

# **A Determination Of National Macroeconomic Variables Impacting Public Trade Policy And Organizational Production Forecasting Related Tothe Domestic Multinational Automobile Industry In The United States**

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## **Abstract**

*Accurate internal vehicle sales forecasts for multinational automobile organizations (MAO) are vital to production planning as both overproduction and underproduction can ruin the bottom line if they do not match consumer demand. While increasing the total number of vehicles sold internationally is a major goal of any MAO, sheer vehicle sales may not enhance the bottom line of an automobile organization. There is intense competition for global market share between MAOs in areas such as innovative technology, branding, and total global vehicle sales. As international supply chains have become more volatile since the onset of the global pandemic and semiconductor shortages are halting the operations of entire factories (Oi, 2022; Reuters, 2022; Printz, 2023), it is more important than ever that sales correspond to projected production schedules. Since supply chain scheduling is coordinated over a year in advance, the most successful MAOs spend a great deal of time and resources on these forecasts so that parts, machining, energy usage, and training can be planned accordingly. This study will examine the effects of macroeconomic variables including national tariff rates, exchange rates, and changes in GDP on imported vehicles in order more accurately predict the likelihood of export vehicle sales in industrialized countries. The results can be used to influence macroeconomic public trade policy recommendations and opportunities for MAOs to enhance profits.*

**Keywords-** *production planning, multinational automobile organization, vehicle sales projections, automobile tariffs, international supply chains*

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## **I. Literature Review**

When developing macroeconomic public trade policy, the domestic automobile industry has increasingly been the focus of governments around the world, especially in industrialized and industrializing countries, where numerous fiscal tools such as tariff rates have been manipulated by bureaucrats to keep imported vehicles from entering the domestic market depending on the political goals of those in charge (Lee and Mah, 2017; Miglani, 2019; Chen et al., 2020). More accurate methods of determining vehicle imports and/or exports due to increased competition are sought after, and various economic strategies have been utilized by federal governments to manipulate vehicle imports. Although consumers are generally in favor of more buying options, including imported automobiles, governments often attempt to protect the politically sensitive domestic automobile industry.

The automobile industry is constantly innovating and attempting to carve out more market share. Of the top 25 international organizations in research and development spending from 2021, seven were MAOs (Petrov, 2022). The total ranking of worldwide vehicle sales is routinely an area of major focus by auto industry executives, and constant advancements in technology with decreasing product life cycles prompt new models of vehicles to be released, usually facilitated by expensive, high-risk organizational marketing endeavors (Hagerman, 1978, Candelo, 2019; Blowers, 2021; Kallman, 2021).

The release of new models makes production scheduling especially difficult to forecast since predicting sales years necessitates production planning around what could be new sales estimates (Kuhn & Tebbe, 2012; Gobetto, 2013). Production planning in the automobile industry in recent decades has become more complex than ever (Balachander et al., 2009; Cacho and Olivares, 2010), and the post-pandemic environment is

additionally facing pressures from the fallout of the global semiconductor shortage, which caused entire factories to halt operations, even at Toyota in Princeton, Indiana, where the factory had not been idle since its inception in the 1990s. In addition, the industry's just-in-time supply chain philosophies are being reconsidered amid a volatile post-pandemic global marketplace where bottlenecks could lead to a domino effect of stalled production facilities, even if just one part is unobtainable for a short amount of time. The current economic environment necessitates accurate predictions of sales to be profitable for both economic practitioners as well as auto executives.

Forecasting vehicle sales in the automobile industry is not a new phenomenon. La Fever (1924) stated that "the automobile industry in its various ramifications affects other industries in almost every part of the world" (p. 735). There is a longstanding literature on global automobile sales forecasting, and even stock markets have been utilized to predict vehicle sales (Pai and Liu, 2018). Automotive sales predictions traditionally focus on factors such as advertising, brand preference, life cycle position, retail price, and technological sophistication (p. 416, 2011, Landwehr et al.). "When economic thinking is applied to the real world, it almost always involves a prediction of events based on past data and model" (Loomis and Cox, 2000, p. 349), and this applies directly to the automobile industry.

Macroeconomic trade policy as it relates specifically to vehicle imports has been an area of economic focus, as trade barriers can be erected by governments to thwart imports and thus spur domestic production. Economic policy experts routinely use a variety of variables to attempt to manipulate vehicle sales at the whims of government bureaucrats due to the automobile industry's impact on issues such as GNP, national pride, economic infant industry theory (advocating for the government to directly protect new organizations in key, undeveloped future industries), lobbying efforts, military connections, and so forth. "Automobile market behavior is of significant interest because of the substantial impacts of automobile production and use on a variety of public policy concerns" (Berkovec, 1985, p. 195). "Quantitative and detailed trade policy information and analysis are more necessary now than they have ever been" (p. 7, WTO, 2012), so public trade policy policies are more than ever based on the needs of the domestic automobile industry.

