Research Article

To What Extent a Possible FTA between China and Kazakhstan Beneficial? A CGE-Based Evidence

Dr. Mazen Diwani[1*], Dr. Mohamed Hamid[2], Dr. Ibrahem Alshbili[3]

[1]Faculty of Social Sciences, Northeastern University London, London E1W 1LP, UK.
[2]Department of Business Administration and Economics, University of the People, CA 91101, USA.
[3]Libyan Audit Bureau, Tripoli 1563, Libya.

*Email: meezdin86@gmail.com

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Abstract

The Eurasian Economic Union (EAEU) recently conducted a free trade agreement with China, which was signed in 2018 but is not yet in force. This paper utilizes the Computable General Equilibrium (CGE) model with the Global Trade Analysis Project (GTAP) database for quantitative analysis of the economy-wide effects of a hypothetical agreed FTA between Kazakhstan (excluding other members of the EAEU) and China. This proposed FTA has relative importance for the two countries since Kazakhstan is a member of the EAEU and because of the recently imposed Western sanctions on Russia, these sanctions might develop channels that could distort the benefits of EAEU. The paper examines four short- and long-term scenarios involving fixed and flexible current account positions. The results highlight how the elimination of tariffs on bilateral merchandise trade would help both Kazakhstan's and China's economies through a potential free trade agreement. Our results indicate four important policy implications: Firstly, rather than trade diversion, this potential FTA is seen as an enhancing factor in generating a larger trade creation effect. Secondly, resources will be reallocated in each economy to the sectors in which they are more advantageous. Thirdly, in terms of the macroeconomic implications, we find that real GDP, EV, and real consumption all show some gains. Finally, as for the sectoral effects, the findings indicate that bilateral trade would increase, with China's exports to Kazakhstan growing more quickly than those of Kazakhstan to China.

Keywords

GTAP Model, China-Eurasian Economic Union FTA, Welfare Effects, Sectoral aspects; Kazakh Economy.

1. Introduction

Over the past two decades, the global trading system has experienced a marked increase in preferential trade agreements (PTAs). According to the World Trade Organization (WTO), the number of Regional Trade Agreements (RTAs) in force rose from 22 in 1990 to 356 by 2022 (WTO, 2022). As of December 1, 2022, WTO records indicate that 355 RTAs were in force, corresponding to 582 separate notifications covering goods, services, and accessions (WTO, 2023).

Kazakhstan has historically pursued deep trade integration within the Commonwealth of Independent States (CIS), particularly with Russia and Belarus. This regional cooperation led to the formation of a customs union in 2007 and subsequently the establishment of the Eurasian Economic Union (EAEU), which initially included Belarus, Kazakhstan, and Russia, and later expanded to Armenia and Kyrgyzstan. However, the geopolitical and economic landscape shifted significantly following the onset of the Russia–Ukraine war in February 2022. In response, sanctions were imposed on Russia—over 10,000— by the United States, the European Union, and allied countries (Sultonov, 2022).

A growing body of literature suggests that political and economic developments in Russia have substantial spillover effects on neighboring CIS countries through trade, remittances, and foreign direct investment (FDI) channels. For instance, Dreger et al. (2016) find that economies with strong linkages to Russia tend to face heightened vulnerability to growth slowdowns. Similarly, the IMF (2015) reports that sanctions on Russia can significantly affect adjacent economies via trade linkages and may constrain the ability of EAEU members such as Kazakhstan to diversify their export destinations.

Given Kazakhstan's economic interdependence with Russia, recent sanctions could generate adverse short-run macroeconomic shocks. This paper is therefore motivated by a critical policy question: What are the economy-wide effects of a potential free trade agreement (FTA) between Kazakhstan and China, and to what extent could such an agreement mitigate the economic fallout from Western sanctions on Russia? Bayramov, Rustamli, and Abbas (2020) use vector autoregression (VAR) models to analyze the impact of sanctions against Russia on Central and Eastern European (CEE) and CIS countries. Their results indicate that a 9% contraction in Russia's GDP could reduce output in CIS economies by up to 6.5%. Makhmutova (2019) observed an initial decline in the GDP of EAEU during the early years of the sanctions (2015–2018), followed by uneven recovery across member states. Furthermore, Sedrakyan (2022) finds that Western sanctions imposed between 2014 and 2018 significantly disrupted bilateral trade between Russia and several transition economies.

In light of these findings, and the persistent vulnerability of CIS countries to Russian economic shocks, this paper investigates whether strengthening trade ties with major Asian economies—specifically China—could offer Kazakhstan an effective strategy for economic diversification and resilience. While this study does not aim to quantify the direct costs of sanctions—imposed on Russia— on Kazakhstan, it assesses the potential gains from an FTA with China using a computable general equilibrium (CGE) framework.

This research addresses an increasingly pertinent debate in national and international policy circles: whether Kazakhstan should deepen its regional integration or instead pivot towards broader trade partnerships, particularly with countries like China and India. Accordingly, this paper has two primary objectives: i) to apply a CGE modeling approach using the Global Trade Analysis Project (GTAP) model and version 9 of its database to estimate the macroeconomic impacts of a proposed FTA between China and Kazakhstan; ii) to simulate four trade liberalization scenarios that capture short-run (flexible current account) and long-run (fixed current account) macroeconomic adjustments.

The remainder of the paper is structured as follows: Section 2 reviews the potential economic benefits of an FTA between Kazakhstan and China. Section 3 provides an overview of the GTAP model and data. Section 4 outlines the simulation scenarios. Section 5 presents and interprets the results. Section 6 discusses policy implications, and Section 7 concludes. Technical details of the CGE model and its equations are presented in Annex A.

2. Literature Review

2.1. The potential Gains of an FTA Signed by Kazakhstan and China: A Closer Look in the Literature

The economic rationale for free trade over protectionism is well-established in mainstream economic thought, primarily grounded in the principles of comparative advantage and the gains from trade. These foundational concepts underpin the near-universal support among economists for trade liberalization (Rodrik, 2018). In his influential paper *"What Do Trade Agreements Really Do?"*, Rodrik highlights the distributional consequences of trade, noting that, akin to technological progress, trade expands the economic pie while leaving some groups behind. He argues: "We did not ban automobiles or light bulbs because coachmen and candle-makers would lose their jobs. So why restrict trade?" This perspective reinforces the notion that Free Trade Agreements (FTAs) inherently produce both "winners" and "losers."

