

Versatility and Specificity of PE Models for Trade Policy Analysis

Saad Ahmad and David Riker

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Abstract

The ex-ante effects of trade agreements are usually predicted with economy-wide models under a general equilibrium closure so that inter-industry linkages are accounted for in the policy simulation. However, modern trade agreements increasingly have policies that target specific industries and are not easily accounted for in the economy-wide analysis. In these instances, partial equilibrium (PE) models can play a key role in the analysis by examining in detail the impact of industry-specific trade provisions and then incorporating these expected trade effects in the overall economy-wide model. This paper shows how PE models can be used to map industry-specific trade policies and highlights some provisions in the recent U.S.-Mexico-Canada Agreement (USMCA) that are well suited for a PE analysis.

1. Introduction

The ex-ante effects of trade agreements are usually predicted with economy-wide models under a general equilibrium closure so that all inter-industry linkages are accounted for in the policy simulation. However, modern trade agreements increasingly feature policies that are narrowly focused on specific industries and are not easily accounted for in general equilibrium models. These policies include non-tariff measures (NTM), rules of origin (ROO), intellectual property rights, and digital trade regulations. In these instances, partial equilibrium (PE) models can play a key role in the analysis by examining in detail the impact of the policy changes on specific industries, and then these partial equilibrium effects can be incorporated into an economy-wide analysis of the trade agreement.¹

PE models have specific advantages when it comes to examining trade policies that target specific sectors and industries. First, these smaller-scale models can be constructed to better capture the unique features of the market such as imperfect competition among firms or scale economies. Second, there is greater flexibility when it comes to designing the policy experiment so that it more accurately reflects the nuances of the policy change and focuses on the narrowly defined products or industries to which it applies. Third, PE models can be adapted to practical limitations on available data, substituting structure for data when necessary. The primary limitation of PE models is that they analyze an industry in isolation and so are unable to estimate spillover effects on other parts of the economy.

Our paper provides an overview of some recent PE models that have been developed by staff of the U.S. International Trade Commission for estimating the economic impact of changes in industry-specific trade policies. Each of these PE models was designed to capture the effects of a narrowly targeted trade policy, and together they demonstrate the versatility of PE models of trade policy. Most of the PE models discussed in the paper are based on an Armington demand structure with products differentiated by source country, a common assumption in the trade literature. They adopt different market structures to fit different industries, including perfect competition, monopolistic competition, and Bertrand price competition, and they differ in how the policy shock is implemented in simulations.

The first PE model was designed to examine policies targeting cross-border e-commerce shipments. An industry-specific PE model was a good candidate for this analysis as there is usually very limited data on cross-border e-commerce transactions and the link between the e-commerce sector and the broader economy is harder to determine. We show that under certain plausible assumptions, the main model inputs to compute the effects on e-commerce shipments are the changes in the AVE costs of shipping e-commerce goods as a result of the new policy, the relevant market shares, and the elasticity of substitution among the different suppliers. This PE model was applied in analysis of the USMCA e-commerce provisions, specifically the increases in the value of de minimis thresholds for shipments into Canada and Mexico handled by express delivery firms.

¹ PE models can also be useful to analyze impact of tariff changes at a more disaggregate level. As noted in Narayanan et al. (2010), most trade policy negotiations are conducted at the tariff line and so changes in tariffs for specific products may not be identified among the relatively aggregated sectors in a general equilibrium analysis.

The second PE model was developed to estimate the impact of changes in ROO in trade agreements. In contrast to the first model, this PE model was based on an assumption of linear demand and Bertrand price competition among firms. It was used to determine the effects of USMCA's automotive ROO on vehicle sales, international trade, production, and employment.

The last PE model examines the effects on the domestic market from a change in fixed costs of import entry, representing NTMs like costly and discriminatory regulatory requirements. The model assumes that consumers have a love of variety and each source country has several symmetric firms that produce unique varieties under monopolistic competition. The effects of a reduction in the fixed costs associated with the NTMs on key economic measures such as prices, quantities, labor and profits are illustrated in a series of policy simulations.

