ESTIMATING THE DIRECT EMPLOYMENT EFFECTS OF INDUSTRY-SPECIFIC TRADE POLICY

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Abstract

We develop a partial equilibrium model of industry-specific trade policy that improves on traditional calculations of the direct effects of trade policy on employment in the competing domestic industry. The model incorporates data on fixed and variable labor inputs and inter-industry labor mobility. We apply the model to two narrowly defined U.S. manufacturing industries – plumbing fixtures and residential electric lighting fixtures – and simulate the effects of hypothetical tariff elimination on industry employment, wages, and the value of domestic shipments in the short run and in the long run.

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1 Introduction

We develop a partial equilibrium model of industry-specific trade policy that improves on traditional calculations of the direct effects of trade policy on employment in the competing domestic industry. We relax the common assumption that employment in the domestic industry changes in proportion to changes in the value of domestic shipments.[1] The model incorporates data on fixed and variable labor inputs and inter-industry labor mobility.

Then we apply the model to two narrowly defined U.S. manufacturing industries – plumbing fixtures and residential electric lighting fixtures – and simulate the effects of hypothetical tariff elimination on industry employment, wages, and the value of domestic shipments in the short run and in the long run. The model simulations demonstrate that industry employment and wage effects can vary significantly between the short run and the long run within each industry, and they can vary significantly across industries when differences in market conditions are taken into account.

The paper is organized into the following parts. Section 2 describes the structural model. Section 3 derives reduced-form expressions for the changes in employment, wages, and the value of domestic shipments. Section 4 derives the labor supply elasticity values implied by the model. Section 5 discusses the data requirements of the model and the method for calibrating model parameters. Section 6 applies the model to the plumbing fixture manufacturing industry and then to the residential lighting fixture manufacturing industry. Section 7 concludes with a discussion of limitations and potential extensions of the model.

[1] Riker and Schreiber (2020) provides many PE models of trade policy, including some with employment effect calculations.

2 Modeling Framework

In the model, there is monopolistic competition in industry i, with CES preferences for the differentiated products of firms within the industry and Cobb-Douglas preferences across industry composites. In the long run, N_i is determined by free entry and exit and a zero profit condition.[2] In the short run, the number of domestic firms in the industry is fixed at N_i. [3]

Equation (1) is the variable component of labor demand associated with the domestic shipments of each firm in industry i, E_{vi}.

$$E_{vi} = A_i \ (P_i)^{\sigma_i - 1} \ (p_i)^{-\sigma_i} \ \theta_i \tag{1}$$

A_i is total expenditures on the products of industry i in the domestic market.[4] σ_i is the elasticity of substitution between the differentiated products of domestic and foreign firms in the industry. θ_i is the unit labor requirement for domestic production in the industry. P_i is the CES price index for industry i. The right-hand side of (1) is, implicitly, a decreasing function of wages through the price p_i and the price index P_i.

$$P_i = \left(N_i \ (p_i)^{1-\sigma_i} \ + \ b_i \ (p_i^* \ \tau_i)^{1-\sigma_i}\right)^{\frac{1}{1-\sigma_i}} \tag{2}$$

N_i is the number of symmetrically differentiated domestic firms in industry i. b_i is a calibrated demand asymmetry parameter that controls for the number of foreign varieties, home

[2]The model of international trade with product differentiation, scale economies, and monopolistic competition in the long run is based on the seminal contribution in Krugman (1980).

[3]Ahmad (2019) develops a partial equilibrium version of the model that can be used to calculate employment effects, though if focuses on the short run, when the number of firms participating in the market is fixed.

[4]This is a constant share of aggregate expenditures and is an exogenous variable. The model treats the exports of the domestic industry as exogenous and focuses on employment associated with the domestic shipments.

bias, and international quality differences. $\tau_i \geq 1$ is the power of the tariff, which is equal to one plus the tariff rate in the industry. p_i^* is the foreign producer price.[5] p_i, the producer price of domestic firms in industry i, is a fixed mark-up over variable labor costs.

$$p_i = \left(\frac{\sigma_i}{\sigma_i - 1} \right) \; \theta_i \; w \tag{3}$$

w is the wage rate.

