DIFFERENT TYPES OF TRADE SHOCKS

IN AN UPSTREAM-DOWNSTREAM PE MODEL

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Abstract

I present a partial equilibrium model of trade that links upstream and downstream industries. The model demonstrates that two types of upstream trade shocks – tariff changes and foreign productivity shocks – have similar effects on the upstream industry but can have very different effects on the downstream industry. I apply the model to 2020 data for the upstream rubber and plastic products industry and the downstream furniture industry, in simulations of the effects of hypothetical tariff reductions and foreign productivity shocks that increase U.S. imports from China.

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1 Introduction

Partial equilibrium (PE) models of trade policy focus on the direct effects of policy changes within a specific industry, while more complex general equilibrium models also try to capture indirect, or spillover, effects on the rest of the economy. The main advantages of PE models are that they have simpler data requirements and can be tailored to specific structural features of the industry of interest.[1] A disadvantage of PE models of trade are that they are missing effects on downstream industries.

This paper develops a middle ground between PE and general equilibrium models by constructing a PE model that links an upstream industry and a downstream industry within a single model. This upstream-downstream model tells a more nuanced story about the effects of different types of upstream trade shocks. In a simpler PE model, foreign production cost reductions and tariff reductions both increase imports and have similar effects on the domestic industry. In a linked upstream-downstream model, these trade shocks in the upstream industry have opposite effects on domestic production and employment in the downstream industry: downstream domestic employment is negatively correlated with upstream imports when the imports are driven by foreign production cost shocks and are positively correlated with upstream imports when the imports are driven by changes in tariff rates.[2]

I demonstrate how the linked PE model works using 2020 data for the upstream rubber and plastic products industry and the downstream furniture industry. I simulate the effects of hypothetical tariff reductions and foreign productivity shocks in the rubber and plastic products industry that increase U.S. imports from China.

Beyond providing a practical tool for trade policy analysis, the model contributes an important distinction to the debate over the effects of trade on labor markets. The literature

[1] In contrast, general equilibrium models generally rely on a more generic representation of individual industries.

[2] This is also the case in a general equilibrium model, but it is intermingled with many other effects.

on this topic splits its focus between the *effects of trade* on labor markets and the *effects of trade policy*. For example, some models – including Hakobyan and McLaren (2016), Pierce and Schott (2016) and Handley and Limão (2017) – focus on the impact of changes in imports due to changes in trade policy or uncertainty about trade policy. Other models – including Autor, Dorn and Hanson (2013) and Caliendo, Dvorkin and Parro (2019) – focus on the impact of changes in imports due to foreign productivity shocks. In other models like Ebenstein, Harrison, McMillan and Phillips (2014) , the distinction between the two types of trade shocks is blurred. The distinction between the effects of trade and the effects of trade policy is also frequently blurred in popular discussions of the impact of trade.

The rest of the paper is organized into four parts. Section 2 describes the modeling framework: first the structural equations, then the calibration strategy, and finally the data and parameter inputs of the model. Section 3 contrasts the effects estimated in alternative model simulations, and Section 4 provides further sensitivity analysis of the simulations. Section 5 concludes.

2 Model

The model includes upstream and downstream production in three countries indexed by i, j, and k. The simulations focus on effects in the downstream market in country i.

2.1 Structural Equations

The prices of the upstream products from country $c \in \{i, j, k\}$ are p_{uc}. These upstream prices reflect constant marginal costs of production and are exogenous variables in the model. The tariff factor (i.e., one plus the tariff rate) for imports of the upstream and downstream products from country c into country i are τ_{uc} and τ_{dc}. These tariff factors are also exogenous variables in the model.