2. A PE model for E-commerce

Consumer demand for goods sold through e-commerce is represented with a constant elasticity of substitution (CES) structure. In this model, consumers have three sources through which they can purchase retail goods: brick-and-mortar retail firms (*bmr*), domestic e-commerce firms (*dec*), and foreign e-commerce firms (*fec*). The model assumes that these three retail channels are imperfect substitutes for each other. That is, domestic consumers in these countries can choose (substitute) between each retail channel at a constant rate that is captured by the elasticity of substitution σ . A higher elasticity of substitution means that consumers would be more willing to switch from one retail channel to another in response to changes in the relative distribution costs of the alternative channels.

When consumers maximize utility subject to a budget constraint, we obtain the standard CES relationship between quantity demanded and the price of the good:

$$q_i^* = \left(\frac{t_i p_i}{P} \right)^{-\sigma} \frac{E}{P} \quad (1)$$

Here q_i is the quantity purchased from retail source $i = bmr, dec, fec$. p_i is the price charged by the firms supplying through retail channel i , and t_i are the transaction costs representing the ad valorem equivalent (AVE) of local sales taxes, import duties, domestic and international shipping costs, as well as the costs of other customs barriers that are incurred by the consumer when purchasing from source i .

$P = (\sum_i (t_i p_i)^{1-\sigma})^{\frac{1}{1-\sigma}}$ is the aggregate CES price index for the goods sold in the market through these different retail channels. Lastly, E is total amount spent on all retail goods by domestic consumers.

Firms are assumed to be perfectly competitive in the model, with the supply for each retail source taken as perfectly elastic so that there is 100 percent pass-through of changes in transaction costs into consumer prices. The assumption of perfectly elastic supply curves greatly simplifies computation, though it might lead to an upward bias in the absolute magnitude of the estimates for the price and quantity effects for domestic consumers from changes in transaction costs.

Under such conditions, changes in the value of sales V_i for each retail source can be decomposed as a function of initial market share $s_i = \frac{V_i}{\sum V_i}$, the elasticity of substitution σ and the change in t_i :²

$$\hat{V}_i = (\sigma - 1) \sum (s_k - 1) \hat{t}_k \quad (2)$$

Equation (2) can be used to analyze the effect on firms supplying through all three retail channels—domestic brick-and-mortar, domestic e-commerce, and foreign e-commerce—from changes in transaction costs. It is a very tractable framework that can be used to analyze the impact of different e-commerce regulations such as changes in sales taxes, shipping costs and customs barriers. All that is required are initial shares of each retail source in the domestic market, the AVE change in transaction costs as a result of the policy change and the elasticity of substitution between the different retail sources. The model also predicts larger effects for higher elasticity of substitution and higher market shares of the retail channel targeted by the new policy.

The above PE model was used to determine the effect of Canada and Mexico increasing their de minimis thresholds (DMT) in the USMCA.³ Data on the market shares of domestic brick-and-mortar firms, non-U.S. e-commerce firms, and U.S. e-commerce firms in the Canadian and Mexican retail industry were obtained from industry groups such as Statista and Paypers. AVE reductions in transaction cost of 1.4% for Canada and 1.1% percent for Mexico were calculated based on Canadian and Mexican consumers no longer paying import duties, sales taxes, and brokerage fees for parcels falling below the new DMTs. Lastly, a substitution elasticity of about 4.3 between online (e-commerce) and offline (brick-and-mortar) retail merchants was used, based on the estimates in Dolfen et al. (2019).

The PE model found that the value of express shipments from U.S. e-commerce firms to Canada would increase by \$333 million if Canada's DMTs rose to US\$30 for sales taxes and US\$117 for import duties. Because there was no increase in the DMT for taxes in Mexico, the impact of Mexico's DMT change on US express shipments was found to be smaller, with additional sales of \$91 million for U.S. e-commerce firms to Mexico. These results, however, are sensitive to the share of packages affected by the higher DMTs and the value of the elasticity of substitution. Lower shares of packages shipped under the new DMTs, along with smaller values for the elasticity of substitution, would lead to a smaller increase in sales.

3. A PE model for Rules of Origin

ROO determine the eligibility of imports for preferential tariff treatment under trade agreements. It is challenging to model ROOs, especially the complex rules for the automotive sector in the USMCA. The new ROO significantly increase the regional content required in vehicles and parts and adds new requirements intended to support well-paying jobs for workers in the industry. Microeconomic analysis of the impact of the new ROO requires firm-level information on the global configuration of the supply chains for each vehicle model and an assessment of the response of parts sourcing – whether they will

² This decomposition assumes no additional price effects, apart from changes in transaction costs.

