IMPORTS AND THE LOCATION OF VEHICLE PRODUCTION WITHIN THE UNITED STATES

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Abstract

Changes in tariffs or foreign production costs can alter the geographic concentration of motor vehicle production within the United States. I simulate the magnitude of these economic effects using a sub-national model of the motor vehicle industry that combines data on vehicle production at the level of individual plants and vehicle models with data on U.S. sales, multi-product ownership, and pricing. A new 25% tariff on U.S. imports from outside of North America would reduce vehicle imports by 73.9%, increase average prices of vehicles in the United States by 5.0%, and increase variable profits from domestic production by 5.2%. The resulting increase in North American vehicle production would be very unevenly distributed, with the largest percent increases in California, Tennessee, Georgia, and Alabama, moderate percent changes in Mexico and Canada, and the smallest percent increases in Missouri, Michigan, and Texas.

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1 Introduction

The motor vehicle industry, a major contributor to the U.S. economy, is especially open to competition from imports. An increase in the cost of imported vehicles – for example due to a new tariff, dollar depreciation, or other increases in the costs of foreign production – would lead to a reduction in vehicle imports, an increase in prices paid by U.S. consumers, and an increase in sales of domestically produced vehicles. In 2019, the U.S. Department of Commerce recommended Section 232 national security tariffs as high as 25% on all vehicle imports from outside of North America and 35% on imports of Sports Utility Vehicles and Crossover Utility Vehicles.[1] These tariffs were not ultimately applied by the President, but if they had been there likely would have been significant economic effects on the domestic industry.

This is suggested by an the economics literature that estimates intricate oligopoly models of the U.S. motor vehicle industry and uses these models to estimate the economic effects of changes in trade policy. Goldberg (1994) uses an econometric model developed in Goldberg (1995) to estimate the effects of the Voluntary Export Restraints (VERs) on exports from Japan in the 1980s and the North American Trade Agreement (NAFTA) in the 1990s. She finds that the VERs increased average vehicle prices in 1983 and 1984 and shifted demand to the used car market and to large and luxury new cars. She also finds that NAFTA shifted demand away from vehicles imported from Japan and Germany but only had small effects on prices and domestic sales. Berry, Levinsohn and Pakes (1999) use an econometric model that they develop in Berry, Levinsohn and Pakes (1995) to estimate the economic effects of the same Japanese VERs. They find that the VERs increased market prices in the United States and increased sales and profits from domestic production. The VERs resulted in a significant net decline in domestic consumer welfare because, unlike tariffs, there was no

[1] The Commerce recommendations are described in U.S. Department of Commerce (2019) and Congressional Research Service (2020).

additional government revenue collected by the VERs.

More recently, Grieco, Murry and Yurukoglu (2023) use an econometric model with data on second choice vehicle models, following the methodology in Berry, Levinsohn and Pakes (2004), to estimate the changes in price-cost margins and market power in the U.S. automotive industry between 1980 and 2018. They find that substitutability between vehicle models is significantly higher within vehicle class, and that U.S. prices rose while market concentration fell over the time period, mostly reflecting upgrading of product characteristics. Although Grieco et al. (2023) do not use their oligopoly model to directly estimate the effects of trade policy, they include a trade-related counterfactual simulation that estimates the economic effects of reassigning the ownership of foreign brands to U.S.-owned vehicle manufacturers.

While these intricate models of trade policy in the motor vehicle industry are informative about the market-wide effects of the trade policies on prices and total sales within the United States, they do not address how changes in trade policy affect production unevenly across states. The current geographic distribution of U.S. production of cars and light trucks is very concentrated, limited to 15 states in 2022, with a regional focus in the Midwest and Southeast. Changes in domestic production and employment due to a reduction in imports would be unevenly distributed across states, depending on the location of production of the vehicle models that most directly compete with the imports. In this paper, I build an industry-specific sub-national model of the motor vehicle industry to address this issue. Its main contribution is that it tracks the state-level effects of changes in trade policy in a detailed way.

I start with a simplified version of the model that includes six single-product firms that produce vehicles in two different domestic locations and one foreign location and sell in a common national product market. This simplified model identifies several economic factors that determine how the production effects are distributed across states. When domestic production is initially distributed unevenly across sub-national regions, the reduction in imports due to a new tariff leads to a greater percent expansion in the region that is initially smaller, resulting in partial convergence of production levels across domestic regions. The uneven distribution of the percent increases in vehicle production is a result of the variable markups that characterizes the Bertrand oligopoly model. Joint ownership of multiple products and multinational production through FDI are also important factors. Inbound FDI generally magnifies the effects on vehicle production in domestic locations where there is foreign transplant production.