Proponents of FTAs contend that such agreements enhance trade in goods and services, stimulate employment, and generate welfare gains through trade creation—where reduced trade barriers increase intra-bloc trade volumes (Jin et al., 2006). However, critics point to trade diversion, where import sources shift from more efficient non-member countries to less efficient member countries, potentially harming global welfare.

Rodrik (2018) further argues that well-designed trade agreements can offset the influence of protectionist special interests and guide economies toward welfare-enhancing outcomes by limiting restrictive regulations. In this context, China emerges as a vital bilateral, regional, and multilateral partner for Kazakhstan—being a key member of the WTO and a leading actor in the Asia-Pacific Economic Cooperation (APEC). Against this backdrop, our study seeks to evaluate the potential economic benefits of an FTA between China and Kazakhstan.

Empirical studies on China's FTAs support the premise of welfare-enhancing outcomes. For example, Lakatos and Walmsley (2012) report that the China–ASEAN Free Trade Agreement (ACFTA), effective since January 1, 2010, generated global welfare gains of USD 18.04 billion, with Malaysia (USD 3.56 billion) and China (USD 3.15 billion) among the top beneficiaries. Similarly, Xiang, Kuang, and Li (2017) demonstrate that the China–Australia Free Trade Agreement (ChAFTA) led to significant trade creation with moderate trade diversion, primarily benefiting Chinese consumers and Australian coal exporters. Arora, Singh, and Mathur (2015) highlight the trade-enhancing potential of a proposed India–China FTA, noting that exploiting sector-specific comparative advantages could boost bilateral and global exports.

According to Qiu et al., (2022), only a few of China's free trade agreements have demonstrated indications of trade diversion, while nine of them have been demonstrated to have a significant impact on trade and social welfare growth. Free trade agreements (FTAs) with Latin American countries such as Chile and Peru have greatly expanded bilateral trade flows and product exchanges, though the effects diminished over time (Lopez, & Munoz, 2021). The same authors claim that by expanding trade volumes and diversifying the products traded, free trade agreements have enhanced China's market opportunities and economic resilience. The results indicate that China's international trade benefits from the deepening of the FTA, favoring imports over exports (Wang et al., 2022). It highlights the greater benefits enjoyed by developed countries and shows a less positive effect on agricultural trade when compared to industrial products.

Given China's economic scale and Kazakhstan's resource-rich, export-oriented economy, it is expected that China would play a dominant role in the trade relationship. The question remains whether Kazakhstan should deepen regional integration or pivot toward stronger economic ties with countries like China and India, especially in light of the investment uncertainty created by the Russia–Ukraine war since 2022.

Kazakhstan's transformation into a market economy since 1991 has attracted considerable foreign investment, particularly in the oil, gas, and mineral sectors. However, its proximity to Russia and historical economic interdependence expose it to external shocks arising from geopolitical tensions and sanctions. While this may deter some investors, others may view Kazakhstan as a viable alternative to Russia or Belarus. Previous FTAs have yielded positive outcomes for Kazakhstan, suggesting that a prospective FTA with China could similarly be advantageous.

Kazybayeva and Tanyeri-Abur (2003) employed a CGE model to simulate the impact of tariff liberalization scenarios on Kazakhstan's economy. Their findings show that a 50% tariff reduction across sectors led to GDP and welfare gains, along with reduced unemployment, albeit at the cost of declining government revenue. In contrast, scenarios promoting import substitution policies resulted in GDP contraction, higher unemployment, and reduced household welfare. Jensen and Tarr (2007) also used a CGE framework to evaluate Kazakhstan's WTO accession and found medium- and long-run consumption gains of 6.7% and 17.5%, respectively. The most significant gains stemmed from liberalizing barriers to multinational service providers.

Free trade agreements (FTAs) carry some risks in addition to their potential for substantial economic gains, especially for nations like Kazakhstan that are becoming more and more involved in China-led projects like the Silk Road Economic Belt. These risks, which include environmental degradation, labor market vulnerabilities, and economic dependency, should be carefully considered in light of the expanding bilateral trade relationship.

Kazakhstan may become more economically dependent on one major trading partner as a result of an FTA with China, particularly in vital industries like agriculture and energy. This reliance may increase the nation's vulnerability to outside shocks, such as shifts in regulatory frameworks or variations in Chinese demand (Nadyrov & Bin, 2022; Zhanakova, 2016). Kazakhstan's bargaining power and policy autonomy may be further limited by an unbalanced trade balance caused by asymmetrical export-import flows.

Trade liberalization has made it easier for Chinese companies to compete, which could cause disruptions in Kazakhstan's domestic labor markets. According to Gleeson & Labonté (2020), industries that are unable to match the cost structures or productivity of their Chinese rivals may face deindustrialization, downward wage pressures, or job losses. The Silk Road Economic Belt and other regional trade corridors may increase Kazakhstan's exposure to global value chains without sufficient labor protections, which could worsen these effects (Janshanlo et al., 2022).

Environmental sustainability is frequently sacrificed in the name of trade expansion and infrastructure development under free trade agreements. Given the size of infrastructure projects associated with the Belt and Road Initiative (BRI) in Kazakhstan, this is especially important because inadequate environmental protections could lead to increased pollution, resource depletion, and habitat destruction (MacDermott et al., 2011; Gleeson & Labonté, 2020). As Kazakhstan negotiates trade and investment frameworks with China, striking a balance between environmental preservation and economic integration continues to be a major policy challenge.

Despite these insights, two important gaps remain in the literature. First, few studies have examined the sector-specific export and import effects of FTAs on Kazakhstan, especially in strategic sectors. Francois and Manchin (2009) address this partially in their CGE analysis of a potential EU–CIS FTA, finding positive income and export effects for Kazakhstan under all scenarios—particularly under full liberalization, where GDP gains reached 2.36%. However, some sectors, such as light manufacturing, did not benefit equally.

