Research Article

Global Journal of Finance, Economics, and Quantitative Research

The International Elasticity Puzzle in CGE Models: Analyzing Tariff Impacts on Exporters

Guandong Wang*, & Guibo Liu

School of Economics, Shandong Women's University, Jinan, Shandong, China

***Corresponding author:** Guandong Wang, School of Economics, Shandong Women's University, Jinan, Shandong, China.

Submitted: 15 December 2025 **Accepted:** 22 December 2025 **Published:** 27 December 2025

https://doi.org/10.63620/MKGJFEQR.2025.1007

Citation: *Guandong Wang, Guibo Liu. (2025). The International Elasticity Puzzle in CGE Models: Analyzing Tariff Impacts on Exporters. Glob J of Finance Econ Quant Res, 1(1), 01-09.*

Abstract

The oversimplification of export price shocks in CGE models encounters the International Elasticity Puzzle in tariff policy simulations. This puzzle manifests in three key discrepancies: (1) the distinct impacts of temporary versus permanent export price adjustments on export quantities; (2) the significantly smaller magnitude of exchange rate elasticity relative to tariff elasticity in export responses; (3) the inverse sign of real exchange rate elasticity compared to tariff elasticity. Among potential improvements to CGE models, accounting for the system-wide effects of price adjustments on resource allocation and income distribution is crucial. The negative sign and minimal magnitude of real exchange rate elasticity compared to tariff elasticity imply that equating their elasticity parameters would lead to underestimation of tariff effects under their interaction. Given the extensive application of CGE models in cross-disciplinary policy simulations, resolving this elasticity paradox promises enhanced theoretical consistency and result accuracy for the models. One alternative approach circumvents temporary export price shocks by incorporating fixed exchange rates within a single-country static CGE framework. Simultaneously, factor markets are configured with short-run rigidity to reflect conditions consistent with a fixed exchange rate regime. A comparative analysis of this fixed-exchange-rate approach versus simulations using the Neoclassical closure reveals that the latter exhibit smaller macroeconomic and sectoral impacts. This finding aligns with the theoretical prediction regarding the underestimated tariff effects.

Keywords: Elasticity Puzzle, CGE, Tariff Impacts, Employment, Income and Expenditure.

Introduction

Adam Smith warned that "when a nation grows opulent through the prosperity of its trade and manufactures...it naturally becomes the country that is most exposed to hostile attacks." Tariffs may serve as one such instrument of attack. However, the literature remains sparse in analyzing the impacts of anti-dumping measures on export-oriented economies. The increased scholarly attention to tariff effects may stem from two factors: (1) real-world dynamics, notably the resurgence of trade protectionism following the 2008 financial crisis and (2) theoretical breakthroughs exemplified by Ruhl's identification of the International Elasticity Puzzle — the paradoxical observation that tariff-induced export elasticity surpasses exchange rate elasticity, combined with the heterogeneity in quantity responses to permanent versus transitory price shocks [1]. These findings challenge classical trade theories [2-4], prompting subsequent empirical research and generating new demands on applied general equilibrium models that incorporate trade modules and current account balance mechanisms.

The genesis of this elasticity paradox can be traced to Ruhl's meta-analysis, which revealed significant discrepancies in Armington elasticity parameters — a core metric converting international shocks into domestic quantity-price feedback and a critical input for trade liberalization welfare analysis [5]. Specifically, International Real Business Cycle (IRBC) models calibrated based on studies such as Zimmermann and Heathcote & Perri typically yield Armington elasticity estimates around 1.5. In contrast, Applied General Equilibrium (AGE) models commonly employ values between 4 and 15. Notably, Yi argued that values exceeding 12 are necessary to adequately reflect observed trade growth patterns.

The divergence in empirical estimates of the Armington elasticity arises from scholars' differing interpretations regarding the nature of the underlying export price shocks. Fundamentally, it reflects heterogeneous responses by economic agents to two distinct types of export price shocks: transitory shocks (temporary price fluctuations) and permanent shocks (sustained price shifts), which elicit differentiated adjustments in export quantities. When a country experiences transitory export price shocks, adjustments in partner countries' import quantities occur solely through the intensive margin — existing exporters modify their trade volumes based on price substitution elasticities, without altering their export participation status. Consequently, the resulting fluctuations in export quantities remain relatively limited, as firms maintain their original export decisions. By contrast, permanent export price shocks (e.g., tariff reductions) structurally alter trade costs. Reduced trade costs enhance the competitiveness of existing exported goods (assuming constant foreign income and the absence of Giffen goods), incentivizing new firms to enter international markets.

In this scenario, export quantity adjustments operate through both the intensive margin and the extensive margin. This dual mechanism significantly amplifies the response of export quantities compared to transitory shocks. The distinct effects of these two types of shocks explain why empirical studies estimating the Armington elasticity report divergent results. This logic is supported by the literature, which emphasizes the critical role of the extensive margin—specifically, how export entry costs and trade costs influence firms' internationalization decisions—as detailed in The International Elasticity Puzzle.

Beyond qualitative analysis, Ruhl introduced stochastic productivity shocks drawn from Real Business Cycle (RBC) models into a static Applied General Equilibrium (AGE) framework, enabling the simulation of both transitory and permanent export price shocks. His simulations demonstrated that transitory shocks replicated the smaller Armington elasticities characteristic of International Real Business Cycle (IRBC) models, while permanent shocks matched the higher values typically employed in AGE models. These computational findings were also validated against empirical results obtained from different research strands.