Next, I use a more detailed and more realistic version of the model that is calibrated to plant-level data for the U.S. light vehicle industry. This full version of the model includes 313 distinct vehicle models, the complete pattern of multi-product ownership and market concentration, and the domestic or foreign location of assembly for each vehicle model. The resulting simulations provide estimates of economic effects that combine all of the factors highlighted by the simplified model. These simulations indicate that a new 25% tariff on all U.S. imports from outside of North America would reduce these imports by 73.9%, increase average prices of vehicles in the United States by 5.0%, and increase variable profits from domestic production by 5.2%. The resulting increase in North American production would be very unevenly distributed, with the largest percent increases in California, Tennessee, Georgia, and Alabama, moderate percent changes in Mexico and Canada, and the smallest percent increases in Missouri, Michigan, and Texas.

I also run simulations that limit the new tariff to imports from a single foreign country. They show that the segment composition of the imports and of domestic production in each state, and the location of foreign transplant production combine to explain the geographic distribution of the changes in domestic vehicle production.

The rest of the paper is organized in five parts. Section 2 starts with summary statistics for the U.S. light vehicle industry in 2022. Section 3 introduces the modeling framework.

Section 4 uses a simplified version of the model to illustrate the economic factors that shape how import shocks affect the level and location of domestic vehicle production. Section 5 reports simulated effects of a new 25% tariff using the full version of the model. Section 6 offers caveats, conclusions, and ideas for further research.

2 Summary Statistics for the Light Vehicle Industry

According to Ward's Intelligence, 21 manufacturers sold light vehicles in the United States in 2022.[2] All but one of these manufacturers sold multiple vehicle models, often under several different makes. For examples, Honda manufactures the Honda and Acura makes, and Ford manufactures the Ford and Lincoln makes. Examples of individual vehicle models include the Ford Escape and the Honda Accord.

Table 1 reports the number of vehicles, makes, and models in eight distinct classes of light vehicles, as well as the class' expenditure shares of imports from outside of North America. Small Crossover Utility Vehicles (CUVs), Luxury Cars, and Small Cars are the most import-intensive, while Mid and Large Cars and Pickups are the least.

Table 1: Light Vehicle Market Segments in 2022

Vehicle Class	Number of Vehicles	Number of Makes	Number of Vehicle Models	Quantity Share of Imports (%)
Small Cars	947,703	11	21	34.6
Mid and Large Cars	1,191,156	15	24	10.2
Luxury Cars	738,775	22	68	42.5
Small CUVs	1,639,542	23	40	46.8
Mid and Large CUVs	4,372,003	30	82	24.2
SUVs	1,388,875	14	25	13.9
Vans	616,048	12	17	10.6
Pickups	2,652,650	10	17	0.0

Table 2 reports the distribution of U.S. production of these vehicles across states in

[2]Ward's Intelligence, "U.S. Vehicle Sales by Vehicle Type and Source, 1931-2022."

2022. Michigan is at the top of the list, accounting for 19.0% of vehicles produced in North America in 2022, and the Upper Midwest states (Michigan, Indiana, Ohio, and Illinois) together account for 42.2%. Table 2 also reports each state's share of foreign transplant production in the United States. Transplant production is the U.S. production of foreign-owned manufacturers.[3] For example, all vehicles produced by Subaru in Indiana or by Honda in Ohio are U.S. transplant production. Alabama has the largest share at 22.9%, followed by Indiana, Kentucky, and Ohio. Together, these four states account of approximately one-third of the vehicles produced by foreign transplants in the United States.

Table 2: Levels and Shares of Production by State in 2022

States	Number of Vehicles	Share of U.S. Vehicle Production (%)	Share of U.S. Transplant Production (%)
Michigan	1,465,854	19.3	
Indiana	866,775	11.8	20.4
Kentucky	880,854	11.6	12.6
Alabama	731,662	9.9	22.9
Ohio	655,866	8.6	10.0
Texas	388,817	5.1	0.2
California	456,100	6.0	
Tennessee	374,515	4.9	8.3
South Carolina	267,846	3.5	8.2
Missouri	445,498	5.9	
Mississippi	305,322	4.0	9.3
Illinois	289,280	3.8	
Georgia	257,047	3.6	8.3
Kansas	137,241	1.8	
Arizona	3,535	0.0	

Overall, approximately 69% of total North American light vehicle production was located in the United States in 2022, 23% was located in Mexico, and the rest of North American production was located in Canada. Approximately 3 million new light vehicles were imported

[3] These calculations do not count U.S. production of Stellantis as transplant production, even though Stellantis is a multinational firm.

into the United States from outside of North America in 2022.

