is limited by an increase in tariffs in an export destination. Production is price-inelastic, reflecting inflexibility within crop cycles. Consumers have nested constant elasticity

[1]Our model is similar to the PE model of tariff changes in Riker and Schreiber (2020a) and the multi-country PE models of the economic effects of tariffs and supply shocks in Riker and Schreiber (2020b).

of substitution (CES) demands. The elasticity between different agricultural products is equal to one, and the elasticity between varieties of product j is equal to $\sigma_j > 1$. Under this setup, the quantity of product j exported to country k (q_{jk}) is given by

$$q_{jk} = \gamma_{jk} \ E_k \ (P_{jk})^{\sigma_j \ - \ 1} \ (p_{jx} \ (1 \ + \ \tau_{jk}))^{-\sigma_j} \ \beta_{jk}. \tag{1}$$

E_k is aggregate expenditure in country k, and γ_{jk} is the Cobb-Douglas expenditure share on product j in this country. p_{jx} is the producer price of the exporting country, which is common to all export markets k and is the focus of our model. τ_{jk} is the tariff rate on exports to country k. β_{jk} is an exogenous preference parameter on imports into country k.[2] P_{jk} is the CES price index for all product j consumed in country k, given by

$$P_{jk} = \left((p_{jk})^{1 \ - \ \sigma_j} \ + \beta_{jk} \ (p_{jx} \ (1 \ + \ \tau_{jk}))^{1 \ - \ \sigma_j}\right)^{\frac{1}{1 \ - \ \sigma_j}} . \tag{2}$$

Finally, equation (3) is the adding-up constraint on the exporter's total supply of product j ($\bar{Q}_j$),

$$\sum_k \ q_{jk} = \bar{Q}_j \tag{3}$$

where the summation over market k demand includes the domestic market in addition to all export destinations. In other words, the quantity of j demanded across all N markets is equal to the total supply ($\bar{Q}_j$), and markets clear.

We log-linearize (1), (2), and (3) to derive a first-order, reduced-form expression for the percent change in the producer price of the exporting country ($\hat{p}_{jx}$) in terms of the changes in the tariff rate ($\Delta \ \tau_{jk}$), holding all else equal.[3] E_k, $\bar{Q}_j$, p_{jk}, and τ_{jk} are exogenous variables

[2] This parameter absorbs other forms of bilateral trade costs not subject to the policy change.

[3] We use the notation $\hat{x}$ to indicate the log-derivative of variable x, which is approximately equal to the percent change ($\hat{x} = \frac{x'-x}{x} = \frac{\Delta x}{x}$). This traditional definition of $\hat{x}$ is different from the alternative "hat algebra" notation in Dekle, Eaton and Kortum (2007), in which $\hat{x} = \frac{x'}{x}$.

in the model, while p_{jx} and q_{jk} are endogenous market equilibrium outcomes.[4] Equation (1) therefore becomes

$$\hat{q}_{jk} = \left((\sigma_j - 1) \ \mu_{jk} - \sigma_j \right) \left(\frac{\Delta \ \tau_{jk}}{1 + \tau_{jk}} + \hat{p}_{jx} \right) \tag{4}$$

where μ_{jk} is defined as the exports' share of country k's total expenditure on product j, i.e. $\mu_{jk} = \frac{p_{jx} \ (1+\tau_{jk}) \ q_{jk}}{\gamma_{jk} \ E_k}$. This can be thought of as a trade share, and is a common object throughout workhorse models of international trade.

Similarly, we can rewrite (3) as

$$\sum_k \theta_{jk} \ \hat{q}_{jk} = 0 \tag{5}$$

with θ_{jk} defined as the share of the total shipments of product j produced in the exporting country that are sent to country k, i.e., $\theta_{jk} = \frac{q_{jk}}{Q_j}$.[5]

Combining (4) and (5) yields

$$\sum_k \theta_{jk} \left((\sigma_j - 1) \ \mu_{jk} - \sigma_j \right) \left(\frac{\Delta \ \tau_{jk}}{1 + \tau_{jk}} + \hat{p}_{jx} \right) = 0 \tag{6}$$

which can be inverted to obtain a reduced-form expression for the percent change in the price of the exporter ($\hat{p}_{jx}$) in response to a change in the tariff rate $\frac{\Delta \ \tau_{jk}}{1 + \tau_{jk}}$:

$$\hat{p}_{jx} = \sum_k \left(\frac{\theta_{jk} \ ((\sigma_j - 1) \ \mu_{jk} - \sigma_j)}{\sum_{k'} \theta_{jk'} \ ((\sigma_j - 1) \ \mu_{jk'} - \sigma_j)} \right) \left(\frac{-\Delta \ \tau_{jk}}{1 + \tau_{jk}} \right). \tag{7}$$

Equation (7) clearly identifies the data requirements of the reduced-form estimate: the price effect depends on the magnitude of the tariff change ($\frac{\Delta \ \tau_{jk}}{1 + \tau_{jk}}$), the elasticity of substitution

[4] The assumption that E_k and p_{jk} are exogenous variables is usually called the small country assumption in models of trade policy.