Subsequent empirical research has further substantiated the International Elasticity Puzzle. Fitzgerald and Haller analyzed Icelandic customs and product-level data to measure the effects of tariffs and exchange rates on firms' export participation decisions and export revenue elasticity. Their results revealed significantly larger tariff elasticities compared to exchange rate elasticities: short-term tariff elasticities ranged between –1.5 and –3.5, with long-term values between –2.0 and –5.0, whereas both short-term and long-term exchange rate elasticities were much lower, at approximately 0.6 and 0.8, respectively. Fontagné and Martin reached similar conclusions using French firm-level data, reporting a tariff elasticity of –1.77 compared to an exchange rate elasticity of 0.6. Additional support comes from Yilmazkuday, whose analysis corroborated these asymmetric elasticity patterns, further confirming the empirical persistence of the International Elasticity Puzzle. The Computable General Equilibrium (CGE) model is grounded in classical economic theory. However, considerations of the International Elasticity Puzzle suggest potential for improvement in its modeling framework, particularly regarding the configuration of the trade module. The price setting mechanism for imported goods is analogous to that for exported goods. Taking exported goods as an example, the exchange rate is used to convert the world market price (denominated in foreign currency) into domestic currency units. After accounting for export tariffs and trade costs, the resulting price represents the actual domestic currency price received by exporting firms. Firms then allocate their supply of goods between domestic and international markets based on relative domestic and export prices, typically modeled as maximizing revenue or profit. The value of the elasticity parameter in the Constant Elasticity of Transformation (CET) function (often referred to as the Armington elasticity for transformation) significantly influences this allocation decision between domestic and foreign markets.

The standard CGE model developed by Lofgren and Harris provides a widely used framework, applied in studies such as Burfisher, Wissema & Dellink, Bourguignon & Robilliard, and Yuan & Wei. In this model:
The export price received by domestic firms (PEX) is denominated in domestic currency. The Free on Board (FOB) export price (PFOB) is denominated in foreign currency.
The export tariff rate is denoted by t_exp.
The exchange rate (EXR) converts between currencies, with foreign currency typically serving as the base currency.
Trade costs per unit of exported goods (tc_exp) are also accounted for.
The relationship between these prices can be represented as: PEX = (PFOB * EXR * (1 - t_exp)) - tc_exp (or similar, depending on the specific model specification).
The set of goods subject to the transformation function is denoted by CT, while CErepresents the set of exported goods.

$$PE_C = pwe_C\, C(1-te_C)\, C\, EXR - 5_{c \in CT}\, PQ_C\, CICE_{CC} \quad C \in CE \tag{1}$$

Examination of equation (1) clearly shows that both the exchange rate (EXR) and tariffs (t_exp) affect the domestic-currency denominated export price (PEX) proportionally according to their respective multiplicative coefficients in the equation. Subsequently, changes in PEX influence export quantity (or revenue) according to the relevant export supply elasticity (e.g., CET elasticity). The Constant Elasticity of Transformation (CET) function embodies firms' optimizing behavior by allocating supplies between domestic and export markets based on the relative price (PEX / PDOM). Therefore, any change in PEX triggers an adjustment in the export quantity share, governed by the CET elasticity parameter.

A critical distinction concerns the so-called International Elasticity Puzzle. This puzzle highlights the empirical observation that tariff elasticity often substantially exceeds exchange rate elasticity. However, standard CGE model implementations typically assume that the elasticity of export quantity with respect to both the exchange rate (EXR) and the tariff (t_exp) is identical and determined by the CET elasticity. This assumed equivalence directly contradicts the core findings of the International Elasticity Puzzle. Therefore, the standard assumption of equal elasticities within the CET function appears to be a limitation that could compromise the accuracy of CGE model simulations of trade policy, warranting reconsideration or refinement to incorporate the insights from the International Elasticity Puzzle.

The empirical evidence discussed thus far primarily reflects experiences in developed economies. Despite potential differences due to factors like tariff absorption and integration into global value chains, if China also exhibits the International Elasticity Puzzle pattern (i.e., tariff elasticity significantly exceeds exchange rate elasticity), and the CGE model assumes a free-floating exchange rate and the standard CET equal-elasticity setting, then the model couldsubstantially underestimate the true impact of tariff changes on China's trade flows. This underestimation depends on the differences between China's tariff elasticity (η_t) and exchange rate elasticity (η_e). Specifically:

If the actual exchange rate elasticity is low relative to the tariff elasticity ($\eta_e < \eta_t$), the assumption of equal elasticities in the CET function will lead to an underestimation of the tariff impact. Conversely, if the actual exchange rate elasticity is close to or equal to the tariff elasticity ($\eta_e \approx \eta_t$), the equal-elasticity assumption may yield a less biased estimate of tariff effects. Furthermore, modeling the adjustment of a free-floating exchange rate (EXR), which endogenously responds to trade imbalances and other macroeconomic forces, adds significant complexity and requires careful specification of the international trade balance mechanism. Critically, scenarios characterized by low exchange rate elasticity represent cases where the underestimation risk is most pronounced.

Standard CGE models often adopt the small-country assumption. This implies that domestic exporting firms are price-takers in international markets. Therefore, when an export tariff is imposed, the burden typically falls on the exporter, resulting in a decrease in the net price (PEX) they receive. Under this scenario, exchange rate depreciation (an increase in EXR) would increase PEX received by firms (assuming constant PFOB), potentially stimulating export volume. However, empirical findings like those documented in the International Elasticity Puzzle show that the short-run responsiveness of exports to exchange rate changes (η_e) is often limited, contrasting sharply with the typically larger responsiveness to tariff changes (η_t).