3 Economic Modeling Framework

The economic modeling framework adopts many of the assumptions in Goldberg (1994), Berry et al. (1999), and Grieco et al. (2023), including logit demand with many differentiated products, Bertrand Nash competition in prices, and constant marginal costs of production. Consumer demand in Berry et al. (1999) and Grieco et al. (2023) includes an outside alternative to new car purchases, while demand in Goldberg (1994) includes a decision about whether to purchase a new car in an earlier step in her sequential logit model. The analysis focuses on a short run equilibrium in which the set of producers and the vehicle models that they offer are pre-determined and therefore exogenous to the model.

While there are many similarities between my model and these earlier models in the literature, there are also important differences. First, Goldberg (1994) and Berry et al. (1999) focused on the national welfare effects of VERs in the 1980s and NAFTA in the 1990s, while the sub-national model in this paper simulates the impact on domestic vehicle production in individual states of a hypothetical new tariff.[4] Second, the earlier studies generate econometric estimates of demand parameters at the level of individual consumers, while the model in this paper calibrates its demand parameters to price-cost margins estimated by these earlier studies.

Consumers have discrete choice logit demands. Equation (1) is the quantity market share of vehicle model j, μ_j.

$$\mu_j = \frac{Exp\ (\beta_j\ -\ \alpha\ p_j\ \tau_j)}{1\ +\ \sum_{k=1}^{N} Exp\ (\beta_k\ -\ \alpha\ p_k\ \tau_k)} \tag{1}$$

p_j is the producer price of j. The tariff factor τ_j is equal to one plus the tariff rate if product

[4] Grieco et al. (2023) does not directly analyze the economic effects of trade policy.

j is imported from outside of North America. k indexes the N vehicle models sold in the U.S. market. The demand parameter β_j represents a composite of product characteristics like vehicle size, engine power, and appearance. This demand parameter is calibrated to initial quantity shares in the market.

If firm j only sells a single product j, then equation (2) is the profits of oligopolist j, π_j.

$$\pi_j = (p_j - c_j)\ \bar{Q}\ \mu_j - f_j \tag{2}$$

$\bar{Q}$ is the fixed total number of consumers in the market, including those who chose the outside option of purchasing a used vehicle or not purchasing any vehicle. c_j is the constant marginal cost of product j, and f_j is a fixed cost of production. Equation (3) is firm j's first order condition for its own price, given demand in equation (1).

$$1 - (p_j - c_j)\ \alpha\ \tau_j\ (1 - \mu_j) = 0 \tag{3}$$

The prices of firm j's competitors enter equation (3) through μ_j.

If the firm that sells product j also sells other products, then the profit function in equation (2) and the first order condition in equation (3) are replaced by the more generalized versions in equations (4) and (5).

$$\pi_j = \sum_{k=1}^{N} \phi_{jk}\ (p_k - c_k)\ \bar{Q}\ \mu_k - f_k \tag{4}$$

$$1 - (p_j - c_j)\ \alpha\ \tau_j + \sum_{k=1}^{N} \phi_{jk}\ (p_k - c_k)\ \alpha\ \tau_j\ \mu_k = 0 \tag{5}$$

Again, k indexes all products in the market, and ϕ_{jk} is an indicator variable that is equal to one if the same firm owns and controls products j and k and is equal to zero otherwise.

The model calibrates the N marginal costs c_j using the N first order conditions. The demand parameter β_j is calibrated according to equation (6).

$$\beta_j = \ln\left(\frac{\mu_j}{\mu_{out}}\right) \; + \; \alpha \; p_j \; \tau_j \tag{6}$$

μ_{out} is the initial share of potential consumers who chose the outside option, either purchasing a used vehicle or no vehicle. The initial share of potential consumers who choose the outside goods μ_{out} is set equal to 0.90, since approximately 90 percent of households do not purchase a new car each year, and either purchase no car or a used car, according to Goldberg (1994). The price-sensitivity parameter α is set equal to 1.275. This is the value of α that fits the median price-cost markup in the full version of the model in Section 5 to the median price-cost markup in 2018 from Grieco et al. (2023).

Finally, the model translates the changes in sales of each vehicle model into changes in the location of domestic vehicle production using data on the plant where each vehicle model is assembled.[5] The change in production in each location is the sum of the changes in production of all vehicle models with plants in that location.

4 Simplified Illustrative Model

To illustrate the many economic effects of a new tariff without the complexity of the plant-level data, I first present a simplified version of the simulation model with a hypothetical initial distribution of vehicle production across regions. In this illustrative model, domestic production occurs in two regions, North and South. Vehicle production in North is always larger or the same size as vehicle production in South. There are two domestic producers of vehicles in each of the two domestic regions and two foreign producers who import into the domestic market. Each producer sells a single vehicle model, so there are six products in the simplified model.