Equation (1) relates the price of the domestic downstream product, p_{di}, to the prices of inputs from the upstream industry, wages, and tariff factors.

$$p_{di} = \left((p_{ui})^{1 - \sigma_u} + (p_{uj}\ \tau_{uj})^{1 - \sigma_u} + (p_{uk}\ \tau_{uk})^{1 - \sigma_u}\right)^{\frac{\beta}{1 - \sigma_u}} (w_i)^{1 - \beta} \tag{1}$$

σ_u is the constant elasticity of substitution (CES) between domestic and foreign products in intermediate inputs of the upstream industry. β, the cost share of the upstream industry in downstream production, is a constant parameter in the model, reflecting a Cobb-Douglas production function that combines upstream inputs and labor in downstream production. w_i, the wage in country i, is also an exogenous variable in the PE model. The foreign downstream prices in equations (2) and (3) add the simplifying assumption that foreign downstream production uses only foreign-produced inputs.

$$p_{dj} = (p_{uj})^{\beta}\ (w_j)^{1 - \beta} \tag{2}$$

$$p_{dk} = (p_{uk})^{\beta}\ (w_k)^{1 - \beta} \tag{3}$$

Equation (4) is the CES price index for the downstream market in country i.

$$P_i = \left((p_{di})^{1 - \sigma_d} + \alpha_j\ (p_{dj}\ \tau_{dj})^{1 - \sigma_d} + \alpha_k\ (p_{dk}\ \tau_{dk})^{1 - \sigma_d}\right)^{\frac{1}{1 - \sigma_d}} \tag{4}$$

σ_d is the CES between domestic and foreign products in downstream production. α_j and α_k are constant demand parameters. Equation (5) is the value of domestic shipments in the downstream industry in country i.

$$V_{di} = X_i\ \left(\frac{p_{di}}{P_i}\right)^{1 - \sigma_d} \tag{5}$$

X_i is the value of aggregate expenditure in country i on the products of the downstream industry. Equation (6) is employment in the downstream industry in country i that supports these domestic shipments.

$$L_{di} = \frac{V_{di}\ (1\ -\ \beta)}{w_i} \tag{6}$$

Finally, equation (7) is the value of domestic shipments in the upstream industry in country i.

$$V_{ui} = V_{di}\ \beta\ \left(\frac{(p_{ui})^{1\ -\ \sigma_u}}{(p_{ui})^{1\ -\ \sigma_u}\ +\ (p_{uj}\ \tau_{uj})^{1\ -\ \sigma_u}\ +\ (p_{uk}\ \tau_{uk})^{1\ -\ \sigma_u}}\right) \tag{7}$$

Adopting the normalization that $p_{ui} = 1$ and $w_i = 1$ and defining $\gamma_j = \alpha_j\ (w_j)^{(1\ -\ \beta)(1\ -\ \sigma_d)}$ and $\gamma_k = \alpha_k\ (w_k)^{(1\ -\ \beta)(1\ -\ \sigma_d)}$, the equations of the PE model can be simplified as follows:

$$p_{di} = \left(1\ +\ (p_{uj}\ \tau_{uj})^{1\ -\ \sigma_u}\ +\ (p_{uk}\ \tau_{uk})^{1\ -\ \sigma_u}\right)^{\frac{\beta}{1\ -\ \sigma_u}} \tag{8}$$

$$P_i = \left((p_{dj})^{\ 1\ -\ \sigma_d}\ +\ \gamma_j\ ((p_{uj})^{\beta}\ \tau_{dj})^{1\ -\ \sigma_d}\ +\ _k\ ((p^{\beta}_{uk)}\ \tau_{dk})^{1\ -\ \sigma_d}\right)^{\frac{1}{1\ -\ \sigma_d}} \tag{9}$$

$$V_{di} = X_i\ \left(\frac{p_{di}}{P_i}\right)^{1\ -\ \sigma_d} \tag{10}$$

$$L_{di} = V_{di}\ (1\ -\ \beta) \tag{11}$$

$$V_{ui} = V_{di}\ \beta\ \left(\frac{1}{1\ +\ (p_{uj}\ \tau_{uj})^{1\ -\ \sigma_u}\ +\ (p_{uk}\ \tau_{uk})^{1\ -\ \sigma_u}}\right) \tag{12}$$