Therefore, if a CGE model assumes equal response elasticities to exchange rates and tariffs within its structure (i.e., $\eta_{e\_model} = \eta_{t\_model}$), while the reality is that $\eta_e << \eta_t$, then the simulated impact of tariff changes will be underestimated. Addressing the International Elasticity Puzzle within the Computable General Equilibrium (CGE) modeling framework presents a significant challenge. This paper proposes a potential strategy to address this issue. The exchange rate acts as a source of transitory price fluctuations for exported goods. Conversely, within standard CGE models, it primarily functions to equilibrate domestic and foreign currency accounts, often mechanically (e.g., through adjustments in international transfer payments). This fundamental distinction between the exchange rate's short-term shock effect on export prices and its longer-term accounting role creates both the rationale and the challenge for our proposed solution.

To achieve greater theoretical consistency regarding the puzzle, this paper adopts a fixed exchange rate within its CGE specification. This eliminates the influence of transitory export price fluctuations induced by exchange rate movements, while preserving the core simulation capabilities of the CGE framework. It is acknowledged that, according to exchange rate determination theories (e.g., the Monetary Approach, Uncovered Interest Rate Parity), the exchange rate is influenced by a range of factors such as interest rate differentials, monetary policy, and the trade balance. Consequently, fixing the exchange rate entails a significant departure from long-run economic reality.

However, for short-term policy simulations, this approach is considered more acceptable. This perspective aligns particularly well with the economic context of China, where exchange rate stability is a notable policy objective. Therefore, the CGE model developed in this paper achieves external balance by fixing the exchange rate, with foreign savings (SFSAV) adjusting exogenously to maintain both internal and external equilibrium. Furthermore, to mitigate the challenges posed by potential temporary export price fluctuations remaining in the system, factor markets are configured to exhibit short-run rigidities (e.g., in wages or capital mobility).

Using the standard Computable General Equilibrium (CGE) model developed by the International Food Policy Research Institute, this paper employs the China-US trade friction as a case study to compare simulation results across different closure settings in CGE models. The analysis contrasts commonly used neoclassical closures assuming full factor employment with an alternative setup designed to mitigate the International Elasticity Puzzle. This alternative incorporates a neoclassical closure with a fixed exchange rate to partially address transient shocks affecting imported and exported goods. For short-term simulations, this study adopts the framework by Lofgren and Harris, which proposes three factor market closure options. The third option – appropriate for short-term analysis – assumes fixed sectoral factor employment, no inter-industry factor mobility, and full employment.

The standard neoclassical closure setting also derives from this literature. The paper conducts comparative analyses across eight scenarios, examining nominal GDP, factor income, and household expenditure under varying tariff rates, tax rates, and macroeconomic closure approaches. Additionally, it investigates sector-specific changes in import and export patterns under the neoclassical closure.

The comparative results demonstrate that incorporating the International Elasticity Puzzle diminishes tariff impacts under floating exchange rates. Short-term closure yields an average nominal GDP reduction approximately 3 percentage points greater than under neoclassical closure. Significant distributional disparities emerge in factor incomes: skilled labor income rises under short-term closure while unskilled labor and capital income decline, contrasting with the neoclassical scenario where all factors contract uniformly by approximately 5%. Household expenditure patterns diverge substantially, with rural spending decreasing under short-term closure while urban remains stable, whereas under neoclassical closure both converge at around-5%. At the sectoral level, neoclassical closure induces a 2% average decrease in US-bound exports (median: -11%), a 17% increase in other-destination exports (median: +7%), and a 13% aggregate import reduction (median: -15%).

This study's model specifications are grounded in established literature. The single-country static framework primarily adopts Ruhl's model architecture. As emphasized by Zhang Youguo and Zheng Shilin, multi-country CGE models typically examine multilateral trade policies within economic regions to analyze resource allocation and welfare effects, whereas single-country models emphasize domestic economic structures for assessing sectoral policy impacts. Consistent with prevailing research practices – evidenced in carbon tariff studies by Lin & Jia, Li, and Yuan – this paper employs a single-country static approach. However, given the inherent unsustainability of trade protectionism and anti-globalization measures, comparative analyses with existing CGE tariff studies are constrained by fundamental model disparities (single- vs. multi-country, static vs. dynamic, closure specifications), which induce methodological biases.

Consequently, this research focuses exclusively on contrasting neoclassical and short-term closure outcomes. For enhanced economic realism, future CGE refinements should incorporate financial modules, capital accounts, and imperfect competition mechanisms. Nevertheless, the persistent ambiguity in quantity-price relationships – particularly in exchange rate models – continues to critically affect resource allocation and income distribution dynamics, warranting prioritized scholarly attention.

This paper investigates how the International Elasticity Puzzle affects standard Computable General Equilibrium (CGE) model simulations. It develops a single-country static CGE framework under short-term conditions to address this issue, contrasting the results with those derived from neoclassical closure. The theoretical significance aligns with Ruhl' s conclusion regarding trade dynamics enhancement, specifically advancing understanding of temporary price shocks affecting imported/exported goods and their impacts on economic actors. From a practical perspective, addressing this methodological gap provides critical insights for CGE modeling applications in policy simulations— particularly concerning tariff barriers, free trade agreements, carbon pricing mechanisms, and energy economics — where accurate quantitative assessment is paramount.

The paper is structured as follows: Section 2 delineates the CGE model architecture, introduces the Social Accounting Matrix framework, and details data sources; Section 3 elaborates eight simulation scenarios; Section 4 presents empirical results with analysis spanning macroeconomic aggregates and sectoral dimensions; and the concluding section synthesizes core findings and contributions.