[5] The plant or plants where each vehicle model is assembled is exogenous to the model.

4.1 Non-Nested Logit Model

Consumer demand for the six products has the non-nested logit form in equation (1). The six products are differentiated, but they are not grouped into classes in the non-nested model. The illustrative model is calibrated to summary statistics for the U.S. market in 2022, including total sales of light vehicles (13.5 million vehicles), the import penetration rate in the United States (21.1%), and the average vehicle price ($40,195).

The model simulates the expansion in domestic production and other economic effects of a new 25% tariff on imported vehicles. Table 3 reports the simulated increase in the number of vehicles and the corresponding percent changes. To illustrate how asymmetry in the initial distribution of domestic production across regions shapes the distribution of production effects, the rows of the table report simulation results for three alternative assumptions about the initial share of domestic production in North.

Table 3: Changes in the Number of Vehicles Produced, Non-Nested Logit

Initial North Share of Domestic Production (%)	Change in North (%)	Change in South (%)	Change in Imports (%)
50	71,604	71,604	-1,810,770
	(1.343)	(1.343)	(-63.510)
60	85,565	57,530	-1,810,760
	(1.338)	(1.349)	(-63.510)
70	99,416	43,336	-1,810,760
	(1.332)	(1.355)	(-63.510)

In response to the new tariff and the increase in import prices, imports decline and vehicle production rises in both domestic regions, North and South. The changes in domestic production are unevenly distributed. The simulated increase in the number of vehicles is larger in the North when North initially accounts for more than half of domestic production.[6]

[6] The estimated changes in the number of vehicles produced assumes that a combined 13,512,553 vehicles are produced in the two regions in the initial equilibrium.

The difference between the change in the number of vehicles produced in the two regions is increasing in the initial relative size of North. On the other hand, the *percent changes* are larger in South when North initially accounts for more than half of domestic production, and this difference between the two regions is increasing with the initial relative size of North. When there is initial asymmetry, South partially catches up as a result of the overall expansion of the domestic industry, and the production levels in the two regions partially converge.

The asymmetries in the simulation results in Table 3 are a result of the variable markups in the Bertrand oligopoly model. If domestic producers were perfectly competitive and set prices equal to marginal costs with no markups, then producers in North and South would both expand at the same rate in response to the new tariff on imports, since there would be no change in their constant marginal costs and therefore no change in their relative prices. This reflects the Independence of Irrelevant Alternatives (IIA) property of the non-nested logit model and the modeling assumption that marginal costs are constant. In a demand system with IIA, an increase in the price of one product will increase demand for a second and a third product at the same rate, so that the demand for the second relative to the third remains the same.[7] To demonstrate this point, Table 4 reports simulations using a more restricted version of the illustrative model without markups. In this case, the percent change in domestic production is the same in North and South, regardless of the initial relative size of the two regions. In contrast, the variable markups in the oligopoly model are responsible for the asymmetric growth rates across regions in Table 3.

The simulations reported in Table 5 extend the simpified model to focus on the implications of multi-product firms, and specifically the impact of joint ownership of foreign and domestic production within the same firm through foreign direct investment (FDI). In this case, the first order conditions for the multi-product firms are based on equation (5) rather

[7]Constant elasticity of substitution demand also has the IIA property.

Table 4: Changes in Vehicles Produced Without Variable Markups, Non-Nested Logit

Initial North Share of Domestic Production (%)	Change in North (%)	Change in South (%)	Change in Imports (%)
50	82,500	82,500	-2,047,130
	(1.548)	(1.548)	(-71.800)
60	99,000	66,000	-2,047,130
	(1.548)	(1.548)	(-71.800)
70	115,500	49,500	-2,047,130
	(1.548)	(1.548)	(-71.800)

than equation (3). This extension of the simplified model assumes that two of the firms manufacture one product in South and import a second product. In other words, there is foreign transplant production in the South owned by firms that also import.

Table 5 reports simulation results for this model extension with FDI, again for the same 25% tariff on imported vehicles. In this case, since production in South is owned and controlled by foreign producers, there is a larger percent increase in production in South than in North *even if* production levels in the two regions are initially equal. Foreign-owned domestic producers increase their prices less in response to the increase in import prices, to offset some of their loss of import sales. There are much larger increases in vehicle production in South compared to North in Table 5. In addition, the increases in production in South in the FDI extension of the model (Table 5) are much larger than the increases in South in the basic model that does not have multi-product firms (Table 3).