π_i is the profits of each of the N_i symmetrically differentiated domestic firms in industry i.

$$\pi_i = \frac{1}{\sigma_i} \; A_i \; (P_i)^{\sigma_i - 1} \; (p_i)^{1-\sigma_i} \; - \; w \; f_i \tag{4}$$

Profits are equal to zero in the long run, though not necessarily in the short run. $w f_i$ is the fixed cost of each firm, for example the labor cost of overhead.

E_i is total domestic employment in industry i. It is the sum of the firms' variable labor inputs, $N_i \; E_{vi}$, and their fixed labor inputs, $N_i \; f_i$.

$$E_i = N_i \; E_{vi} \; + \; N_i \; f_i \tag{5}$$

Finally, equation (6) is a labor market clearing condition that sums over all other industries (indexed by k) in the same *labor supply pool* as industry i. Workers are mobile across industries, and this arbitrages the wage rate, but only across industries that use similar skills and are therefore in the same labor supply pool.[6]

$$E_i \; + \sum_{k \neq i} \; E_k = E \tag{6}$$

[5] Foreign producer prices and tariffs are treated as exogenous variables in the model.

[6] The relationship between labor mobility and labor supply pools is discussed in more detail in Riker (2020b).

E is the total supply of labor in the relevant pool.[7]

Next, we log-linearize the model and express (1) through (6) in percent changes, first in the short run and then in the long run. In both cases, we assume that all exogenous variables other than tariff rates remain constant, including A_i, p_i^*, θ_i, and f_i. On the other hand, employment, prices, shipments, and wages adjust endogenously to the tariff change.

In the short run, fixed costs are sunk, irreversible expenditures that have not yet recurred. With prices a constant mark-up over marginal costs, variable profits are always positive, and incumbent firms will not exit in the short run, even if a tariff reduction leads to negative total profits. Likewise, in the short run even if a tariff increase leads to positive total profits, firms cannot enter for a while due to a time-to-build. In the long run, when these fixed costs would recur and new entry is feasible, firms decide whether to exit the market, remain in the industry, or enter based on the total profits they would earn.

In the short run, $\hat{N}_i = 0$, the zero profit condition is not necessarily binding, and the changes in equilibrium prices and quantities are characterized by (7) through (11).[8]

$$\hat{E}_{vi} = (\sigma_i \ - \ 1) \ \hat{P}_i \ - \sigma_i \ \hat{p}_i \tag{7}$$

$$\hat{P}_i = (1 - m_i) \ \hat{p}_i \ + \ m_i \ \hat{\tau}_i \tag{8}$$

$$\hat{p}_i = \hat{w} \tag{9}$$

$$s_i \ \hat{E}_{vi} \ + \sum_{k \neq i} \ s_k \ \hat{E}_{vk} = 0 \tag{10}$$

[7] It is straightforward to extend the model to allow for some wage elasticity of E rather than assuming that it is constant, as in (6).

[8] For a variable x, $\hat{x}$ is the proportional change in x, equal to $\frac{dx}{x}$.

$$\hat{E}_i = \left(\frac{E_{vi}}{E_i}\right) \ \hat{E}_{vi} \tag{11}$$

m_i is the initial import penetration rate in industry i. s_i is the share of the total labor supply pool that is initially employed in industry i, $\frac{E_i}{E}$. The amount of variable labor inputs, E_{vi}, adjusts in proportion to the change in production, but total employment adjusts by less, since fixed labor inputs do not adjust in the short run.