Model

The Computable General Equilibrium (CGE) model is widely applied in policy analysis. Grounding its construction in the Walrasian paradigm, it achieves equilibrium through simultaneous optimization of behaviors across agents—households, firms, domestic government, and foreign entities. This study adapts the standard CGE framework by Lofgren and Harris to incorporate China-specific economic structures. While originally designed to accommodate developing economies' features like rural household self-consumption, this element is omitted here due to data constraints. To enable analysis of U.S.-bound export tariffs, the model partitions export destinations into two categories: the United States vs. other countries. Export allocation follows China's 2012 U.S.-bound export share of total exports. Adopting Yuan's methodology, goods are optimally allocated between these destination groups based on differential FOB prices.

Despite its utility in policy analysis, the Computable General Equilibrium (CGE) model exhibits recognized limitations [6]:

1. It assumes policy changes induce no adjustments in involuntary unemployment, capital formation, firm competition, or technological progress;
2. Its dependence on exogenously defined parameters reduces predictive robustness;
3. Its data requirements exceed those of input-output (IO) analysis, necessitating micro-founded specifications of agent behaviors beyond IO's sectoral scope.

Production Module

This framework assumes each industry comprises a single representative firm producing a homogeneous good. Production follows a Leontief function, combining intermediate inputs and value-added in fixed proportions. Value-added composition incorporates factor substitutability, with labor and capital shares calibrated via input-output tables to mirror real-world conditions. Intermediate inputs include domestically sourced and imported goods, modeled as imperfect substitutes under the Armington assumption—a specification critical for capturing import-export duality in trade, consistent with the International Elasticity Puzzle discussed in prior sections.

Income and Expenditure Module

Households accrue income from factors of production (directly or indirectly via firms), government transfers, and foreign remittances. This income allocates to consumption, savings, and direct taxes. Firms generate revenue from goods sales to compensate factors, pay taxes, and transfer profits, under the assumption of zero own-consumption. Government revenue—sourced from taxes and foreign transfers—funds consumption, savings, and transfers. The model simplifies government behavior to fixed-quantity goods consumption. Interactions with the Rest of the World (ROW) include trade flows and transfers, with external balance maintained through endogenous exchange rate adjustment or foreign savings variation.

Commodity Flows

Domestic aggregate output comprises sectoral contributions. Export-domestic sales allocation follows a Constant Elasticity of Transformation (CET) function, implementing firms' revenue-maximizing behavior. Domestic supply—aggregating locally sold and imported goods—distributes to institutional consumption, investment, and intermediate usage through cost-minimization-driven import-domestic substitution. Foreign demand for exports is perfectly elastic at given prices, implying full exporter absorption of export tariffs. Concurrently, exchange rate fluctuations transmit to export prices, thus modulating export quantities per the International Elasticity Puzzle framework.

Macroeconomic Closure

The CGE model features three fundamental types of macroeco-

nomic closures: the government balance closure, the external balance closure, and the savings-investment balance closure. Achieving government budget balance (government closure) involves three primary methods. Under the assumption of constant government consumption, government revenue is manifested through tax rates, while savings are flexibly adjusted to satisfy the budget constraint. These methods are: (1) changes in government savings, (2) an increase in the average tax rate, and
(3) proportional increases in tax rates relative to their initial levels.

External balance is reflected in the current account balance and can be achieved through either exchange rate fluctuations or adjustments in foreign savings. For instance, when foreign savings are fixed, exchange rate appreciation or depreciation alters the prices of imported and exported goods, thereby maintaining stable foreign savings.

Since the model assumes that all savings are converted into investment, the savings-investment balance closure ensures overall model equilibrium. The model offers two broad categories of closure approaches: savings-driven and investment-driven. The investment-driven approach can be further subdivided into four distinct methods, a feature that distinguishes this model from many other CGE models in terms of closure specifications.
The commonly used neoclassical closure is savings-driven. In this setup, non-government sector savings are held fixed, and aggregate investment is scaled by a factor to equate it with total savings.

By default, the model employs an investment-driven closure. This approach fixes real investment quantities and adjusts non-government sector savings rates proportionally relative to their baseline equilibrium levels to ensure savings equal investment. This implies an assumption that the government can influence private savings behavior to accommodate desired investment levels. Other investment-driven approaches differ primarily in their specific mechanisms for adjusting sectoral savings rates and whether they incorporate changes in government savings.

Commodity and Factor Market Equilibrium
The commodity market necessitates a supply-demand balance. In contrast, factor markets exhibit greater complexity in achieving equilibrium. To address this, the original model offers three distinct closure options for factor markets. The first closure assumes conditions of full employment and free factor mobility. Under this setting, factor supply is fixed at the baseline equilibrium level, and wages adjust flexibly to balance supply and demand. The second closure incorporates unemployment while still allowing for some factor mobility; here, wages are fixed, and factor supply adjusts to reflect only factor demand levels, utilizing a distortion factor to achieve balance. The third closure involves market segmentation, essentially constraining firms to employ only the baseline quantity of factors. As Lofgren notes, this third closure is particularly suitable for short-term analysis. Figure 1 provides a schematic overview of these closure mechanisms.