2.2 Calibration

Equations (13) and (14) calibrate initial upstream prices p_{uj} and p_{uk} using functions of the initial import penetration rates in the upstream market in country i (μ_{uj} and μ_{uk}), the elasticity of substitution in the upstream market (σ_u), and the initial upstream tariff factors in country i (τ_{uj} and τ_{uk}).

$$p_{uj} = \left(\frac{\mu_{uj}}{1 - \mu_{uj} - \mu_{uk}}\right)^{\frac{1}{1 - \sigma_u}} \frac{1}{\tau_{uj}} \tag{13}$$

$$p_{uk} = \left(\frac{\mu_{uk}}{1 - \mu_{uj} - \mu_{uk}}\right)^{\frac{1}{1 - \sigma_u}} \frac{1}{\tau_{uk}} \tag{14}$$

Equations (15) and (16) calibrate γ_j and γ_k using functions of the initial import penetration rates in the downstream market in country i (μ_{dj}, and μ_{dk}), the initial prices of foreign upstream production (p_{uj} and p_{uk}), the cost share (β), the elasticity of substitution in the downstream market (σ_d), and the initial downstream tariff factors in country i (τ_{dj} and τ_{dk}).

$$\gamma_j = \left(\frac{\mu_{dj}}{1 - \mu_{dj} - \mu_{dk}}\right) \left(\frac{1}{(p_{uj})^{\beta}\ \tau_{dj}}\right)^{1 - \sigma_d} \tag{15}$$

$$\gamma_k = \left(\frac{\mu_{dk}}{1 - \mu_{dj} - \mu_{dk}}\right) \left(\frac{1}{(p_{uk})^{\beta}\ \tau_{dk}}\right)^{1 - \sigma_d} \tag{16}$$

2.3 Data and Parameter Inputs

The data requirements of the PE model are fairly limited, and so it is practical to apply the model. In this paper, I apply the model to 2020 data for the upstream rubber and plastic products industry (NAICS code 326) and the downstream furniture industry (NAICS code 337).

I calculate the values of import penetration rates, average tariff rates, and total industry expenditure using import and export data for 2020 from the USITC's Trade Dataweb and value of total shipments data from the Annual Survey of Manufactures (ASM) for 2020. The U.S. employment level in the downstream industry in 2020 is also from the ASM. The share of NAICS 326 shipments in the cost of NAICS 337 production is based on the BEA's Use Table for the U.S. economy in 2020. I calculate the elasticity of substitution values for the upstream and downstream industries from 2017 Economic Census data using the methodology in Ahmad and Riker (2020). Table 1 reports the data and parameter inputs for the model application.

Table 1: Model Inputs

Variable	**Value**
Total Expenditure in the Downstream Market	\$89.92 billion
Elasticity of Substitution in the Upstream	2.6
Elasticity of Substitution in the Downstream	2.5
China's Share of the Upstream Imports	9.40%
China's Share in the Downstream Imports	23.36%
Initial Tariff Rate on Upstream Imports from China	12.35%
Initial Tariff Rate on Downstream Imports from China	18.19%
Cost Share of Upstream in Downstream Production	7.02%
Domestic Workers in the Downstream Industry	349,925

3 Comparison of Simulations

Table 2 reports simulation results for two different types of upstream trade shocks. The first simulation completely eliminates the tariff on U.S. imports of plastic and rubber products from China, while leaving the tariff on U.S. imports of furniture unchanged. The second simulation reduces production cost in China in the upstream rubber and plastic products industry by 10%, due to an increase in productivity, with no changes in tariff rates.