4.2 Nested Logit Model

The independence of irrelevant alternatives (IIA) property of logit models is a limitation that is usually addressed in the literature on competition in the motor vehicle industry. For example, Goldberg (1994) and Goldberg (1995) develop a sequential nested logit framework

Table 5: Changes in Vehicles Produced with FDI, Non-Nested Logit

Initial North Share of Domestic Production (%)	Change in North (%)	Change in South (%)	Change in Imports (%)
50	69,973	111,732	-1,811,270
	(1.313)	(2.096)	(-63.528)
60	84,011	89,781	-1,811,160
	(1.313)	(2.105)	(-63.524)
70	98,067	67,637	-1,811,060
	(1.314)	(2.115)	(-63.520)

to allow for more complex patterns of substitution among pairs of vehicle models.[8] In the same spirit, this section considers a nested logit extension of the illustrative model. There are two classes of vehicles, and two corresponding nests in the logit demand system. One product from each class is produced in each of the three locations, so there are still six differentiated products. Equation (7) is the share equation for the nested logit model, with a nesting parameter θ that ranges from zero to one and is lower when the products are more similar.

$$\mu_j = \left(\frac{Exp\ (\theta\ \gamma_c)}{1\ +\ \sum_d Exp\ (\theta\ \gamma_d)} \right) \left(\frac{Exp\ \left(\frac{\beta_j\ -\ \alpha\ p_j\ \tau_j}{\theta}\right)}{1\ +\ \sum_{k \in c} Exp\ \left(\frac{\beta_k\ -\ \alpha\ p_k\ \tau_k}{\theta}\right)} \right) \tag{7}$$

Class c is the nest that includes product j, and d indexes both of the classes. γ_c is defined in equation (8).

$$\gamma_c = Log\ \left(\sum_{j \in c} Exp\ \left(\frac{\beta_j\ -\ \alpha\ p_j\ \tau_j}{\theta} \right) \right) \tag{8}$$

The first order condition for single-product firms in equation (3) still applies, though μ_j is defined differently, according to equations (7) and (8).

[8] Berry et al. (1995) and Berry et al. (1999) develop a random coefficients logit model that also avoids the IIA property.

Table 6 illustrates the importance of nesting by varying the nesting parameter θ across the rows of the table. All three simulations assume that domestic production is initially distributed unevenly, with 60% in North and 40% in South, and that each firm produces a single product. The estimates with $\theta = 1$ are identical to the middle row in the non-nested simulations reported in Table 3. Lowering θ increases the magnitude of the estimated effects on domestic production and imports. Nesting does not change the signs of these effects.

Table 6: Changes in Vehicles Produced, Nested Logit

Nesting Parameter θ	Change in North (%)	Change in South (%)	Change in Imports (%)
1.00	85,565	57,530	-1,810,760
	(1.338)	(1.349)	(-63.510)
0.75	350,894	236,683	-2,078,600
	(5.485)	(5.550)	(-72.904)
0.50	720,465	495,289	-2,435,310
	(11.404)	(11.614)	(-85.415)

4.3 Market-Wide Effects

The four versions of the illustrative model also generate estimates of market-wide effects. Table 7 reports the percent changes in total market demand, the quantity of imports, average vehicle prices in the market, and variable profits from domestic production for the four versions of the model. These market-wide effects are not especially sensitive to the initial share of North in domestic production, so all of the simulations reported in Table 7 assume that this initial share is equal to 60%.

In all four simulations, the new tariff reduces total quantity demanded in the market and reduces the number of imported vehicles, while it increases the average price in the market and the variable profits from domestic production. The changes in market-wide aggregates

Table 7: Percent Changes in Market-wide Aggregates

Estimated Effect	Non-Nested Model	Non-Nested Model without Markups	Non-Nested Model with FDI	Nested with $\theta = 0.75$
Total Market Demand	-12.3	-13.9	-12.1	-11.0
Imports	-63.5	-71.8	-63.5	-72.9
Average Prices	4.2	5.3	4.2	4.2
Variable Profits from Domestic Production	1.4	n/a	1.4	5.6

are generally magnified when the simulations do not include variable markups or when there is nested logit demand.

The illustrative model isolates the effects of several different factors, one at a time, including the initial location of domestic vehicle production, variable markups from Bertrand competition in prices, and joint ownership and control over multiple vehicle models. In fact, the economic effects on the industry are a complex mix of all of these factors. The full version of the model in the next section brings them all together.