[5] While this shipment share is denoted in terms of quantity, given uniform pricing it is equivalent to a share denoted in terms of trade value.

(σ_j), the shares of the total shipments of the exporter that are sent to each country (θ_{jk} and $\theta_{jk'}$), and the trade share of the exporter within each country ($\mu_{jk'}$ and μ_{jk}). The absolute value of the price elasticity of demand that the exporter faces in country k is decreasing in μ_{jk}, and the shipment shares θ_{jk} indicate the importance of country k as an alternative destination for the exports. Neither of these shares are exogenous fundamentals in the model; they are both equilibrium outcomes prior to the change in the tariff rate. The shares implicitly incorporate exogenous model fundamentals like β_{jk}, γ_{jk}, τ_{jk}, E_k, p_{jk}, and $\bar{Q}_j$.

3 Adding Impediments to Trade Diversion

Equation (3) assumes linear transformation as shipments of the agricultural product are diverted to other countries, subject to ad valorem tariffs and possibly other trade costs that vary by country. The tariff rates are represented in the model by τ_{jk}, and other ad valorem trade costs that remain fixed are absorbed in β_{jk}. Both are implicit in equilibrium μ_{jk} and θ_{jk}. There are several tractable alternatives for including greater impediments to trade diversion in the model while still maintaining a reduced-form expression for price effects that is similar to (7).

3.1 Non-linear Transformation

One alternative is non-linear transformation (or diversion) as shipments shift between countries, with constant elasticity. Equation (8) is an alternative to the adding-up constraint in (3) that has non-linear diversion. λ_j is the constant elasticity of transformation for product j. Imperfect transformation on the supply side might reflect differences in the production process for goods exported to different national markets, for example due to differences in national sanitary and phytosanitary measures.[6] It also might reflect limitations in distri-

[6] These measures as discussed at length in U.S. International Trade Commission (2021).

bution and shipping, for example due to capacity constraints in switching between national marketing, shipping, and distribution channels.

When there is non-linear transformation in trade, the system of (3), (5), and (7) is replaced by

$$\sum_k (q_{jk})^{\lambda_j} = (\bar{Q}_j)^{\lambda_j}, \tag{8}$$

$$\sum_k \lambda_j \ (\theta_{jk})^{\lambda_j} \ \hat{q}_{jk} = 0, \tag{9}$$

$$\hat{p}_{jx} = \sum_k \left(\frac{(\theta_{jk})^{\lambda_j} \ ((\sigma_j \ - \ 1) \ \mu_{jk} \ - \ \sigma_j)}{\sum_{k'} (\theta_{jk'})^{\lambda_j} \ ((\ \sigma_j \ - \ 1) \ \mu_{jk'} \ - \sigma_j)} \right) \left(\frac{-\Delta \ \tau_{jk}}{1 \ + \ \tau_{jk}} \right). \tag{10}$$

Equation (10) is very similar to (7): it just substitutes θ_{jk} for $(\theta_{jk})^{\lambda_j}$. The two expressions are identical if $\lambda_j = 1$.

3.2 Strict Geographic Segmentation

A second alternative for including impediments to trade diversion is to assume strict geographic segmentation between groups of national markets. For example, supply to export markets could be completely separate from supply to the domestic market.[7] This segmentation redefines the share inputs θ_{jk} and μ_{jk} but otherwise does not change the reduced-form expression for price effects in (7). For example, if domestic shipments have a completely separate supply than exports, then θ_{jk} and $\theta_{jk'}$ is the share of countries k and k' among all exports (but not domestic shipments), and likewise the domestic market is not included in either of the summations in the reduced-form expression.