Social Accounting Matrix
Most parameters in the model are derived through calibration, utilizing the Social Accounting Matrix (SAM) as the foundational data source. The model employs the 2007 SAM sourced from the International Food Policy Research Institute (IFPRI) as its baseline. To reflect contemporary economic structures, this study supplements the baseline with the 2022 macroeconomic SAM, subsequently balanced using the RAS method to yield the final 2022 SAM. This SAM encompasses 42 distinct activities and commodities, involving 27 exporting industries and 22 industries utilizing imported goods. Parameters that cannot be calibrated through the SAM — specifically factor substitution elasticities, Armington elasticities, elasticities within the Constant Elasticity of Transformation (CET) function, the Frisch parameter, and demand expenditure elasticities — are exogenously specified. These exogenous parameter values are drawn from established literature, referencing studies by Wang and Wang (2017), Bao and Tang (2013), and Mu and Cai (2018). Table 1 presents key elasticity data for selected industries, defining: σA as the Armington elasticity, σT as the CET elasticity, σV as the elasticity of substitution between intermediate inputs and value-added, and σF as the elasticity of substitution between labor and capital.

Table 1: Key Elasticity Data in the CGE Model

Industry	σ_A	σ_T	σ_V	σ_F
Petroleum and Natural Gas Extraction	2.80	1.98	1.26	1.12
Agriculture	2.20	1.41	0.24	0.23
Textile Industry	4.00	1.44	1.26	0.96
Industry	σ_A	σ_T	σ_V	σ_F
Petroleum Processing, Coking, Nuclear Fuel Processing	1.90	1.22	1.26	1.23
General and Specialized Equipment Manufacturing	3.00	1.75	1.26	1.23
Wholesale and Retail Trade	1.90	1.33	1.26	1.29

Data Source: Compiled by the authors based on the literature.

Simulation
This study first establishes a baseline solution derived from the Social Accounting Matrix (SAM). Subsequently, by altering exogenous variables, the model simulates endogenous responses to various shocks. As the model primarily comprises nonlinear equations, it yields only a local equilibrium solution. To verify reliability and ensure internal balance, a Walras variable is introduced into the savings-investment equation. When balanced, this variable equal zero. The model satisfies both criteria, achieving a locally optimal solution with the Walras variable approaching zero.

Given the high uncertainty of tariff risks facing exporting countries, simulation tariffs reference existing studies. These tariffs target Chinese exports to the United States, specifically applying 10% and 25% rates to 200billionand200billionand300 billion worth of goods, respectively. Simulations employ both neoclassical and short-term closures, with the following scenarios were summarized in Table 2

Short-term closure:

- S1/S2: $200 billion exports at 10%/25% tariffs
- SA/SB: $300 billion exports at 10%/25% tariffs Neoclassical closure:
- L1/L2: $200 billion exports at 10%/25% tariffs
- LA/LB: $300 billion exports at 10%/25% tariffs

Table 2: Simulation Design for Different Periods, Goods, and Tariff Rates

Scenario	Goods (USD)	Tariff Rate (%)
L1	Neoclassical Closure, $200B	10
L2	Neoclassical Closure, $200B	25
LA	Neoclassical Closure, $300B	10
LB	Neoclassical Closure, $300B	25
S1	Short-Term Closure, $200B	10
S2	Short-Term Closure, $200B	25
SA	Short-Term Closure, $300B	10
SB	Short-Term Closure, $300B	25

Although the model incorporates 42 industries, it cannot fully capture the specific products subject to actual tariffs. Consequently, following Cui Lianbiao's methodology, a tariff-equivalence approach is applied to convert original tariff rates. For instance, in Scenario L1, a 10% tariff on $200 billion of exports translates to an equivalent 5% tariff on approximately $400 billion worth of total U.S.-bound exports. Other scenarios employ analogous conversions.

Results

Additional tariffs can trigger comprehensive economic equilibrium shifts, necessitating careful variable selection. Studies analyzing tariff effects typically present both macroeconomic indicators and industry-specific impacts. Macroeconomic variables—aligned with GDP expenditure approaches—include household consumption, investment, imports-exports, employment, inflation, terms of trade, and welfare analysis. Industry impacts focus on export values, quantities, and prices across economies. Given consumption's growing contribution to economic growth, this paper examines household expenditure alongside GDP and factor income. Under the assumption of infinite export price elasticity, tariff rate changes immediately reduce export prices, making terms-of-trade analysis redundant. Welfare analysis (capturing household utility changes) partially overlaps with household expenditure measurements.

GDP

Figure 1 presents percentage changes in nominal GDP relative to baseline equilibrium across all eight scenarios. The use of nominal GDP—despite its volatility due to unadjusted inflation—is justified by two considerations. First, as Zhang and Zheng demonstrate when addressing similar contexts, minor negative shocks (e.g., low tariff rates) may yield positive GDP growth through efficient internal factor allocation, thereby obscuring tariff impacts. Second, Li and Zhang establish that firms absorb tariff effects via nominal price adjustments, which are intrinsically linked to real economic consequences. Consequently, inflationary changes become partially attributable to tariffs, warranting the inclusion of nominal price effects in the analysis.

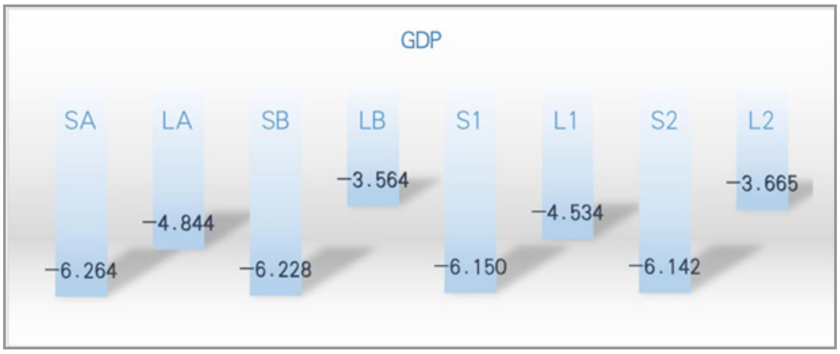

Figure 1: Impact on Nominal GDP Data Source: Calculated by the authors.