³ USITC, *U.S.-Mexico-Canada Trade Agreement*, 2019.

adjust parts sourcing or make no changes in sourcing to comply and forego preferential treatment. It also requires assessments of how adjustments in sourcing will affect production costs, how changes in costs will be passed through into prices and how competitors will respond to the price increases of firms with cost increases.

There were several efforts to model the USMCA automotive ROO using computable general equilibrium (CGE) models with highly aggregated sectors and perfect competition, but CGE models do not seem to be the right tool for this particular task, because ROO apply to the sourcing of *specific products*. They are not based on industry average content, and they will affect the production costs of some firms in an industry and not others, and only for some product lines. Other factor is that vehicle markets are highly concentrated, not perfectly competitive.

To address these issues, staff economists at the U.S. International Trade Commission developed a detailed PE model of passenger vehicle and light truck markets in North America. The economic model tracks vehicle production and sales at the level of 393 individual vehicle models, such as the Chevrolet Malibu and the Toyota Tundra. It assumes that the market for vehicles in North America is segmented by country and by vehicle class. The four groups of vehicle classes included in the model are subcompact and compact cars, mid-size and full-size cars, multi-passenger vehicles, and pickup trucks.

The model represents the demand for these differentiated vehicle models using linear demand curves, with price coefficients calibrated to elasticity values from the econometric literature on consumer demand for motor vehicles. The model includes imperfect competition among the 22 manufacturers that sell vehicles in each North American market segment. The economic model assumes that there is a Bertrand-Nash equilibrium in prices, with firms choosing their own prices (for their multiple vehicle models) to maximize their joint profits across their products, taking the prices of their competitors as given. The initial marginal cost of producing each vehicle model was calibrated to initial prices and market shares using the first-order conditions from the manufacturers' profit-maximizing pricing.

Some of the manufacturers respond to the new ROO by adjusting their sourcing of core parts, like engines and transmissions. A shift to North American sourcing increases their costs of vehicle production. Some of the sourcing would be shifted from European and Asian manufacturers, to satisfy the new regional value content requirements; other sourcing would shift from manufacturers in Mexico, to satisfy the new labor value content requirements. The model predicts adjustments to the sourcing of these two core parts based on data at the level of the 393 individual vehicle models and on interviews with individual North American vehicle producers.

The supply chains for passenger vehicles and light trucks sold in North America vary across manufacturers, and even across vehicle models within the same manufacturer. Some vehicle models are assembled in the United States, Mexico, or Canada, while others are imported from Europe or Asia. The manufacturers also vary in the sourcing of their parts. Foreign-owned companies that build vehicles in North America are more likely to import their engines, transmissions, and other core parts from their home countries in Europe or Asia.

Differences in supply chains across passenger vehicle and light truck models would likely result in different responses to the new ROO. Some manufacturers would already meet the new ROOs for their vehicle models without any adjustments in their current North American supply chains, while others would probably not be willing to make the changes necessary to meet the new ROO and would lose their tariff preferences. A third group would be able to comply with the new ROO, but only after making adjustments to their sourcing of core parts.

The model simulates the new equilibrium price of each vehicle model in each of the three countries in USMCA by finding the Nash equilibrium under the new ROO. The simulated changes in equilibrium prices imply changes to vehicle sales, international trade, production, and employment. The model estimates that changes associated with the new ROO requirements will have a negative impact on consumers, since light vehicle prices are likely to increase, which would decrease consumption. The market-average price increase would range from 0.37 percent for pickup trucks to 1.61 percent for small cars. The small increases in vehicle prices are averages of moderate price increases for vehicle models that would experience direct cost increases and much smaller price increases for all other vehicles. Many vehicle models would not experience a direct cost increase, either because they would meet the new ROO without any adjustments to sourcing or because almost all of their production is already outside of North America and they would not adjust to try to meet the new ROO.

The new ROO also lead to an increase in U.S. imports from outside North America. The direction of change in U.S. imports from Canada is mixed: a reduction in imports of small cars and MPVs and an increase in imports of mid- and full-size cars. Small cars are more heavily affected by the changes in ROOs because these vehicles tend to source more content from outside North America, so it is more expensive for manufacturers to bring those vehicles into compliance. These changes in imports and production are small relative to total sales. Combining the three classes of passenger vehicles, U.S. vehicle production decline by 1.31 percent, U.S. exports to Canada and Mexico would decline by 1.76 percent, and total U.S. imports would decline by 0.52 percent. Imports from outside of North America would increase.