Second, previous studies generally fail to consider different macroeconomic closure rules, such as flexible versus fixed current account positions across short- and long-run horizons. This limitation may affect the robustness of CGE-based policy analysis. Nejati et al. (2020) examine the welfare effects of tariff reduction between Iran and the EAEU, showing substantial gains for Russia, Iran, and Kazakhstan, though they omit detailed short- and long-run macroeconomic closure scenarios. Similarly, Cheong and Turakulov (2022), using the GTAP model, simulate the effects of tariff reduction and trade facilitation across Central Asian economies, finding strong GDP and welfare improvements for countries including Kazakhstan. Yet, they too do not incorporate alternative closure assumptions that reflect short-run versus long-run economic dynamics.

Our study addresses both these gaps by examining the sectoral trade effects and adopting a scenario-based approach that distinguishes between flexible and fixed current account positions. This allows for a more nuanced understanding of the potential macroeconomic and sectoral impacts of a China–Kazakhstan FTA under varying economic adjustment conditions.

3. Methodology

3.1. Outlines of the GTAP Model and Database

3.1.1. The GTAP Model

In this paper, we apply the standard GTAP model which is a type of CGE model for comparative static analysis. Hertel (1997) discusses the theoretical structure of GTAP which provides an overview of GTAP. A detailed account of the construction of the standard CGE model is included in Appendix A for which the GTAP is one particular type. According to the GTAP model, every market is perfectly competitive. In every market, supply and demand are equal, meaning that the producer's marginal cost and the price they receive are equal. By taxing and subsidizing commodities and primary factors, regional governments can create a gap between the prices that buyers pay and the prices that producers receive. Buyers make a distinction between imported and domestically produced goods in markets for traded commodities. Additionally, imports can be differentiated by their region of origin. This enables each tradable product to be traded in both directions across regions. Primary factors and intermediate inputs are the two categories of inputs utilized in production.

According to the model, the inputs in each sector—in each region—are combined to minimize the overall cost at a specific output level. A three-level nested production technology limits the sectors' choice of inputs. At the first level, two bundles—the intermediate input and the primary factor—are used in predetermined ratios based on a Leontief function. Bundles of intermediate input are configured at the second level as a combination of domestic goods and imported bundles with the same input-output name. Similarly, combinations of labor, capital, and land form bundles of primary factors. The Constant Elasticity of Substitution (CES) form of the aggregator function is present in both scenarios. CES composites of imported items from each region that share the same name are used to create imported bundles at the third level. Each region has one representative household. Aggregate household spending is calculated as a fixed percentage of total regional income, which is the sum of national savings, government spending, and household consumption. The household purchases bundle of goods to maximize its utility while adhering to financial constraints. The import bundles are CES aggregations of imports from each region, while the bundles are CES combinations of imports and domestic goods. The percentage of total government spending in each region's income is kept constant. The Cobb-Douglas distribution is used to divide government spending among commodities. The same nesting scheme that is used to allocate total household expenditure on each good is also used to allocate total expenditure on each good to domestically produced and imported versions. Global savings are used to finance investments in each region. A set percentage of each region's income is added to the savings pool. Each region's savings are distributed in one of two ways under standard GTAP. Allocating based on a predetermined percentage of the pool is the first step. Allocating investments based on the prevailing relative rates of return is the second step.

3.1.2. GTAP 9 Database

The data for this study was obtained using the GTAP database which is a publicly accessible, fully documented global database with comprehensive bilateral trade information, transport, and protection linkages. An essential component of modern applied general equilibrium (AGE) analysis of international economic problems is the GTAP database, which provides a representation of the global economy. The current release, the GTAP 9 database, features 2004, 2007, and 2011 reference years as well as 140 regions for all 57 GTAP commodities. In the year base of the version used in this study (version 9 for which the year 2011 was chosen as a reference year), the GTAP database provides a consistent picture of the global economy. National input-output tables, trade, macroeconomic, and protection data from multiple sources underpin the database. The underlying input-output tables are heterogeneous with respect to base years, sectoral detail, and sources; therefore, significant efforts are made to achieve comparability between the disparate sources to achieve consistency. Aguiar et. al (2016) published in the Journal of Global Economic Analysis provides a complete account of the Global Trade Analysis Project (GTAP) and a bit of history on the database. The GTAP model captures world economic activity in 57 different industries of 140 regions (database version 9). For our analysis, we have aggregated these into *9 regions and 10 sectors* (See Appendix B, Table B1).

Due to methodological consistency and data accessibility, this paper uses the GTAP 9 database with 2011 as the reference year. The most recent available iteration of the GTAP database, known as GTAP 9, provides a thorough, globally harmonized dataset appropriate for Computable General Equilibrium (CGE) analysis. Although more recent iterations of GTAP (such as GTAP 10 and GTAP 11) use 2014 and 2017 as base years, respectively, they are not publicly available and are therefore not included in the resources of this study. More importantly, the fundamental structural characteristics of the economies included in the GTAP 9 dataset, including production technologies, trade links, and macroeconomic balances, are largely consistent with those found in subsequent iterations.

The updates between versions usually represent minor improvements rather than significant modifications to the data structure or methodology, as mentioned in the GTAP documentation and related studies (Aguiar et al., 2016). Because this study is counterfactual and comparative-static, the use of GTAP 9 does not materially impair the analysis's validity. Additionally, the simulations are designed to represent stylized trade policy scenarios that emphasize structural relationships over exact short-term forecasting to increase the findings' relevance. Because they seek to examine the possible long-term impacts of a Kazakhstan–China free trade agreement rather than replicate current trade volumes, the conclusions drawn are therefore robust to the particular base year. Additionally, each version of the GTAP database is built on the basis of bilateral trade flows, factor endowments, consumption patterns, and input-output tables.