The economic impact under neoclassical closure is substantially smaller than negative short-term effects. Among short-term scenarios, SA, SB, S1, and S2 reduce nominal GDP by-6.264%, -6.228%, -6.150%, and -6.142%, respectively. By contrast, neoclassical closure scenarios LA, LB, L1, and L2 exhibit reductions of -4.844%, -3.564%, -4.534%, and -3.665%, respectively. From multiple analytical perspectives, post-exchange-rate-adjustment impacts remain smaller than short-term effects. Minor tariff increases yield nonlinear GDP responses — sometimes even decreasing impacts — reflecting complex variable interactions within the model system. Conversely, expanding tariff-covered goods volumes consistently correlates negatively with GDP growth. When controlling for inflation, short-term effects persistently exceed neoclassical impacts under floating exchange rates, though the differential remains within 0.5%. These findings align with established GDP-impact literature [7].

Factor Income

Figure 2 presents changes in factor returns. Short-term impacts show significant declines in capital and unskilled labor income, with capital experiencing the steepest reduction (approximately -12% on average). Conversely, skilled labor income increases counter-cyclically, averaging +17%. Long-term equilibrium reveals convergence: skilled labor income decreases substantially, while unskilled labor and capital exhibit moderate gains (+3-5% range). The net effect yields an overall 5% reduction in total factor income.

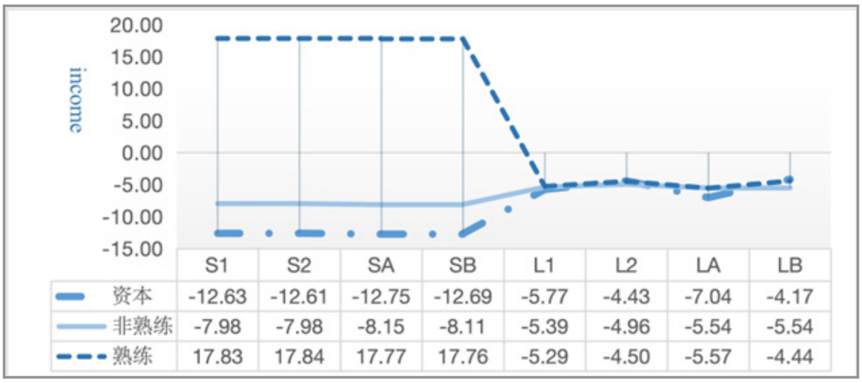

Figure 2: Changes in Income for Three Factors Data Source: Calculated by the authors.

Household Expenditure

Compared to factor income, household expenditure exhibits lower volatility, with fluctuations remaining below 10% (Figure 3). In short-term scenarios, rural household expenditure declines significantly (>8%), primarily because rural labor—classified as unskilled—experiences substantial income reductions. Long-term analysis shows rural expenditure gradually rising alongside increased unskilled labor income, approaching urban household levels. Urban households demonstrate greater short-term stability, with income/expenditure declines limited to ≈ 2%. This reflects consumption rigidity and skilled labor income buffering effects. However, urban expenditure deterioration accelerates long-term, exceeding -4% across all scenarios.

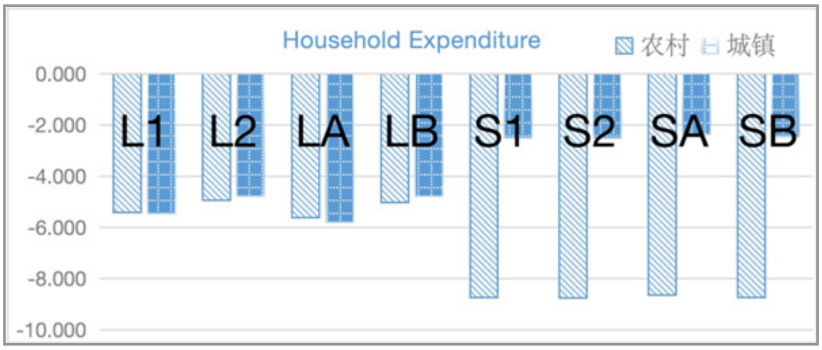

Figure 3: Changes in Household Expenditure Data source: Authors' calculations.

Industry-Level Analysis

Figure 4 depicts the variations in imports and exports across different industries under the S2 simulation relative to the baseline equilibrium. Exports are disaggregated into shipments to the United States and those to the rest of the world (ROW), while all imports are sourced exclusively from ROW. In this scenario, a 25% tariff is imposed on $200 billion worth of exports to the United States, with tariff rates for exports to ROW remaining unchanged. This facilitates an examination of the short-term impacts of heightened tariff rates on specific industries in the exporting country. Due to significant inter-industry variations, extreme values were excluded to ensure the figure clearly reflects marginal changes in the majority of industries. Figure 4 lists import and export variations for 20 key industries, accounting for 75% of the 27 export-oriented industries and 90% of the 22 import-reliant industries. The overall industry trends are summarized in Table 3, with both import and export figures expressed as percentage changes relative to the baseline equilibrium.

Table 3: Statistical Analysis of Import and Export Quantities Across All Industries Data Source: Calculated by the authors.