The effects on trade and production of pickup trucks is different, because there are almost no imports of pickup trucks to North American markets from Canada, Europe, or Asia, and few from Mexico. The model results indicate that U.S. pickup truck production decline by nearly 2,000 vehicles (-0.07 percent), U.S. exports to Canada and Mexico rise by more than 100 vehicles (0.02 percent), and total U.S. imports decline by nearly 13,000 vehicles (-2.26 percent), again due to some increases in U.S. production costs and even greater increases in Mexican production costs.

The increase in U.S. production of core parts, due to the reshoring effects of the new ROO, have a positive effect on industry employment in the United States. The reduction in U.S. vehicle production due to the cost effects of the new ROO has a negative effect on industry employment, but these effects are relatively small, according to the economic model, and they offset little of the employment increase from reshoring.

The effects of the new ROO on production costs that were estimated using the industry-specific partial equilibrium model were then incorporated into a GTAP model to calculate economy-wide effects. Specifically, the disaggregated effects of USMCA on vehicle production costs in each country were first aggregated to the level of GTAP sectors. Then the aggregated effects were used as targets to calibrate shocks to the cost of importing parts in the GTAP simulation of economy-wide effects.

Despite the complexity of the economic model, it has some clear limitations. For example, due to data constraints, the modeling focuses on the cost effects on the sourcing of two core parts, engines and transmissions, while the new ROO are likely to affect the sourcing of many other automotive parts. The model does not attempt to quantify the effect of the new ROO on U.S. exports to the rest of the world. Finally, the estimated employment effects are limited to employment in vehicle, engine, and transmission production, and do not include other indirect effects on dealers or other parts suppliers.

4. A PE model for Fixed Costs

NTMs in CGE/PE models are often incorporated as ad valorem equivalent (AVE) tariffs or as import-augmenting technological (or iceberg) changes (Andriamananjara et al., 2004). However, trade agreements often address NTM that create fixed, rather than variable, costs for exporting firms, such as product licensing and registration requirements. Ignoring the effects on fixed costs can lead to an incorrect assessment of new trade policies, and specifically will not capture factors driving changes on the extensive margin of trade. Accordingly, we propose a simple PE model that can assess the economic impact of changes in fixed costs of entry as a result of policy changes.

The PE model for fixed costs assumes that consumers have a love of variety and substitute between varieties at a constant rate. Consumers can buy products from three sources: home country (d), foreign country that is subject to the trade policy change (s), and those not subject to the policy change (n).

As equation (1), we get the following the relation between quantity demand and the CES price index:

$$q_i = k B_i p_i^{-\sigma} P^{\sigma-1} \quad (2)$$

$$P = [\sum_k n_k B_k p_k^{1-\sigma}]^{\frac{1}{1-\sigma}} \quad (3)$$

B_i is a parameter capturing asymmetries in consumer preferences for each source $i \in (d, s, n)$, k is the aggregate expenditures for the industry, while n_i is the number of homogeneous firms from each country.

Following Krugman (1980), each firm produces a unique variety and operates under monopolistic competition.⁴ All firms have constant marginal costs, with labor as the only input in production. $\mu_i w_i$ is

⁴ Monopolistic competition may not be an appropriate assumption for highly concentrated industries, limiting the applicability of the model to certain sectors of the economy.

the firms' unit labor cost. Profit-maximizing firms will charge a constant markup over their marginal costs such that:

$$p_i = \frac{\sigma}{\sigma-1} (\mu_i w_i) \quad (2)$$

Firms must pay a fixed cost f_i to enter a given market. Free entry condition under monopolistic competition necessarily leads to zero profits in equilibrium with each firm producing the following output:

$$q_i = \frac{(\sigma-1)f_i}{\mu_i} \quad (3)$$

In Krugman's general equilibrium model, the number of firms in equilibrium is given by a labor market clearing condition such that the total labor used by all firms equals the total number of workers in the country. In our PE version of the model, we relax this assumption and assume an upward-sloping labor curve for the sector so that changes in wages lead to a change in labor supply and consequently the ultimate number of firms operating in the market.

$$\begin{aligned} L_i^d &= n_i(f_i + \mu_i q_i) \\ w_i &= a_i + b_i L_i^s \\ L_i^d &= L_i^s \end{aligned} \quad (4)$$

Having endogenous labor supply in the model allows us to link changes in fixed costs of entry with the number of firms in the policy simulations. The supply parameters a_i and b_i in (4) can be calibrated based on information on labor supply elasticity and unit labor costs.