5 Simulations Using the Full Version of the Model

The full version of the model is much more elaborate. It incorporates detailed data on plant-level production and sales in 2022 and 313 specific vehicle models. It is similar to the detailed calibrated simulation models of the light vehicle industry in U.S. International Trade Commission (2019) and U.S. International Trade Commission (2023). These two reports develop vehicle model-level simulation models that estimate the economic effects of the automotive rules of origin in the U.S.-Mexico-Canada Agreement (USMCA).[9]

[9] The two reports find that the change in the USMCA rules of origin increased U.S. employment in parts production while slightly reducing U.S. employment in vehicle assembly. The rules led to a small increase in average vehicle prices, a reduction in U.S. vehicle imports from Mexico and Canada, and an increase in

The full version of our model has a more elaborate nested logit demand system with eight distinct classes of vehicles represented by eight nests.[10] Another distinction is that our model tracks the sub-national location of vehicle production and the uneven distribution of production effects across states. Vehicle production occurs in 18 distinct production locations (15 states, Canada, Mexico, and the Outside of North America).[11]

The full version of the model uses detailed sales and production data from Ward's Intelligence.[12] It uses prices of the most popular trim of each vehicle model in 2022 from the Kelley Blue Book at the level of individual vehicle models.[13]

5.1 A New Tariff on All Imports from Outside North America

Table 8 reports the market-wide effects of a new 25% tariff on all U.S. imports from outside of North America for alternative assumptions about the nesting parameter θ. The first column of estimates, with $\theta = 1.00$, is non-nested logit. In every column, the new tariff reduces total demand and imports and increases average prices and variable profits from domestic production. In the case with moderate segmentation of the market into vehicle classes ($\theta = 0.75$), the new tariff reduces these imports by 73.9%, increases average prices of vehicles in the United States by 5.0%, and increases the variable profit from domestic production by 5.2%. As θ is lowered, the percent changes in total demand and average prices are dampened or the same, while the percent changes in imports and the profits of domestic producers are amplified.

U.S. imports from outside of North America.

[10]Table 1 lists the eight market segments.

[11]The 15 states are Alabama, Arizona, California, Georgia, Illinois, Indiana, Kansas, Kentucky, Michigan, Mississippi, Missouri, Ohio, South Carolina, Tennessee, and Texas.

[12]Ward's Intelligence, "North America Vehicle Production by State and Plant, 2017–2021" and "U.S. Vehicle Sales by Vehicle Type and Source, 1931-2022."

[13]`https://www.kbb.com/car-prices/`.

Table 8: Simulated Market-Wide Effects – All Countries

Estimated Changes (%)	$\theta = 1.00$	$\theta = 0.75$	$\theta = 0.50$
Total Market Demand	-12.7	-11.2	-8.9
Imports	-66.0	-73.9	-84.6
Average Prices	5.0	5.0	5.0
Variable Profits from Domestic Production	1.4	5.2	10.4

Table 9 indicates that the new tariff also results in an overall shift in U.S. light vehicle sales toward Pickups, Mid and Large Cars, Vans, and SUVs. These are the four vehicle classes with the lowest import penetration rates in 2022 (Table 1).

Table 9: Shifts in Class Shares and Average Prices ($\theta = 0.75$)

Vehicle Classes	Initial Share (%)	New Share (%)
Small Cars	7.0	6.7
Mid and Large Cars	8.8	9.5
Luxury Cars	5.2	4.1
Small CUVs	12.1	10.4
Mid and Large CUVs	32.4	31.5
SUVs	10.3	10.6
Vans	4.6	4.9
Pickups	19.6	22.4

Table 10 reports the simulated changes in the total number of vehicles produced for the U.S. market by location (state or country in North America). With moderate segmentation of the market into vehicle classes ($\theta = 0.75$), the largest percent increases in vehicle production are in California, followed by Tennessee, Georgia, and Alabama.[14] This ranking reflects many factors. These states generally focus on production of Luxury Cars and Mid and Large CUVs, and most have significant foreign transplant production.

[14]It is important to keep in mind that the model is estimating the expansion of production at existing plants in specific states and not the addition in new plants or new states.

Alternatively, the production effects can be ranked by the share of the total increase in North American vehicle production that is contributed by each state and country in North America. According to this second ranking, Mexico accounts for 21.4% of the total increase in North American production, while Canada accounts for 9.9%. The largest contributing state is Alabama (accounting for 9.6%), followed by Michigan (8.5%), California (8.4%), and Indiana (8.1%).[15] This second ranking reflects the large initial production levels in Mexico, Canada, Michigan, and Indiana.

A comparison of the estimates for the different columns in Table 10 demonstrates the impact of nesting on the geographic dispersionf of production effects. In the first column ($\theta = 1$), there is no nesting and there is much less heterogeneity in the percent changes across states and countries in North America. In this case, the coefficient of variation of the percent changes for the 13 states in the table is 0.04. In contrast, when $\theta = 0.50$, the coefficient of variation of the percent changes is 0.50.