Although updates between versions may include more recent national input-output tables and updated macroeconomic aggregates, they usually improve rather than change the underlying economic relationships. This indicates that the fundamental elements of a country's economic structure—production technologies, trade elasticities, and Armington preferences—remain substantially the same throughout GTAP iterations. For example, Aguiar et al. (2016) explain that the main modifications to GTAP 9 compared to earlier versions were improved data reconciliation, improved alignment with national accounts, and the inclusion of new countries and industries. Similarly, GTAP 10 and 11 expand the coverage of countries and update the base year, but they do not significantly alter the structural economic relationships that support the simulation results in a CGE model. For comparative-static analyses like ours, the findings from GTAP 9 are therefore still applicable.

3.2. Simulation Design

Table 1 presents the bilateral import tariffs between Kazakhstan and China based on data from GTAP version 9. The data reveal that Kazakhstan imposes its highest tariffs on Chinese imports in sectors typically deemed sensitive for domestic agriculture and food security. These include grains and crops (15.63%), processed food (13.87%), and livestock (13.12%). Such tariff structures likely reflect protectionist policies aimed at shielding local producers from competition in labor-intensive, subsistence-critical sectors.

On the other hand, China's tariffs on imports from Kazakhstan are notably higher in select sectors, particularly grains (23.12%) and textiles (36.44%). These elevated rates suggest China's attempt to protect its domestic agricultural and textile industries, which are vital for employment and social stability, especially in rural provinces. Interestingly, outside these sensitive sectors, China's average tariff levels are generally lower than Kazakhstan's, including in mining and extraction, a sector where Kazakhstan has a comparative advantage. This disparity may reflect China's strategic interest in maintaining affordable access to Kazakhstan's abundant natural resources, while Kazakhstan seeks to diversify away from extractive exports by protecting its nascent manufacturing and agricultural sectors.

Overall, the observed tariff patterns illustrate how both countries' trade policies are shaped not only by economic efficiency but also by the political economy of sector-specific considerations and developmental priorities.

Table 1. Existing Bilateral Tariffs of Kazakhstan and China Merchandise Trade (%)

Sector	Tax on ICK	Tax on IKC
Grains and Crops	23.12	15.63
Livestock and Meat Products	11.56	13.12
Mining and Extraction	0.05	4.86
Processed Food	7.56	13.87
Textiles and Clothing	36.44	8.36
Light Manufacturing	7.15	6.53
Heavy Manufacturing	2.97	5.56
Utilities and Construction	0.00	0.00
Transport and Communication	0.00	0.00
Other Services	0.00	0.00

ICK: Imports to China from Kazakhstan
IKC: Imports to Kazakhstan from China Source: GTAP database version 9.

This paper simulates the economic implications of a potential Free Trade Agreement (FTA) between Kazakhstan and China by modeling the complete elimination of bilateral tariffs on goods trade, using 2011 as the base year from GTAP 9. All other distortions in the model—such as taxes, subsidies, and factor endowments—are held constant to isolate the effects of tariff liberalization (Aguiar et al. 2016).

Table 2 outlines four simulation scenarios, designed to reflect different macroeconomic environments based on model closure assumptions and time horizons (short-run vs. long-run). In a CGE framework, model closure determines which variables are endogenous (solved within the model) and exogenous (held fixed). This distinction is crucial for capturing the structural constraints and policy flexibility of the economy (Dixon & Jorgenson, 2013; Hosoe, Gasawa, & Hashimoto, 2010).

- **Scenario 1** (short-run, flexible current account) assumes capital, natural resources, and land are fixed (exogenous), while wages adjust endogenously to clear labor markets. Labor is mobile and endogenous, while the exchange rate is fixed, allowing the trade balance to adjust (Hertel, 1997).
- **Scenario 2** (long-run, flexible current account) treats capital as mobile and endogenous, while land, natural resources, and labor supplies are fixed. Again, the exchange rate is fixed, and the current account adjusts endogenously.
- **Scenarios 3 and 4** mirror Scenarios 1 and 2, respectively, but assume a fixed current account. Here, the exchange rate is allowed to adjust, and the trade balance remains constant, reflecting external balance constraints.

These alternative closures are not merely technical choices—they capture different real-world assumptions about factor mobility, wage flexibility, and external account constraints. By comparing across scenarios, we can assess the robustness of FTA-induced effects under diverse macroeconomic settings, providing deeper insights into the distributional and aggregate outcomes of trade liberalization between Kazakhstan and China (van der Mensbrugghe, 2005; Dixon & Jorgenson, 2013).

Table 2. Simulation Design with Zero Tariff for FTA between China and Kazakhstan in GTAP

Full liberalization				
Scenario	**Flexible Current Account**		**Fixed Current Account**	
Scenario 1	Short run			
Scenario 2		Long run		
Scenario 3			Short run	
Scenario 4				Long run

4. Results and Analysis

The outcomes of the GTAP simulations of a hypothetical free trade agreement between China and Kazakhstan are presented in this section. The findings will emphasize the effects on trade patterns, sectoral effects, and macroeconomic effects. The findings will show whether trade is created or diverted after this free trade agreement is formed, as well as the estimated effects on trade flows in the global trade content of a hypothetical free trade agreement between China and Kazakhstan.

4.1.Macro-economic Effects

Table 3 presents the simulation results for full bilateral liberalization of goods trade between Kazakhstan and China under four alternative model closure scenarios, incorporating both short-run and long-run dynamics, and flexible versus fixed current account assumptions. The analysis yields several noteworthy economic insights and policy-relevant implications.

Firstly, the simulations indicate that both countries experience real GDP gains, although the distribution of benefits is markedly asymmetric. Kazakhstan's real GDP rises by 0.31% to 0.70%, depending on the scenario, whereas China records a marginal increase of 0.01% across all cases. This disparity underscores Kazakhstan's relatively higher pre-liberalization tariff levels and greater sensitivity to external shocks. The stronger response in Kazakhstan also highlights its higher marginal returns from trade liberalization due to a more protected and less diversified economic base. In contrast, China's already liberal trade regime and diversified industrial structure yield smaller incremental gains. These findings align with the broader literature on the disproportionate distribution of benefits in North-South FTAs, where the smaller economy often reaps larger relative gains (Brown et al., 2005; Siriwardana, 2006).