Metric	Exports to USA	Exports to ROW	Imports
Number of Industries	27	27	22
Mean (%)	-2	17	-13
Median (%)	-11	7	-15
Maximum (%)	148	189	21
Minimum (%)	-100	-100	-39
Standard Deviation	48	56	17

The average change in exports to the United States is -2%, while exports to ROW increase by 17%, reflecting tariff-induced shocks and trade diversion effects. Imports decline at a faster rate than exports, with an average reduction of 13%. Due to the influence of extreme values, the median values better capture export quantity changes: exports to the United States decrease more substantially than suggested by the mean, while exports to ROW increase less than implied by the mean, underscoring the negative impact of tariffs.

Transportation and Warehousing exhibit the largest positive change in both export directions. In contrast, Instruments, Meters, and Cultural and Office Machinery Manufacturing shows the smallest change and approaches complete exit from international markets. The standard deviation is largest for exports to ROW and smallest for imports across all categories. Despite the increased tariffs on exports to the United States, some industries exhibit counter-trend growth, such as those shown in Figure 4: (2) Coal Mining and Washing, (6) Metal Ore Mining, (7) Non-Metallic Ore Mining, and (20) Culture, Sports, and Entertainment. Conversely, certain industries experience significant reductions in exports to the United States, including (12) Metal Smelting and Rolling Processing, (14) Transportation Equipment Manufacturing, (16) Communication Equipment, Computers, and Other Electronic Equipment Manufacturing, and (19) Leasing and Business Services.

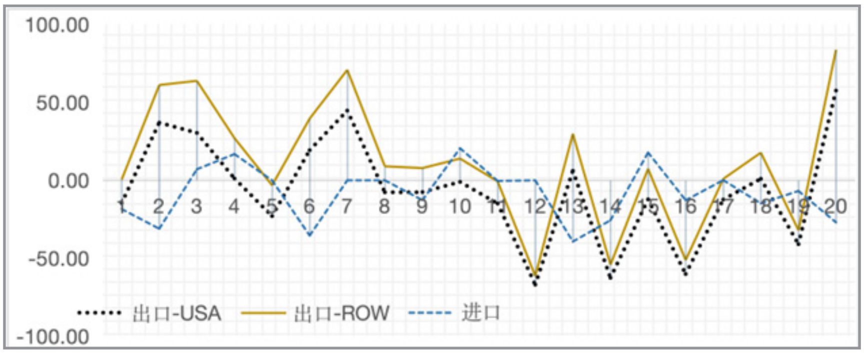

Figure 4 S2: Changes in Sectoral Imports and Exports Relative to Baseline Equilibrium Note: Data source: Author's calculations.

Changes in exports to the rest of the world generally follow a similar pattern as exports to the United States, with two key differences: when export volumes increase, the growth rate to the rest of the world exceeds that to the U.S.; when export volumes decrease, the decline to the rest of the world is smaller than that to the U.S. There are also industries where exports to the U.S. decrease while exports to the rest of the world increase, such as wood processing and furniture manufacturing, and paper printing and cultural goods manufacturing. The empirical simulations show no cases where exports to the U.S. increase while exports to the rest of the world decrease.

Overall, import data shows a downward trend, with most sectors located below the horizontal axis. Industries with significant import reductions include coal mining and washing, textiles, and general and special equipment manufacturing. Industries with rapid import growth include metal ore mining, petroleum processing and coking, and electrical machinery manufacturing. Since the relationship between imports and exports is not visually evident from the figure, the calculated correlation coefficients between imports and exports to the U.S. and the rest of the world are -0.12 and -0.14, respectively.

The standard CGE model used in this study is widely applied and highly credible. Although this study does not incorporate certain model extensions such as value-added classification for exporters or endogenous monetary modules — partly to focus on the impact of the international elasticity puzzle and partly for explanatory simplicity— it is important to note the limitations of CGE models, including the difficulty in determining exogenous elasticities, which affects predictive accuracy.

Conclusion

Computable General Equilibrium (CGE) models have been extensively applied in energy economics, free trade zones, and tariff analysis for simulating and predicting policy impacts. Concurrently, CGE modeling methodologies have progressively evolved. Taking literature on China-US trade friction as an example, Li Chunding and He Chuantian et al. incorporated internal currency trade imbalance structures and trade cost assumptions into multi-country CGE models to examine tariff effects; Huang Peng and Wang Jianxin et al. modified the GTAP model through trade value-added adjustments to investigate tariff impacts. Numerous scholars have refined models to better approximate economic realities and improve prediction accuracy, though conventional CGE simulations employing floating exchange rates may underestimate actual tariff effects [8-10].

The study established eight distinct simulation scenarios incorporating with varying commodity coverage, tariff rates, and macroeconomic closure rules [11-15]. Comparative analysis was conducted to examine examined nominal GDP, factor income, and household expenditure outcomes between short-term simulations and neoclassical closure models with floating exchange rates [16-20]. Sector-specific export variations to the US and other countries, as well as import changes, under short-term conditions were also reported. Results demonstrated relatively lower impact magnitudes scales in neoclassical closure scenarios, consistent with which is consistent with our theoretical propositions [21-25].

Concerning Regarding the International Elasticity Puzzle, current CGE research has not yet developed have yet to develop definitive solutions. The fixed exchange rate approach for simulating short-term impacts impact simulation may potentially overestimate tariff effects by completely disregarding neglecting exchange rate adjustments on export prices, rendering [26-30]. Consequently, this methodology remains inherently incomplete for resolving the puzzle. Furthermore, whether China's empirical conditions can validate provide empirical validation for the International Elasticity Puzzle requires additional investigation. These limitations highlight the necessity for continued research to advance enhance model specifications and verification approaches [31-34].