In the long run, the zero profit condition is binding, $\hat{E}_{vi} = 0$, and the changes in equilibrium prices and quantities and the changes in the equilibrium number of domestic firms are characterized by (12) through (16).[9]

$$0 = (\sigma_i \ - \ 1) \ \hat{P}_i \ - \sigma_i \ \hat{p}_i \tag{12}$$

$$\hat{P}_i = (1 - m_i) \ \left(\hat{p}_i \ + \ \frac{1}{1-\sigma_i} \ \hat{N}_i\right) \ + \ m_i \ \hat{\tau}_i \tag{13}$$

$$\hat{p}_i = \hat{w} \tag{14}$$

$$s_i \ \hat{N}_i \ + \sum_{k \neq i} s_k \ \hat{N}_k = 0 \tag{15}$$

$$\hat{E}_i = \hat{N}_i \tag{16}$$

In the long run, both variable labor inputs and total industry employment adjust in proportion to the change in production.

[9]Firm size is invariant to market size in the long run. This is a standard result in Krugman monopolistic competition models of trade with Dixit-Stiglitz perferences, e.g., Krugman (1980).

3 Reduced-Form Expressions

Equations (7) through (11) imply the following reduced-form expressions for the short-run changes in employment, wages, and the value of domestic shipments D_i:

$$\hat{E}_{vi} = \left(\frac{((1 - m_i)(\sigma_i - 1) - \sigma_i)\ s_i\ (1 - \sigma_i)}{\sum_j s_j\ ((1 - m_j)(\sigma_j - 1) - \sigma_j)} + (\sigma_i - 1) \right) m_i\ \hat{\tau}_i \tag{17}$$

$$\hat{w} = \left(\frac{s_i\ (1 - \sigma_i)}{\sum_j s_j\ ((1 - m_j)(\sigma_j - 1) - \sigma_j)} \right) m_i\ \hat{\tau}_i \tag{18}$$

$$\hat{D}_i = \hat{E}_{vi} + \hat{w} \tag{19}$$

j indexes all industries in the same labor supply pool as industry i.

Equations (12) through (16) imply the following reduced-form expressions for the long-run changes in these variables:

$$\hat{E}_i = \left(\frac{\left((\sigma_i - 1) - \frac{\sigma_i}{1 - m_i}\right) s_i\ (1 - \sigma_i)}{\sum_j s_j\ \left((\sigma_j - 1) - \frac{\sigma_j}{1 - m_j}\right)} + (\sigma_i - 1) \right) \left(\frac{m_i}{1 - m_i} \right) \hat{\tau}_i \tag{20}$$

$$\hat{w} = \left(\frac{s_i\ (1 - \sigma_i)}{\sum_j s_j\ \left((\sigma_j - 1) - \frac{\sigma_j}{1 - m_j}\right)} \right) \left(\frac{m_i}{1 - m_i} \right) \hat{\tau}_i \tag{21}$$

$$\hat{D}_i = \hat{E}_i + \hat{w} \tag{22}$$

4 Industry Labor Supply Elasticity

It is not necessary to calculate the labor supply elasticity implied by the structural model in order to apply the reduced-form expressions in (17) through (22). Still, calculating the implied elasticity values can provide a useful comparison to simpler models that assume that this supply elasticity has a constant value.[10] Equation (23) is the labor supply elasticity (LSE) of industry i in the short run, when $\hat{E}_{vi} \neq 0$ and $\hat{N}_i = 0$, as a function of the variables and parameters of the structural model.[11]

$$\textit{Short Run } LSE_i = \sum_{k \neq i} \left(\frac{s_k}{s_i} \right) \left(\sigma_k - (1 - m_k) \left(\sigma_k - 1 \right) \right) \tag{23}$$

k indexes industries other than i in the same labor supply pool as i. This elasticity is the percent change in variable labor inputs ($\hat{E}_{vi}$) for a percent change in the wage ($\hat{w}$), holding fixed labor inputs constant.