The United States has a long history of using public policy to try to enhance the automobile industry. Kelly (1924) noted the US federal government's protectionist economic mindset as it related to the domestic auto industry in the early twentieth century: "The romance of American business holds no more interesting chapter than that which deals with the rise of the automobile industry. And that industry has no more interesting or significant phase than its export trade" (p. 251). In 1981, the US government requested to Japan that its government initiate voluntary export restraints on Japanese-produced vehicles, saving US auto-related jobs but ultimately harming US vehicle consumers. Nevertheless, this plan was ultimately deemed to be successful for the US auto industry (Berry et al., 1999). The overall implications of the economy over the long run, including for consumers, have been mixed. No matter the impact, today, many national economies take their automobile industry into account when formulating federal monetary policies. For example, South Korea has depended on automobile exports to propel its economy over the past few decades and has developed public policy to facilitate this (Green, 1992; Lee et al., 1996). Other countries such as Vietnam are actively pursuing changes in automobile supply chain trade policies (Schröder, 2021), and it is common for countries around the world to engage in macroeconomic trade policy around their domestic automobile industry's interests.

Both automobile organizations and federal monetary policies tend to heavily focus on the number of imported vehicles being bought domestically. Since the automobile industry is considered politically important in many countries, protectionist trade policies to limit imports which might compete with domestic production via macroeconomic public trade policy are commonly based on various forecasting methodologies using a variety of monetary tactics (Nelson, 1996; US Customs Service, 1997; Feenstra, 2008; Maswood, 2018). Even with increased consumer demand for imported vehicles, federal trade barriers can limit opportunities to buy these imports, as "Direct export opportunities and import competition also determine industrial preferences over trade" (Osgood, 2018, p. 456).

Federal trade policies tend to be "carried out on the very detailed level of tariff lines, for which several million pieces of tariff information exist" (Pelikand and Brockmeier, 2008, p. 685) and in particular, tariffs are directed towards geopolitically sensitive domestic industries by federal governmental actions such as levying taxes on imports, anti-dumping duties, quota limits, and a variety of other measures like subsidies (WTO, 2012, p. 63-64). The notion that a country can improve select industries through the imposition of federal monetary policy "has been in the economics literature for over a century" (Broda et al., 2008, p. 2064). Tariffs in particular are a public policy tool of governments that can help control imports (Pelikand and Brockmeier, 2008; WTO, 2012), and studies on tariff rates as they relate to the automobile industry have been common for decades (Arthagnani, 1970, Goldberg, 1995; Deng and Ma, 2010, Lee, 2011, Shioji, 2012, Schröder, 2021). Countries are constantly assessing optimal tariff rates that will enhance their domestic automobile industries and overall economy (Broda et. al, 2008). "The economic policy of restricting imports and the economic policy of opening exports remain two critical measures of international trade" and there exists a "statistically significant

correlation of trade policy variables on exports and imports” (Yeo & Deng, 2019, p. 43). Since taxes on automobile imports have been used as an economic tool for protectionism in the automobile industry, tariffs are an important variable when attempting to forecast future vehicle sales.

This study utilizes a macroeconomic economic model approach because microeconomic forecasting involves variables at the firm level, whereas this study focuses on federal monetary policy and the domestic automobile industry as a whole (Loomis and Cox, 2000). Creating accurate predictive models based on relevant economic variables “is not necessarily straightforward. It involves choosing between descriptive statistics and modelling approaches” (WTO, 2012, p. 8). Because of the high stakes involved in the global automobile industry in terms of vehicle sales and supply chain planning, this study will construct predictive models to better forecast sales of imported vehicles.

## **II. Methodology**

This study will analyze total American-manufactured vehicles exported to each of the top ten industrialized countries. Data for this analysis was acquired from multiple sources. The total number of American automobile exports by year was obtained from the United States Trade Commission (USTC, 2023). US automobile exports were used as the proxy for imports, by identifying the top ten countries in which the US sells automobiles abroad. In addition to using tariff rates (or ad valorem duties for each import subtype) on imported vehicles, other variables were included in the models to account for extraneous economic factors with the potential to impact the dependent variable. For instance, currency fluctuations could influence the likelihood of imports, so international exchange rates were also utilized. Tariff and exchange rate data were obtained from the World Trade Organization Tariff Data (2023) service.