References

1. Arkolakis, C., Costinot, A., & Rodríguez-Clare, A. (2012). New trade models, same old gains? American Economic Review, 102(1), 94–130.
2. Bao, Q., Tang, L., Zhang, Z., & Wang, S. (2013). Impacts of border carbon adjustments on China's sectoral emissions: Simulations with a dynamic computable general equilibrium model. China Economic Review, 24, 77-94.
3. Bourguignon, F., Robilliard, A. S., & Robinson, S. (2005). Representative versus real households in the macroeconomic modeling of inequality. In Frontiers in Applied General Equilibrium Modeling: In Honor of Herbert Scarf (pp. 219–254).
4. Burfisher, M. E. (2017). Introduction to computable general equilibrium models. Cambridge University Press.
5. Chandra, P., & Long, C. (2013). Anti-dumping duties and their impact on exporters: Firm-level evidence from China. World Development, 51(4), 169–186.
6. Cui, L. B., Zhu, L., Song, M. L., & Zheng, H. T. (2018). Assessment of the global economic impact of China–US trade friction. Journal of Finance and Economics, 44(12), 4–17.
7. Eaton, J., & Kortum, S. (2002). Technology, geography, and trade. Econometrica, 70(5), 1741–1779.
8. Feng, Y. J., & Lou, F. (2018). Research on the macroeconomic effects of China's VAT reform. Macroeconomics, 2018(4), 30–39.
9. Fitzgerald, D., & Haller, S. (2018). Exporters and shocks. Journal of International Economics, 113, 154–171.
10. Fontagné, L., Martin, P., & Orefice, G. (2018). The international elasticity puzzle is worse than you think. Journal of International Economics, 115, 115–129.
11. Heathcote, J., & Perri, F. (2002). Financial autarky and international business cycles. Journal of Monetary Economics, 49(3), 601–627.
12. Huang, P., Wang, J. X., & Meng, X. (2018). Rebalancing economic globalization and China–US trade friction. China Industrial Economics, 2018(10), 156–174.
13. Krugman, P. (1979). A model of balance-of-payments crises. Journal of Money, Credit and Banking, 11(3), 311–325.
14. Lan, Y. S., & Xu, X. F. (2019). The impact mechanism of tariffs on China's participation in global value chains: Evidence from mediating effects. Finance & Trade Economics, 2019(1), 63–74.
15. Li, C. D., He, C. T., & Lin, C. W. (2018). Evaluation of the effects of China–US trade friction countermeasures. China Industrial Economics, 367(10), 139–157.
16. Li, J. F., & Zhang, Y. X. (2012). Quantitative analysis of the impact of international trade green barriers on China's economy: A CGE model analysis of carbon tariffs. Journal of International Trade, 2012(5), 105–118.
17. Lin, B. Q., & Mou, D. G. (2008). The impact of energy prices on the macroeconomy: A CGE-based analysis. Economic Research Journal, 2008(11), 88–101.
18. Lin, B., & Jia, Z. (2018). Energy, environmental, and economic impacts of carbon tax rates in China: A CGE-based study. Energy, 159, 558–568.
19. Lin, B., & Jia, Z. (2019). Impacts of China's carbon emission trading market with electricity sector coverage only: A CGE-based study. Energy Economics, 78, 301–311.
20. Löfgren, H., Harris, R. L., & Robinson, S. (2001). A standard computable general equilibrium (CGE) model in GAMS (TMD Discussion Paper No. 75). IFPRI.
21. Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica, 71(6), 1695–1725.
22. Mu, Y., Cai, W., Evans, S., Wang, C., & Roland-Holst, D. (2018). Employment impacts of renewable energy policies in China: A decomposition analysis based on a CGE modeling framework. Applied Energy, 210, 256-267.
23. Robinson, S., Kilkenny, M., & Hanson, K. (1990). The USDA/ERS computable general equilibrium model of the United States. USDA Economic Research Service.
24. Ruhl, K. J. (2008). The international elasticity puzzle. Unpublished manuscript, New York University.
25. Smith, A. (1776/1937). The wealth of nations. Modern Library.
26. Tian, Z. W., & Hu, Y. J. (2013). Dynamic analysis of VAT reform impacts on industrial tax burdens: A CGE approach. Journal of Finance and Economics (Zhejiang University), 173(4), 29–34.
27. Wang, X. M., Qin, X. Z., & Shang, Q. (2014). Trade protectionism and China's industrial exports since the financial crisis. Journal of International Trade, 2014(9), 88–97.
28. Wang, Y., Wang, E. D., & Bi, Y. (2017). Economic impacts of carbon emissions peaking in China under different scenarios: A CGE analysis. Resources Science, 39(10), 1896–1908.
29. Wu, Y. W., Wang, S., & Li, X. D. (2018). Research progress on tariff absorption in international trade: A theoretical framework. Journal of International Trade, 2018(5), 13–27.
30. Yilmazkuday, H. (2019). Understanding the international elasticity puzzle. Journal of Macroeconomics, 59, 140–153.
31. Yi, K. M. (2003). Can vertical specialization explain the growth of world trade? Journal of Political Economy, 111(1), 52–102.
32. Yuan, P. F., & Wei, W. X. (2012). A general equilibrium study on the economic impact of real estate price fluctuations (Doctoral dissertation).
33. Yuan, Y. (2013). Quantitative analysis of the impact of carbon tariffs on China's economy: A CGE model approach. Journal of International Trade, 2013(2), 92–99.
34. Zhao, H., Liu, J., & Wu, J. (2023). The impact of vertical fiscal asymmetry on carbon emissions in China. Environmental Science and Pollution Research, 30(24), 65963-65975.
35. Zimmermann, C. (1997). International real business cycles among heterogeneous countries. European Economic Review, 41(2), 319–356.