Equation (24) is the LSE of industry i in the long run, when $\hat{N}_i \neq 0$ and $\hat{E}_{vi} = 0$, again as a function of the variables and parameters of the structural model.

$$\textit{Long Run } LSE_i = \sum_{k \neq i} \left(\frac{s_k}{s_i} \right) \left(\frac{\sigma_k}{1 - m_k} - \left(\sigma_k - 1 \right) \right) \tag{24}$$

In both the short and long runs, the LSE approaches infinity when the industry is a small part of the relevant labor supply pool (as s_i approaches zero), and the LSE approaches zero when the labor input is very specific to industry i and skills are not transferable to other industries (as s_i approaches one).

Models that assume a constant elasticity of labor supply typically adopt a value for the elasticity from econometric estimates in the academic literature. However, (23) and (24) suggest that this practice can be problematic: the elasticity should reflect market data for the specific industry and should take into account the industry's size relative to total employment in the relevant labor supply pool. A labor supply elasticity value estimated for

[10] This modeling simplification is a common way to abbreviate an industry's labor supply connection to other parts of the economy.

[11] This elasticity is derived by substituting (8) and (9) into (7) for industry $k \neq i$, and then invert (10): $\hat{E}_{vi} = -\sum_{k \neq i} \left(\frac{s_k}{s_i} \right) \hat{E}_{vk}$

one industry and time period is probably not a good fit in other settings.

5 Data Inputs and Calibration of the Model

The data requirements of the model are the initial import penetration rate in industry i (m_i), the initial share of workers in industry i that are variable inputs in the short run ($\frac{E_{vi}}{E_i}$), and the share of the labor supply pool that is initially employed in the industry (s_i). For the model applications that follow, we calculate m_i as the ratio of the landed duty paid value of imports to the sum of the value of these imports and the value of domestic shipments of the industry; $\frac{E_{vi}}{E_i}$ as the ratio of production workers to total employment in the industry; and s_i as the industry's share of total employment in the relevant labor supply pool.[12]

There are two alternatives for calibrating the remaining parameters of the model. If the modeler has a reliable estimate of $\frac{E_{vi}}{E_i}$, the share of variable labor inputs, then the elasticity of substitution σ_i can be calibrated by setting σ_i equal to $\frac{E_i}{E_i - E_{vi}}$, assuming that the industry is initially in a long-run equilibrium. If the modeler *instead* has a reliable estimate of σ_i but is uncertain about $\frac{E_{vi}}{E_i}$, then $\frac{E_{vi}}{E_i}$ can be calibrated by setting $\frac{E_{vi}}{E_i}$ equal to $\frac{\sigma_i - 1}{\sigma_i}$.[13]

6 Application to Specific Industries

In this section, we illustrate the model by applying it to two narrowly defined U.S. industries, Plumbing Fixture Fitting and Trim Manufacturing (NAICS code 332913) and Residential Electric Lighting Fixture Manufacturing (NAICS code 335121).

We use annual industry data from the 2019 Annual Survey of Manufactures.[14] We define

[12] Another data source for calibrating $\frac{E_{vi}}{E_i}$ for an industry is the U.S. Bureau of Labor Statistics, Occupational Employment Statistics at `bls.gov/oes/#data`.

[13] For example, Riker (2020a) provides an econometric approach for estimating σ_i for narrowly defined products.

[14] These data are publicly available at `census.gov/programs-surveys/asm/data.table.html`.

labor supply pools as groups of NAICS six-digit industries within the same NAICS three-digit code. We aggregate together all other industries in the labor supply pool into a "rest of 332" aggregate for the model of plumbing fixtures and a "rest of 335" aggregate for the model of residential lighting fixtures. We use annual trade data for 2019 from the ITC/DOC Trade Dataweb.[15]

Table 1 reports the inputs for the model of plumbing fixtures. Table 2 reports the percent changes in domestic industry employment, wage, and the value of domestic shipments from tariff elimination, estimated by applying (17) through (22) to the model inputs in Table 1. As expected, the decline in employment in the long run is larger than the decline in the short run – more than twice as large. The model estimates that employment would decline by 411 workers in the short run, and by 978 workers in the long run.