Secondly, the impact on trade flows is similarly skewed. Kazakhstan's exports increased by 1.10–1.34%, while imports grew by 1.33–1.75%, reflecting enhanced market access and trade creation effects. China's trade volumes, however, remain comparatively stable, with exports and imports rising by only 0.04% and 0.07%, respectively. The larger import expansion in both countries reflects a classic substitution effect—domestic buyers shift from higher-cost domestic production to more efficient foreign suppliers following tariff elimination (Viner, 1950). Notably, scenarios with a fixed current account (Scenarios 3 and 4) exhibit slightly higher export expansion, suggesting that balance-of-payment constraints can influence trade composition via exchange rate adjustments. From a policy perspective, this implies that macroeconomic flexibility—especially in exchange rate policy—can meaningfully shape trade outcomes following liberalization.

Thirdly, improvements in the trade balance are evident in both the short and long run. In the short run (Scenario 1), China's trade surplus increases by approximately USD 27 billion, while Kazakhstan's rises by USD 295 million. In the long run (Scenario 2), Kazakhstan's surplus improves further to USD 447 million, reflecting gradual efficiency gains and deeper integration benefits. Although terms of trade (ToT) effects are limited—with only a 0.02% gain for Kazakhstan and negligible change for China—welfare improvements are primarily driven by allocative efficiency and consumer price effects rather than by favorable movements in relative export prices.

Welfare outcomes, measured by equivalent variation (EV) and real consumption expenditure, further confirm the positive effects of the proposed FTA. Kazakhstan exhibits significant welfare improvements, particularly in the short run (EV and consumption gains of 0.77% and 0.33%, respectively), while China registers modest but positive effects (0.01%). The results also reveal modest negative EVs for non-member regions, reflecting trade diversion—a common byproduct of preferential trade agreements when trade is reoriented away from more efficient third-country suppliers (Siriwardana, 2007). This reinforces the importance of considering multilateral compatibility and WTO consistency in the design of regional FTAs.

Further insight is provided in Table 4, which decomposes the welfare gains to identify the primary drivers of EVs in both economies. For China, welfare gains across all scenarios are predominantly attributed to allocative efficiency, endowment effects, and modest improvements in terms of trade (goods). In contrast, Kazakhstan's welfare gains in the short-run scenarios (1 and 3) are more strongly influenced by allocative efficiency and factor endowment adjustments, reflecting short-term productivity gains and more efficient resource allocation. Notably, terms of trade improvements contribute positively to Kazakhstan's EV across all scenarios but negatively for China, highlighting Kazakhstan's relative advantage in sectoral gains from bilateral tariff reductions. Other potential welfare drivers—such as technical change, population growth, and preference shifts—are negligible in all cases, underscoring the dominant role of market access and price adjustment channels in determining welfare outcomes.

Given the significant increases in output, welfare, and consumption, these findings imply that Kazakhstan has a compelling economic reason to seek bilateral trade liberalization with China from a policy perspective. To gain from these advantages, policymakers should give complementary reforms in infrastructure, labor mobility, and customs facilitation top priority. The simulations also highlight how macroeconomic flexibility can maximize trade benefits, suggesting that close coordination between Kazakhstan's central bank and fiscal authorities is necessary to maintain macro-stability during the implementation phase of any free trade agreement.

Furthermore, given the modest but favorable effects on China, these agreements may have strategic uses beyond financial gain, especially when considering the larger regional integration objectives of the Silk Road Economic Belt. To reduce welfare losses for third countries, the existence of trade diversion effects necessitates the careful sequencing of free trade agreements, ideally integrated into multilateral or regionally inclusive frameworks. Lastly, the welfare decomposition results emphasize the significance of sector-specific policies to maximize national gains and leverage allocative efficiency, such as increasing Kazakhstan's agricultural and processed food productivity. In conclusion, the model-based evidence backs the goal of a "China–Kazakhstan FTA," but it also emphasizes how crucial targeted complementary policies and regional cooperation are to achieving and maintaining the agreement's advantages.

Table 3. Macro-Economic Effects of China-Kazakhstan Under Four Scenarios							
	Real GDP (%)	Export volume (%)	Import volume (%)	ToT * (%)	TB** (US$ million)	EV*** (US$ million)	RCE**** (%)
Scenario 1 (SHORT-RUN & FLEXIBLE CA)							
China	0.01	0.04	0.07	0.01	27085.96	447.54	0.01
East Asia	0.00	0.00	-0.01	0.00	20525.50	-51.07	0.00
EU	0.00	0.00	0.00	0.00	-8302.15	-97.58	0.00
India	0.00	0.00	0.00	0.00	-5818.87	-9.16	0.00
Kazakhstan	0.70	1.11	1.75	0.00	294.69	750.42	0.77
North America	0.00	0.00	0.00	0.00	-79815.39	-47.77	0.00
ROW	0.00	-0.01	-0.01	0.00	33987.19	-6.23	0.00
South East Asia	0.00	0.00	0.00	0.00	15405.91	-5.75	0.00
South Asia	0.00	0.00	0.00	0.00	-3362.81	-1.36	0.00
Scenario 2 (LONG-RUN & FLEXIBLE CA)							
China	0.01	0.04	0.07	0.01	27046.36	365.94	0.01
East Asia	0.00	0.00	-0.01	0.00	20508.32	-41.77	0.00
EU	0.00	0.00	0.00	0.00	-8337.22	-87.03	0.00
India	0.00	0.00	0.00	0.00	-5821.12	-5.64	0.00
Kazakhstan	0.32	1.12	1.41	0.02	447.18	255.99	0.26
North America	0.00	0.00	0.00	0.00	-79846.57	-37.99	0.00
ROW	0.00	-0.01	-0.01	0.00	33964.15	-55.79	0.00
South East Asia	0.00	0.00	0.00	0.00	15402.40	-6.35	0.00
South Asia	0.00	0.00	0.00	0.00	-3363.50	-0.82	0.00
Scenario 3 (SHORT-RUN & FIXED CA)							
China	0.01	0.04	0.07	0.01	27099.35	444.26	0.01
East Asia	0.00	0.00	0.00	0.00	20491.91	-44.11	0.00
EU	0.00	0.00	0.00	0.00	-8382.25	-87.46	0.00
India	0.00	0.00	0.00	0.00	-5823.57	-7.36	0.00
Kazakhstan	0.58	1.34	1.43	-0.04	518.94	609.11	0.33
North America	0.00	0.00	0.00	0.00	-79884.63	-34.23	0.00
ROW	0.00	-0.01	-0.01	0.00	33943.99	-17.39	0.00
South East Asia	0.00	0.00	0.00	0.00	15400.24	-5.94	0.00
South Asia	0.00	0.00	0.00	0.00	-3363.98	-0.87	0.00
Scenario 4 (LONG-RUN & FIXED CA)							
China	0.01	0.04	0.07	0.01	27091.74	353.38	0.01
East Asia	0.00	0.00	0.00	0.00	20493.68	-39.28	0.00
EU	0.00	0.00	0.00	0.00	-8372.76	-83.00	0.00
India	0.00	0.00	0.00	0.00	-5823.14	-5.17	0.00
Kazakhstan	0.31	1.18	1.33	0.00	506.03	240.01	0.16
North America	0.00	0.00	0.00	0.00	-79877.16	-31.65	0.00
ROW	0.00	-0.01	-0.01	0.00	33945.52	-54.74	0.00
South East Asia	0.00	0.00	0.00	0.00	15400.00	-6.18	0.00
South Asia	0.00	0.00	0.00	0.00	-3363.96	-0.67	0.00