As seen in equation (3), fixed costs affect the equilibrium quantity produced by firms in each source country. Note that if the policy change only affects the fixed costs of entry of firms in the subject country, then firms in the domestic and non-subject country (who experience no change in their fixed costs) will continue to produce the same quantity as before. The model is solved for a new equilibrium to obtain the number of firms and wages in each source country after the policy shock. From these variables, we can compute changes in prices and total quantities ($n_i q_i$) for each type of firm serving the domestic market.

Table 1 reports the simulated effects on the domestic industry from a reduction in the fixed costs of entry for firms in the subject country. The table reports five different versions of the model with alternative assumptions about data inputs such as changes in fixed costs, market shares and elasticity parameters. We also assume that the total firm revenues from all sources in the industry sum to \$100

million so that the total firm revenues in each source also represents its respective market share, in percent, in Table 1.

Column v1 in table 1 serves as our benchmark simulation. We see that a reduction in fixed costs by 10 percent increases the prices of subject firms by 2.8 percent and total quantity by 14.1 percent. Domestic firms see a reduction in prices of -0.7 percent and total quantity by -3.6 percent. The overall consumer price index for this industry experiences a negligible change as the price reductions by domestic firms is countered by price increases of subject firms.

The remaining columns in table 1 report the sensitivity of these effects on the domestic industry to the main data inputs of the model. In column v2, we double the magnitude of the shock to fixed costs and find much larger effects for both domestic and subject firms. In column v3, we reduce the market share of subject firms, reflecting an industry where subject firms are less competitive with domestic firms than in the benchmark scenario. Compared to v1, there is a smaller effect to domestic firms and almost no change in the overall consumer price index. In column v4, we increase the elasticity of substitution from the benchmark so that consumers view domestic and foreign goods as more substitutable. We find smaller effects for both domestic and subject firms as a result of increasing the elasticity of substitution. In our framework, a higher elasticity of substitution corresponds to a lower fixed cost for subject firms in the baseline and so a reduction in fixed costs has less overall effect for market participants. Lastly, column v5 explores the effect of reducing the labor supply elasticity from the benchmark simulation. We find smaller changes in quantity for the firms, the sluggishness in labor markets limiting growth in labor supply and the number of new firms as a result of the reduction in fixed costs.

5. Conclusion

This paper discusses a trio of PE models recently developed at the U.S. International Trade Commission for mapping industry-specific policies in a trade agreement. We describe the main features of each PE model and illustrate how they can be used to analyze complex trade provisions, such as the effects on cross-border exports of U.S. e-commerce firms from the new USMCA de minimis provisions and the effects on the auto industry from new ROOs. We also discuss a PE model that can be used to determine effects of NTMs that raise the fixed costs of foreign firms. Given their versatility and practical simplicity, PE models are well-suited for challenging ex-ante quantification of other, non-tariff policies found in modern trade agreements, such as domestic regulations, investment, competition, and intellectual property rights.

Table 1: Model Simulations with Different Data Inputs

	V1	V2	V3	V4	V5
Inputs					
Revenue of Domestic Firms (millions of dollars)	40	40	45	40	40
Revenue of Foreign Firms of Subject Country (millions of dollars)	20	20	10	20	20
Revenue of Foreign Firms of Non-Subject Imports (millions of dollars)	40	40	45	40	40
Elasticity of Substitution	3	3	3	5	3
Labor Elasticity	5	5	5	5	3
Reduction in Fixed Costs (percent)	-10	-20	-10	-10	-10
Simulated Effects					
Change in Industry Price Index	-0.01	-0.02	-0.00	-0.00	-0.01
Domestic Firms					
Change in Price (percent)	-0.73	-1.60	-0.37	-0.43	-0.72
Change in Quantity (percent)	-3.63	-7.98	-1.83	-2.15	-2.17
Foreign Firms of Subject Country					
Change in Price (percent)	2.82	6.00	3.20	1.69	2.82
Change in Quantity (percent)	14.11	30.01	15.90	8.45	8.47

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