Table 2: Simulations with Different Types of Upstream Trade Shocks

Modeled Outcome	**Tariff Elimination**	**Increase in Foreign Productivity**
Upstream Domestic Industry		
% Change in Domestic Shipments	-1.736%	-1.696%
Change in Domestic Shipments	-$63.3 million	-$61.8 million
Downstream Domestic Industry		
% Change in Domestic Shipments	0.045%	-0.099%
Change in Domestic Shipments	$32.2 million	-$70.4 million
Change in Domestic Employment	149	-327
% Change in the Industry Price Index	-0.049%	-0.137%

In both of the simulations reported in Table 2, the cost of the upstream product from China declines, and this increases upstream imports, reduces upstream domestic shipments, and reduces the industry price index that consumers face in the downstream market. However, while U.S. consumers benefit from both types of upstream trade shocks, the effects on downstream producers in the United States depends on the type of shock. Tariff elimination reduces the cost of imported upstream inputs of the domestic industry, and this leads to an expansion in the value of downstream domestic shipments. The increase in foreign productivity also reduces the cost of imported upstream inputs of the domestic industry, but it reduces the costs of producing downstream imports by even more, since downstream foreign production is especially intensive in foreign upstream inputs, and the net effect is a reduction in the value of domestic shipments of downstream producers. Domestic downstream employment is positively correlated with upstream imports if they are due to tariff elimination in the upstream industry but negatively correlated if they are due to increased foreign productivity in the upstream industry.

4 Sensitivity Analysis

To illustrate the sensitivity of the simulation results to parameter inputs, I repeat the simulation of tariff elimination on upstream imports from China and then rerun the model, first doubling the cost share of the upstream in the downstream (β) and then doubling the elasticity of substitution in the upstream market (σ_u). Table 3 reports simulated effects for these alternatives. Increasing β and σ_u both magnify the effects of tariff elimination on the downstream industry (compared to the simulation results in Table 2). Increasing β dampens the effects on the upstream industry, while increasing σ_u magnifies the upstream effect.

Finally, to illustrate the importance of trade in both upstream and downstream products, I repeat the simulation of the 10% increase in productivity in the Chinese upstream industry and then rerun the model, first eliminating all downstream trade but maintaining the upstream trade and then eliminating all upstream trade but maintaining the downstream trade. Table 4 reports simulated effects for these two hypothetical trade elimination scenarios. Without downstream trade, the increase in upstream foreign productivity still has a negative effect on the domestic upstream industry and no effect on the domestic downstream industry. In other words, the negative effect on the domestic downstream industry requires

Table 3: Simulations of Tariff Elimination with Different Parameter Values

Modeled Outcome	**Values in Table 2**	**Doubled the Value of β**	**Doubled the Value of σ_u**
Upstream Domestic Industry			
% Change in Domestic Shipments	-1.736%	-1.693%	-5.239%
Downstream Domestic Industry			
% Change in Domestic Shipments	0.045%	0.090%	0.052%
Change in Domestic Employment	149	297	173
% Change in the Industry Price Index	-0.049%	-0.098%	-0.056%

downstream trade. The last column reports the scenario with no upstream trade. In this final column, the negative effect on the domestic upstream industry is dampened (compared to the full-trade case in the first column of simulation results), the negative effects on the domestic downstream industry are magnified, and the negative effect on the industry price index is dampened.

Table 4: Simulations of Productivity Shocks with Different Restrictions on Trade

Modeled Outcome	**Up and Downstream Trade**	**No Downstream Trade**	**No Upstream Trade**
Upstream Domestic Industry			
% Change in Domestic Shipments	-1.696%	-1.599%	-0.141%
Downstream Domestic Industry			
% Change in Domestic Shipments	-0.099%	0.000%	-0.141%
Change in Domestic Employment	-327	0	-466
% Change in the Industry Price Index	-0.137%	-0.071%	-0.094%

5 Conclusions

The upstream-downstream PE model illustrates, in a simple way, how changes in imports due to changes in trade policy or changes in foreign productivity can have very different effects on domestic downstream industries when there is significant international trade in downstream products. Domestic downstream employment is positively correlated with upstream imports if they are due to tariff elimination in the upstream industry but negatively correlated if they are due to increased foreign productivity in the upstream industry. To preserve this distinction, it is useful to try to link closely related industries, and the upstream-downstream PE model provides a practical way to do this with limited, industry-focused data.

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