Table 11 examines the sensitivity of the simulation model to incorporating the pattern of joint ownership across individual vehicle models.[16] The simulation in the last column removes joint ownership and multi-product profit maximization by setting ϕ_{jk} equal to one if j is the same as k and equal to zero otherwise. This restriction has only a small effect on the percent changes in vehicle production due to the new tariff. Indiana, Alabama, Kentucky, Georgia, Mississippi, and Texas have the largest reductions in their percent changes when the pattern of joint ownership is removed from the model. They are top states for transplant production according to Table 2.

[15]For brevity, the table does not report the small effects on vehicle production in Kansas (5,149 vehicles, 0.9% of the North American total increase) or Arizona (532 vehicles, 0.1%).

[16]All of the simulations in Table 11 assume that θ is equal to 0.75.

Table 10: Simulated Changes In Production Due to Tariff Changes on All Imports

States and Countries	$\theta = 1.00$	$\theta = 0.75$	$\theta = 0.50$
Alabama	11,476	55,487	123,395
	1.524%	7.369%	16.387%
California	6,321	48,533	106,215
	1.386%	10.641%	23.288%
Canada	15,160	57,134	116,150
	1.489%	5.612%	11.409%
Georgia	4,142	20,728	46,456
	1.517%	7.591%	17.013%
Illinois	4,021	14,080	26,731
	1.390%	4.867%	9.240%
Indiana	13,701	46,474	92,304
	1.523%	5.166%	10.260%
Kentucky	13,272	45,058	88,262
	1.510%	5.128%	10.045%
Mexico	30,158	123,503	271,112
	1.456%	5.963%	13.089%
Michigan	20,589	48,860	86,261
	1.404%	3.333%	5.884%
Mississippi	4,597	13,327	27,214
	1.504%	4.360%	8.902%
Missouri	6,205	8,597	11,653
	1.395%	1.933%	2.619%
Ohio	9,096	28,327	53,639
	1.389%	4.326%	8.191%
South Carolina	4,018	16,869	34,353
	1.496%	6.281%	12.790%
Tennessee	5,335	29,601	65,686
	1.424%	7.904%	17.539%
Texas	5,753	14,784	25,681
	1.480%	3.802%	6.605%
Imports from the	-1,867,790	-2,089,770	-2,394,010
Rest of the World	-66.017%	-73.863%	-84.616%

Table 11: Simulated Changes without Joint Ownership

States and Countries	With Joint Ownership	Without Joint Ownership
Alabama	55,487 7.4%	54,481 7.2%
California	48,533 10.6%	48,769 10.7%
Canada	57,134 5.6%	56,245 5.5%
Georgia	20,728 7.6%	20,398 7.5%
Illinois	14,080 4.9%	14,161 4.9%
Indiana	46,474 5.2%	45,258 5.0%
Kentucky	45,058 5.1%	43,998 5.0%
Mexico	123,503 6.0%	122,574 5.9%
Michigan	48,860 3.3%	49,005 3.3%
Mississippi	13,327 4.4%	13,012 4.3%
Missouri	8,597 1.9%	8,686 2.0%
Ohio	28,327 4.3%	28,578 4.4%
South Carolina	16,869 6.3%	16,630 6.2%
Tennessee	29,601 7.9%	29,606 7.9%
Texas	14,784 3.8%	14,404 3.7%
Imports from the Rest of the World	-2,089,770 -73.9%	-2,090,660 -73.9%

5.2 Country-Specific Tariff Changes

The final simulations examine the effects of a new tariff that is limited to imports from a single country outside of North America, either Japan, Korea, or Germany. The estimated percent increases in production vary across the states depending on the segment concentration of imports from the country, the vehicle class concentration of each state's production, and the location of the transplant domestic production of Japanese, Korean, or German manufacturers.

Table 12 indicates that vehicle imports from Japan were relatively concentrated in the Mid and Large CUV sales in 2022. In contrast, vehicle imports from Korea were relatively concentrated in the Small CUVs, while imports from Germany were relatively concentrated in Luxury Cars.

Table 12: Vehicle Class Shares by Country of Origin

Vehicle Class	All (%)	Japan (%)	Korea (%)	Germany (%)
Small Cars	11.6	13.5	16.7	
Mid and Large Cars	4.3	4.8	5.2	6.1
Luxury Cars	11.1	3.2	3.2	58.5
Small CUVs	27.1	21.2	45.0	5.9
Mid and Large CUVs	36.6	42.5	27.5	29.4
SUVs	6.8	14.9		
Vans	2.3		2.4	0.2
Pickups				

Table 13 indicates the location of North American foreign transplant production owned by Japanese, Korean, and German manufacturers. For Japan, the top states and countries in North America are Indiana, Canada, Mexico, and Kentucky. For Korea, they are Alabama, Georgia, and Mexico. For Germany, they are Mexico, South Carolina, and Alabama.