Sales of imported vehicles must be taken into account when considering changes in discretionary income available for vehicle purchases in general. Therefore, gross domestic product (GDP), a comprehensive measure of federal economic activity, was included as an additional extraneous control variable; data were obtained from the United Nations (UN Data, 2023), specifically gross domestic product per capita (GDP / population) in \$USD, for all ten export countries (2011-2020).

Information about the specific vehicles being exported came from economic data from the North American Industry Classification system (NAICS), which is a benchmark in determining economic value. Specifically, data for NAIC number 336111, representing “AUTOS & LIGHT DUTY MOTOR VEHICLES, INCL CHASSIS”, which includes sub areas 3361 (Motor Vehicles), 336112 (Light Truck and Utility Vehicle), and 33611 (Autos, light duty, motor vehicles, incl chassis), were used. “This U.S. industry comprises establishments primarily engaged in (1) manufacturing complete automobiles (i.e., body and chassis or unibody) or (2) manufacturing automobile chassis only” (SIC Code, 2023), so using those values covers all the value of that final product, or “whose economic value is represented via a final level code of the entire manufacturing sector” (SIC Code, 2023). There were 408 American companies verified as active in this industry during the years of the study, with an estimated employment of 90,890 people in 2021 (SIC Code, 2022). This classification was recommended as a means of value because it also included the production process to create the final product, whereas “The products made may be sold separately or may be assembled on purchased chassis and sold as complete vehicles” (SIC Code, 2023). In general, this classification is for vehicles made for highway use, including electric vehicles. The data covered the years 2014-2020 (see appendix A).

Data from the European Union comprised France, Germany, and Italy for all years and the UK for ten years, until 2020. The tariff rates were not disparate for all EU countries given that they share the same rate. Data for Russia were incomplete for years 2017 and 2018. Japan had a unique policy among the selected countries that an import tariff on automobiles is not levied, so values for Japan were “0” to reflect the true tariff policy (Valdes-Dapena, 2018; Japan Customs, 2022), and as such, Japan was removed from the sample set prior to analysis. This was a limitation of this study, that would have forced an additional quantitative transformation with implications for the parameter estimates. India and Japan stood out as the highest and lowest exchange rates, respectively. The variables were generally stable over time, with the only notable exception being imports from India in 2018 and later and the overall downward trend of Russia.

This study reflected a longitudinal analysis due to the various variables being considered over a span of time. In the modeling process, a single value for the tariff rate was calculated for each country during each year as a weighted average across the respective year. All economic variables were transformed by the natural logarithm prior to running the model, leading to the parameter estimates being an analog to “elasticity” as defined in econometrics. Automobile exports were modeled as the dependent variable with the individual country statistics including tariff rate, exchange rate, and GDP as the independent variables. Time was included as a continuous covariate with Year = 1 corresponding to 2014. Analysis followed a repeated measures design using the proc mixed procedure from SAS<sup>TM</sup> Software (SAS Institute, v9.4). Data visualizations were prepared using R v4.3.0.

A first-order heterogenous autoregressive (ARH(1)) covariance structure with countries as the subject of repeated measures over the years was utilized, and the heteroscedasticity consistent sandwich estimator was used for standard error estimation. An autocovariance structure model plots points closer in time and is more correlated with a predictable decay over time. The heteroscedasticity consistent estimator accounts for the difference in variance of data between the countries. Additionally, random effect terms were considered in conjunction with and separately from a correlated error design. Model performance at this stage was assessed by multiple information criteria (BIC, AICc) and likelihood ratio tests. Information criteria worked as a relative metric of model fit while accounting for model complexity. The lower of two values represents better model fit, with a magnitude of a difference of 3 being the smallest difference considered meaningful.

### III. Results/Reactions

Performance of the full three-variable (exchange rate, GDP, and tariff rate) model (Model 1) and the three reduced models (Models 2, 3, and 4) were compared by multiple information criteria. Removing the tariff rate (Model 1 to Model 2) provided a marginal improvement in the overall model performance without a statistically significant reduction in model fit (Likelihood Ratio Test,  $p = 0.58$ ), with minimal impact to parameter estimates for exchange rate and GDP. In general, both models 1 and 2 have superior fit to both models 3 and 4 (LRT with Model 1,  $p = 0.003$  and  $p < 0.001$ , respectively). These findings suggest that among these three variables, tariff rate may have the least predictive value for automobile exports. Further, Model 2 would be the best predictive model.