This alternative is a more extreme and stark version of the non-linear transformation alternative, and it would only apply if there is a dedicated supply line to each destination, and no evidence of shifting between destinations. As with the nonlinear transformation alternative, it could reflect international differences in product requirements, like national

[7] Another possibility is that there could be segmentation of export destinations by geographic region.

differences in sanitary and phytosanitary measures, or capacity constraints on marketing, shipping, and distribution in different national markets. Strict segmentation has the practical advantage that it only requires grouping national markets into segments without further quantification, while the non-linear transformation alternative requires a specific estimate of λ_j, which might be difficult to quantify.

4 Adding Price Elasticity of Supply

It is also straightforward to extend the basic PE model to allow for a constant price elasticity of supply from the exporting country, $\epsilon_j > 0$, rather than assuming a fixed production level in the exporting country. For example, crop cycles might be shorter than a year, while economic effects might be calculated on an annual basis. In this case, even when production is price-inelastic within a crop cycle, it will have some price elasticity in analysis of annual effects. Returning to the assumption of linear transformation, now (11) replaces (6), and (12) replaces (7).[8]

$$\sum_k \theta_{jk} \left((\sigma_j - 1) \mu_{jk} - \sigma_j \right) \left(\frac{\Delta \tau_{jk}}{1 + \tau_{jk}} + \hat{p}_{jx} \right) = \epsilon_j \hat{p}_{jx} \tag{11}$$

$$\hat{p}_{jx} = \sum_k \left(\frac{\theta_{jk} \left((\sigma_j - 1) \mu_{jk} - \sigma_j \right)}{\sum_{k'} \theta_{jk'} \left((\sigma_j - 1) \mu_{jk'} - \sigma_j \right) - \epsilon_j} \right) \left(\frac{-\Delta \tau_{jk}}{1 + \tau_{jk}} \right) \tag{12}$$

The data requirements for implementing the above are identical to the base model, with the added requirement that an estimate of ϵ_j is now needed. Finally, another reason a price elasticity of supply may be appropriate is the possibility of storing the product for future periods, though this is better represented by an explicitly dynamic model, which we discuss in the next section.

[8] The two expressions for price effects are identical if $\epsilon_j = 0$.

5 Adding Storage

In general, adding storage and inter-temporal price arbitrage can significantly complicate a model; however, these features can be added to our analysis in a simple way that still maintains the reduced-form expression for price effects with only slight modification. In this extension, there are two time periods, storage, and inter-temporal price arbitrage such that

$$p_{jx1}\ (1\ +\ r)\ (1\ -\ s) = p_{jx2} \tag{13}$$

where p_{jx1} and p_{jx2} are the prices of the exporter in periods 1 and 2, r is the interest rate, and s is an ad valorem storage cost. Provided r, s are constant, then $\hat{p}_{jx1} = \hat{p}_{jx2} \equiv \hat{p}_{jx}$. The reduced-form expression for this time-invariant price effect can then be written as

$$\hat{p}_{jx} = \sum_{k,t} \left(\frac{\theta_{jkt}\ \left((\sigma_j\ -\ 1)\ \mu_{jkt}\ -\ \sigma_j\right)}{\sum_{k',t} \theta_{jk't}\ \left((\sigma_j\ -\ 1)\ \mu_{jk't}\ - \sigma_j\right)} \right) \left(\frac{-\Delta\ \tau_{jkt}}{1\ +\ \tau_{jkt}} \right). \tag{14}$$

Equation (14) is similar to (7); the difference is that trade shares and summation are calculated across time periods t, in addition to across countries k.

If the change in the tariff rate is permanent ($\Delta\ \tau_{jk1} = \Delta\ \tau_{jk2} > 0$), then the price effect is the same in both periods, and the possibility of storage and inter-temporal price arbitrage does not matter. However, if the change in the tariff rate is temporary and occurs only in the first of the two periods ($\Delta\ \tau_{jk1} > \Delta\ \tau_{jk2} = 0$), then the price effect in the first period is diluted and extended by storage; supply is smoothed over time by adjusting stocks.

Storage costs might be determined by weight or quantity rather than unit dollar value.[9] However, the assumption of an ad valorem storage cost s is standard in economic models of inventories and international trade, like Alessandria, Kaboski and Midrigan (2010) and

[9] Storage costs are usually proportional to value if related to product obsolescence, depreciation, or insurance value. On the other hand, they are usually determined by weight or quantity if related to physical warehousing costs.

Blum, Claro, Dasgupta and Horstmann (2019). It is convenient in our model, because it incorporates inventory considerations in a tractable way, with only a slight modification and re-interpretation of the reduced-form expression for the price effects of the tariff changes.

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