Table 1: Model Inputs for Plumbing Fixtures

	NAICS 332913	Rest of NAICS 332
Total Employment	8,907	1,375,435
Production Workers	6,599	1,042,375
Total Shipments	5,418,502,000	370,601,818,000
Exports	321,016,231	41,914,226,632
Imports	1,552,989,638	81,673,450,645
Initial Tariff	15.6%	
Import Penetration Rate m_i	23.4%	19.9%
Variable Input Share $\frac{E_{vi}}{E_i}$	74.1%	75.8%
Industry Employment Share s_i	0.6%	
Elasticity of Substitution σ_i	3.86	4.13

Table 3 reports the inputs for the model of residential lighting fixtures. Table 4 reports percent changes in domestic industry employment, wage, and the value of domestic shipments

[15]These data are publicly available at `dataweb.usitc.gov`.

Table 2: Model Outputs for Plumbing Fixtures

	Short Run (% Change)	Long Run (% Change)
Employment for Domestic Shipments		
Variable Labor Inputs	-6.616	-11.674
Fixed Labor Inputs	0.000	-11.674
Wages	-0.036	-0.037
Value of Domestic Shipments	-6.651	-11.711

from tariff elimination, estimated by applying (17) through (22) to the model inputs in Table 3. The model estimates that industry employment would decline by 671 workers in the short run, and by 3,386 workers in the long run. The percent changes in employment in this second industry are much larger than their counterparts in the plumbing fixtures industry. This reflects the higher import penetration rate and higher initial tariff in the plumbing fixtures industry.

7 Conclusions

The traditional assumption that employment effects will adjust in proportion to the value of domestic shipments can be a reasonable approximation when industry employment is a small share of the relevant labor supply pool and all labor inputs are variable. However, we can improve on this calculation – by incorporating data on variable and fixed labor inputs and inter-industry labor mobility – while keeping the equations tractable and the data requirements modest.

The simulations in our two applications of the model show that the magnitudes of the effects on industry employment and wages can vary significantly between the short run and

Table 3: Model Inputs for Residential Lighting Fixtures

	NAICS 335121	Rest of NAICS 335
Total Employment	5,831	340,212
Production Workers	4,121	230,560
Total Shipments	2,169,078,000	131,145,686,000
Exports	149,283,367	45,734,360,648
Imports	3,030,458,189	131,037,705,436
Initial Tariff	21.3%	
Import Penetration Rate m_i	60.0%	60.5%
Variable Input Share $\frac{E_{vi}}{E_i}$	70.7%	67.8%
Industry Employment Share s_i	1.7%	
Elasticity of Substitution σ_i	3.41	3.10

Table 4: Model Outputs for Residential Lighting Fixtures

	Short Run (% Change)	Long Run (% Change)
Domestic Industry Employment		
Variable Labor Inputs	-17.487	-62.358
Fixed Labor Inputs	0.000	-62.358
Wages	-0.188	-0.186
Value of Domestic Shipments	-17.675	-62.544

the long run within each industry, and they can vary significantly across industries when differences in market conditions are taken into account.

There are several limitations of the model that could be addressed in future extensions. First, the model currently focuses on labor and does not include other factors of production. This simplification is common in monopolistic competition models of international trade. Second, the model does not assign a dollar value to domestic industry employment losses, just a change in number of employees. However, there can be significant industry-specific productivity losses and often unemployment of displaced workers. Third, the model could be extended to capture downstream, indirect employment effects (e.g., on installers and retailers) and upstream employment effects (e.g., on parts and materials suppliers). Finally, the model currently considers different time horizons by comparing short-run and long-run effects, but it could be extended to include more elaborate dynamics along the adjustment path.

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