Note: All projections are percentage deviations from the base period except the trade balance and the equivalent variation (EV) which are in US$ million. *Terms of Trade; **Trade Balance; ***Equivalent Variation; ****Real Consumption Expenditure.
Source: Model Simulation.

4.2. Sectoral Effects

As sectors adapt to shifts in relative prices and competitiveness, trade liberalization frequently leads to structural change through the reallocation of key resources like labor, capital, and land. Theoretically, resources move toward industries with comparative advantage when trade is liberalized bilaterally or multilaterally, improving overall efficiency and welfare (Brown et al., 2006; Siriwardana and Yang, 2008). The simulated sectoral effects of a prospective China–Kazakhstan Free Trade Agreement (FTA), reported in Tables 5–7, offer important insights into these dynamics.

In terms of trade balance effects (Table 5), Kazakhstan's comparative advantage in natural resources is reflected in the notable advancements in the mining and extraction industry. Following this, there have been improvements in the trade balance in the areas of transportation and communication as well as grains and crops, indicating a rise in the demand for Kazakhstan's agricultural exports and transportation services post-liberalization. The trade balances of the majority of other industries, such as processed foods, apparel, and textiles, are declining, though, suggesting increased competition from imports and potential crowding out of domestic production. On the other hand, China's comparative advantage in labor-intensive industries drives significant trade balance gains in the light manufacturing and textile and clothing sectors. The trade balance is deteriorating in sectors like mining and extraction, grains and crops, and livestock, indicating that resources may need to be reallocated away from these less competitive industries.

As for the output effects (Table 6), the direction of output changes broadly aligns with trade balance trends. In Kazakhstan, Mining, Grains and Crops, and Transport see significant output expansion. Interestingly, Heavy Manufacturing shows output growth despite a deteriorating trade balance, implying that domestic production is being absorbed internally—possibly as intermediate inputs or due to rising domestic demand. Sectors such as Textiles contract sharply (–6.09%), consistent with import penetration effects and declining competitiveness. In China, output growth is concentrated in Light Manufacturing and Textiles, though the scale is modest. These results confirm that bilateral tariff removal induces sectoral restructuring in line with each country's comparative advantage profile.

Table 7 reports factor demand effects. The findings show that changes in factor demands correspond to changes in sectoral outputs. Except for livestock and meat products, Kazakhstan exhibits widespread decreases in land usage across all sectors, highlighting the land-intensive nature of this industry. Capital and labor, both skilled and unskilled, are redirected toward expanding industries like transportation, heavy manufacturing, and mining. Interestingly, employment in textiles decreases by more than 5% in all scenarios, whereas employment in heavy manufacturing and transportation increases by more than 2% and 1%, respectively. While sectoral employment effects are less pronounced in China, most sectors—except for mining, heavy manufacturing, and livestock, where labor and land usage slightly decline—show positive adjustments. These trends support the predictions of Heckscher-Ohlin trade theory, which holds that economies specialize in industries that make extensive use of their plentiful resources. China consolidates gains in labor-intensive manufacturing, while Kazakhstan, with its relative abundance of natural resources, gains in resource-based sectors. The dynamic reallocation process required to maximize trade gains is exemplified by the movement of labor away from declining sectors and toward expanding ones.

The effects of a proposed FTA between China and Kazakhstan on sectoral reallocation draw attention to several policy issues. First, to assist displaced workers in contracting industries like textiles, Kazakhstan will require active labor market policies, such as retraining, mobility subsidies, and unemployment protection. Transitioning into growing industries like mining, transportation, and heavy manufacturing may be made easier with the help of strategic vocational training. Second, in terms of industrial policy, sectoral declines in the light industry imply that certain domestic industries might not be able to survive import competition in the absence of complementary measures (such as increasing productivity or upgrading technology). To increase competitiveness in a few value-added manufacturing sectors, Kazakhstan might think about implementing targeted industrial upgrading strategies. Third, the growth of Kazakhstan's transport and communication industry suggests that advancements in connectivity and logistics infrastructure may further boost trade benefits in terms of infrastructure and trade facilitation. It would be especially beneficial to improve corridor connections within the Belt and Road Initiative (BRI) framework. Fourth, Kazakhstan might experience more environmental pressures due to the anticipated growth in resource-intensive industries like mining. To manage extraction activities effectively and responsibly, policymakers should prepare for this by implementing frameworks for sustainable resource governance. Last but not least, to comprehend the strategy in terms of inclusive growth, inclusive policies are required to guarantee widespread participation in the benefits of trade due to the unequal distribution of sectoral gains, particularly between urban-industrial and rural-agricultural areas. In underdeveloped areas, social investments and regional development initiatives would promote fair results.