Table 13: Production Location by Foreign Nationality

Location in North America	Japan (%)	Korea (%)	Germany (%)
Canada	16.2		
Mexico	14.8	22.0	42.8
Alabama	9.1	51.8	11.6
Georgia		26.2	
Indiana	19.7		
Kentucky	12.1		
Mississippi	9.0		
Ohio	9.7		
South Carolina			37.0
Tennessee	6.2		8.6
Texas	3.2		

These vehicle class and production location shares of manufacturers from the three countries help to explain the simulation results for country-specific tariff changes in Table 14.[17] In the simulation with the new tariff applied only to imports from Japan, the largest percent increase in North American vehicle production are in Illinois, followed by Tennessee, Texas, Georgia, and Alabama. In the simulation that focuses on a tariff on imports from Korea, the largest percent increase in North American vehicle production are in Georgia, followed by Alabama, Tennessee, and Mexico. Finally, in the simulation that focuses on imports from Germany, the largest percent increase in North American vehicle production are in California, followed by Kentucky, South Carolina, and Tennessee.

[17] The first column of estimates repeats the $\theta = 0.75$ column from Table 10.

Table 14: Simulated Changes in Vehicles Produced – Specific Countries

States and Countries	All	Japan	Korea	Germany
Alabama	55,487	18,883	16,976	4,202
	7.4%	2.5%	2.3%	0.6%
California	48,533	10,003	5,724	21,484
	10.6%	2.2%	1.3%	4.7%
Canada	57,134	23,160	13,276	5,868
	5.6%	2.3%	1.3%	0.6%
Georgia	20,728	6,898	6,639	1,696
	7.6%	2.5%	2.4%	0.6%
Illinois	14,080	8,855	1,577	905
	4.9%	3.1%	0.5%	0.3%
Indiana	46,474	19,106	10,461	4,709
	5.2%	2.1%	1.2%	0.5%
Kentucky	45,058	16,326	7,681	11,928
	5.1%	1.9%	0.9%	1.4%
Mexico	123,503	42,146	37,759	10,781
	6.0%	2.0%	1.8%	0.5%
Michigan	48,860	24,360	8,378	6,109
	3.3%	1.7%	0.6%	0.4%
Mississippi	13,327	6,007	4,147	1,112
	4.4%	2.0%	1.4%	0.4%
Missouri	8,597	1,986	2,389	863
	1.9%	0.4%	0.5%	0.2%
Ohio	28,327	13,076	5,188	3,794
	4.3%	2.0%	0.8%	0.6%
South Carolina	16,869	5,852	3,447	2,517
	6.3%	2.2%	1.3%	0.9%
Tennessee	29,601	10,396	7,821	3,167
	7.9%	2.8%	2.1%	0.8%
Texas	14,784	10,453	1,396	704
	3.8%	2.7%	0.4%	0.2%
Imports from the	-2,089,770	-804,261	-523,249	-316,464
Rest of the World	-73.9%	-28.4%	-18.5%	-11.2%

6 Conclusions

A new tariff on all U.S. light vehicle imports from outside of North America would increase domestic production and the average prices of vehicles in the United States. The production effects would be unevenly distributed, with the largest percent increases in California, Tennessee, Georgia, and Alabama, moderate percent changes in Mexico and Canada, and especially small percent increases in Missouri, Michigan, and Texas. This distribution of economic effects reflects the vehicle class of imports and vehicle production in each state, as well as the location of foreign transplant production.

There are important caveats and limitations of the model that are worth noting. First, the model estimates changes in vehicle production levels, but not changes in employment levels, due to data limitations at the plant level. Direct employment effects will likely be closely linked to production effects, especially if there are constant returns to labor and wages are determined on a broader economy-wide labor market. There may be substantial indirect employment effects as well, as the shifts in labor demand spill over to the supply chain, affecting manufacturers of engines, transmissions, brakes, electronics, steel, and aluminum producers, though these effects are also not included in the model due to data limitations. Second, as noted by Goldberg (1994) and Berry et al. (1999), it would be very useful to expand the analysis into a dynamic framework, but this will be difficult due to the complexity of the capital-intensive motor vehicle industry. Hashmi and van Biesebroek (2016) provides an interesting example of a dynamic model of the motor vehicle industry; however, their dynamic model is at the firm level rather than the vehicle model level, and it focuses on how market structure affects incentives to innovate rather than trade policy.

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