**Table 1.**  
**Summary of Comparative Model Fit: Repeated Measures**

Model	Parameter Estimates* (p-value)				-2logLik**	AICc**	BIC**	Rank
	GPD	ExRate	TariffRate	Year				
1	<b>2.2475</b> (0.002)	<b>1.5443</b> ( $<0.0001$ )	0.267 (0.533)	<b>-0.1404</b> (0.0013)	88.0	121.7	116.5	2
2	<b>2.071</b> (0.0002)	<b>1.56</b> ( $<0.0001$ )		<b>-0.1348</b> (0.0001)	88.3	118.8	114.6	1
3	0.6622 (0.1983)		<b>0.6115</b> (0.0453)	<b>-0.1282</b> (0.0079)	96.9	127.4	123.2	3
4		0.2841 (0.1639)	-0.2493 (0.3187)	<b>-0.119</b> (0.0024)	98.8	129.3	125.1	4

\*Based on Restricted Maximum Likelihood; \*\*Based on maximum likelihood method

Fixed effect parameter estimates for the full model (Model 1) and the three possible two-variable with time models (Model 2, 3, 4) are shown in Table 1. Model 2 as the top ranked shows significant effects for Exchange Rate ( $p < 0.0001$ ) and GDP ( $p = 0.002$ ), representing 1.54% and 2.25% increases in the imports (exports) per 1% change, respectively; the tariff rate was deemed to be non-significant in this forecasting ( $p = 0.533$ ). The -0.14 estimate for the year represents an average 0.87-fold annual decrease in Exports over this period, other variables held constant. Although it is statistically significant, inspection of the Export trend over time (Appendix ##) suggests that this may be influenced by the apparent overall negative trend in data for Russia and the substantial short-term decreases observed for Italy and India from 2018-2020. To account explicitly for potential between-country differences, models including a random intercept and random slope were explored. No comparable model including both correlated errors and random effects converged, and the full model including both random terms did not surpass the performance of the repeated measure model (Table 2). However, both GDP and Year were statistically significant, with similar magnitude of estimates for the different specifications of Models 1 and 2. Further, significant variance estimates for the random intercept suggest that the heterogeneity among individual countries' baselines should be considered in future analysis.

**Table 2:**  
**Summary of Comparative Model Fit: Random Slope-Intercept Models**

Model	Parameter Estimates* (p-value)				Variance Components*		-2logLik*	AICc*	BIC**
	GPD	ExRate	TariffRate	Year	Intercept	Year			
5	<b>1.8002</b> (0.0041)	0.6952 (0.1566)	-0.0783 (0.7403)	<b>-0.1544</b> (0.0418)	<b>3.5749</b> (0.0419)	0.0109 (0.192)	113	131.8	130
6	<b>1.8313</b> (0.0031)	0.7156 (0.1383)		<b>-0.1573</b> (0.006)	<b>3.4420</b> (0.0386)	0.01158 (0.1208)	113.2	129.3	128

\*Based on Restricted Maximum Likelihood; \*\*Based on maximum likelihood method

An analysis of the connections and associations between these economic variables allows for a better determination of the number of imported vehicles, which is salient for both production planning in the supply chain as well as – perhaps more importantly – in establishing federal macroeconomic trade policy to manipulate these trends as it relates to political goals related to the domestic automobile industry. If the high tariff rates were intended to limit the number of American vehicles being exported into that country, monetary analysis and/or government agencies might pause because taxes on these vehicles do not seem to be a relevant factor in limiting vehicle sales into a country. This is especially noteworthy in assessing the zero-tariff rate for American vehicles entering the Japanese market. Subsequent studies should ascertain if Model 2 is similarly accurate if the dependent variable is automobiles being imported to the same countries but originating or being manufactured in a country other than the US.

Utilizing only three economic metrics as independent variables may not take into account extraneous variables such as consumer demand for new models, fluctuations in pricing strategies, caveat public policies such as the Cash For Clunkers phenomenon, consumer boycotts, and other microeconomic issues. In this case, additional models might more accurately ascertain other non-financial factors involved. As such, while statistically significant associations were indeed uncovered, there is no justification for causal assumptions at this stage. However, the exchange rate trends and GDP provide general indicators of what automakers might analyze when marketing and later exporting into particular markets. Furthermore, protectionist policies beyond trade barriers such as taxes on imported vehicles might not be the best tactic to prevent products from entering a market.

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