In conclusion, China undergoes slight but favorable sectoral changes following its industrial endowment, while Kazakhstan undergoes a reshaping of its production and employment structure toward its areas of comparative strength as a result of the proposed FTA. Proactive policy support is essential to ensure smooth transitions and sustained long-term gains, and the simulation results highlight the importance of sectoral and factor market responses in comprehending the practical implications of trade agreements.

Table 4. Decomposition of Estimated Equivalent Variation on Kazakhstan/China Under Various Scenarios (US$ Million)

Country	Resource allocation	Endowment	Technical change	Population growth	Change in ToT* (goods)	Change in ToT** (savings and investment)	Changes in preferences	Total
China								
Scenario 1	77.58	232.00	0.00	0.00	165.67	-27.65	0.00	447.60
Scenario 2	78.21	143.92	0.00	0.00	172.89	-29.02	0.00	366.00
Scenario 3	77.69	231.80	0.00	0.00	163.71	-28.89	0.00	444.31
Scenario 4	75.80	140.92	0.00	0.00	165.02	-28.31	0.00	353.43
Kazakhstan								
Scenario 1	175.45	563.64	0.00	0.00	1.14	10.20	0.00	750.42
Scenario 2	76.53	164.73	0.00	0.00	8.09	6.63	0.00	255.99
Scenario 3	141.30	471.02	0.00	0.00	-17.56	14.34	0.00	609.11
Scenario 4	71.72	158.08	0.00	0.00	2.17	8.04	0.00	240.01

Source: Model Simulation.
***'**ToT:** Terms of Trade

Table 5. Estimated Change in Kazakhstan/China Trade Balance by Sector Under Various Scenarios (US$ Million)

Sector	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Kazakhstan				
Grains and Crops	120.48	116.95	128.25	119.37
Livestock and Meat Products	6.91	7.10	8.62	7.59
Mining and Extraction	2441.48	2511.44	2461.53	2514.04
Processed Food	-129.38	-123.89	-118.62	-120.98
Textiles and Clothing	-266.41	-258.30	-258.14	-256.30
Light Manufacturing	-844.87	-816.89	-812.73	-808.90
Heavy Manufacturing	-398.78	-365.19	-305.96	-339.42
Utilities and Construction	-412.85	-402.96	-390.90	-396.93
Transport and Communication	135.38	133.53	144.86	136.42
Other Services	-357.26	-354.59	-337.99	-348.86
China				
Grains and Crops	-1101.66	-1103.41	-1101.45	-1102.60

Livestock and Meat Products	-214.94	-216.09	-214.73	-215.62
Mining and Extraction	-14747.41	-14752.04	-14749.91	-14754.67
Processed Food	565.00	563.80	565.41	564.84
Textiles and Clothing	14096.01	14080.98	14094.39	14085.45
Light Manufacturing	18375.08	18370.02	18381.13	18381.13
Heavy Manufacturing	8396.61	8384.90	8406.26	8410.35
Utilities and Construction	258.12	257.22	257.17	257.20
Transport and Communication	1978.53	1981.56	1979.49	1984.06
Other Services	-519.37	-520.57	-518.43	-518.40
Source: Model Simulation				

Table 6. Estimated Change (%) in Output by Sector in Kazakhstan and China Under Various Scenarios

Sector	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Kazakhstan				
Grains and Crops	0.34	0.05	0.33	0.06
Livestock and Meat Products	0.80	0.38	0.51	0.31
Mining and Extraction	0.02	0.04	0.10	0.06
Processed Food	0.59	0.21	0.37	0.16
Textiles and Clothing	-6.09	-6.71	-6.19	-6.70
Light Manufacturing	0.37	-0.43	0.36	-0.40
Heavy Manufacturing	2.02	1.53	2.17	1.60
Utilities and Construction	0.99	0.46	0.84	0.44
Transport and Communication	0.75	0.29	0.57	0.26
Other Services	0.60	0.15	0.36	0.11
China				
Grains and Crops	0.01	0.00	0.01	0.00
Livestock and Meat Products	0.00	0.00	0.00	0.00
Mining and Extraction	0.00	-0.01	0.00	-0.01
Processed Food	0.00	0.00	0.00	0.00
Textiles and Clothing	0.04	0.04	0.04	0.04
Light Manufacturing	0.02	0.02	0.02	0.02
Heavy Manufacturing	0.00	0.00	0.00	0.00
Utilities and Construction	0.01	0.01	0.01	0.01
Transport and Communication	0.00	0.00	0.00	0.00
Other Services	0.01	0.01	0.01	0.00
Source: Model Simulation				

4.3. Effects on Trade Patterns

Trade liberalization, particularly in the form of Free Trade Agreements (FTAs), typically reshapes bilateral trade flows by reducing tariffs and other trade barriers, thereby altering relative prices and enhancing market access. Tables 8–10 report the simulated changes in trade flows arising from the proposed China–Kazakhstan FTA under four macroeconomic scenarios.

Table 8 reports the bilateral trade effects. The simulations reveal significant gains in bilateral trade across virtually all sectors, with Kazakhstan experiencing larger proportional benefits than China—highlighting its greater marginal exposure and potential for trade expansion. In Kazakhstan, the most dynamic sector is Textiles, which registers an exceptional increase in exports to China of over 217% in scenario 1, followed by Grains and Crops (~95%) and Livestock and Meat

Products (~75%). These results reflect Kazakhstan's latent comparative advantage in land- and resource-intensive sectors as well as potential productivity gaps that the FTA may help bridge via scale effects and increased competition.

China also records large bilateral export growth, particularly in Livestock and Meat Products (~84%), Grains (~63%), and Mining and Extraction (~55%), albeit from a different comparative advantage profile. The notable expansion in trade in agricultural and extractive sectors for both economies suggests increased two-way trade—a classic sign of intra-industry trade and deeper integration, particularly in vertically disintegrated value chains.

Tables 9 and 10 report the net trade creation effects. The FTA is found to be net trade creating in all sectors for both Kazakhstan and China. For Kazakhstan, this implies that increased imports from China more than offset any diversion of imports from the rest of the world (RoW), suggesting efficiency gains rather than mere redirection of trade. For instance, Kazakhstan's imports of Heavy Manufacturing from China increased by nearly USD 800 million, while imports of the same from RoW fell by only USD 470 million—indicating a net increase in overall import volume and consumer welfare.

Similarly, China experiences net trade creation across all sectors. This confirms that the FTA enhances total trade rather than reallocating existing trade flows inefficiently—a central condition for welfare-improving agreements under the Vinerian trade theory. Importantly, the pattern of trade creation rather than diversion mitigates the risk of negative spillovers to non-member countries and supports a more globally consistent trade liberalization process.

These findings align with the classical insights of Viner (2014) and Meade (1955), who argue that FTAs enhance welfare when trade creation exceeds trade diversion (Robinson & Thierfelder, 2002; Cheong & Wong, 2009; Breinlich, 2018).

The findings also show changes in dynamic comparative advantage, where competition and expanded market access lead to scale economies, reallocation, and potentially learning-by-exporting effects. These findings suggest various important policy ramifications. First, to promote export readiness, Kazakhstan should put policies in place that improve the competitiveness of its three most important export industries: livestock, grains, and textiles. These policies should include improving logistics infrastructure, enforcing sanitary and phytosanitary (SPS) regulations, and facilitating firm-level market access.

Second, given the rise in two-way trade, support for value chain integration ought to be given top priority; as a result, both nations ought to encourage integration into regional and international value chains. The benefits of the FTA could be increased through strategic collaboration on regulatory alignment, digital trade facilitation, and customs harmonization.

Thirdly, both governments should think about temporary safeguards, adjustment assistance, and credit facilities to help businesses and workers move toward more competitive sectors. This is because the substantial changes in bilateral trade flows suggest that import-competing industries may experience short-term disruptions.

Finally, since the FTA's net trade-creating nature implies that there will be few negative externalities for non-member nations, external trade relations should be taken into account. Therefore, to reduce conflict with third parties, China and Kazakhstan should both guarantee transparency and complementarity with larger multilateral commitments under the WTO.

Table 7. Estimated Change (%) in Demand for Key Primary Factors by Sector in Kazakhstan and China																
	Scenario 1				Scenario 2				Scenario 3				Scenario 4			
Sector	Land	Un-skilled labour	Skilled labour	Capi-tal	Land	Un-skilled labour	Skilled labour	Capi-tal	Land	Un-skilled labour	Skilled labour	Capi-tal	Land	Un-skilled labour	Skilled labour	Capi-tal
Kazakhstan																
Grains and Crops	-0.04	0.54	0.54	0.26	-0.06	0.06	0.08	0.26	0.03	0.48	0.48	0.25	-0.04	0.06	0.09	0.26
Livestock and Meat Products	0.04	1.17	1.17	0.65	0.05	0.34	0.39	0.73	-0.03	0.80	0.80	0.35	0.03	0.27	0.33	0.64
Mining and Extraction	-0.23	0.16	0.16	-0.04	-0.10	-0.02	-0.01	0.13	-0.04	0.27	0.27	0.10	-0.06	0.02	0.04	0.16
Processed Food	-0.57	1.21	1.21	0.09	-0.39	-0.26	-0.16	0.58	-0.43	0.90	0.90	-0.06	-0.36	-0.29	-0.18	0.52
Textiles and Clothing	-3.67	-5.57	-5.57	-6.83	-3.43	-7.11	-7.00	-6.16	-3.44	-5.75	-5.75	-6.82	-3.38	-7.09	-6.96	-6.18
Light Manufacturing	-0.87	0.76	0.76	-0.51	-0.61	-0.73	-0.62	0.21	-0.60	0.68	0.68	-0.39	-0.54	-0.68	-0.56	0.22
Heavy Manufacturing	-0.09	2.51	2.51	1.25	0.23	1.15	1.26	2.10	0.25	2.59	2.59	1.51	0.31	1.24	1.36	2.14
Utilities and Construc-tion	-0.58	1.57	1.57	0.20	-0.29	0.02	0.14	1.04	-0.37	1.33	1.33	0.17	-0.24	0.02	0.15	0.99
Transport and Com-munication	-0.84	1.30	1.30	-0.33	-0.37	-0.13	0.01	1.08	-0.61	1.04	1.04	-0.35	-0.32	-0.15	0.01	1.02
Other Services	-0.72	1.09	1.09	-0.17	-0.39	-0.25	-0.14	0.69	-0.56	0.78	0.78	-0.30	-0.36	-0.28	-0.16	0.62
China																
Grains and Crops	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01
Livestock and Meat Products	-0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	-0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
Mining and Extraction	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Processed Food	-0.01	0.01	0.01	0.00	-0.01	0.00	0.00	0.01	-0.01	0.01	0.01	0.00	-0.01	0.00	0.00	0.01
Textiles and Clothing	0.01	0.05	0.05	0.03	0.01	0.03	0.03	0.05	0.01	0.05	0.05	0.03	0.01	0.03	0.03	0.05
Light Manufacturing	0.00	0.03	0.03	0.01	0.00	0.01	0.01	0.03	0.00	0.03	0.03	0.01	0.00	0.01	0.01	0.03
Heavy Manufacturing	-0.01	0.01	0.01	-0.01	-0.01	-0.01	0.00	0.01	-0.01	0.01	0.01	0.00	-0.01	0.00	0.00	0.01
Utilities and Construc-tion	-0.01	0.02	0.02	0.00	0.00	0.01	0.01	0.02	-0.01	0.02	0.02	0.00	0.00	0.01	0.01	0.02
Transport and Com-munication	-0.01	0.01	0.01	-0.01	-0.01	-0.01	-0.01	0.01	-0.01	0.01	0.01	-0.01	-0.01	-0.01	-0.01	0.01
Other Services	-0.01	0.01	0.01	0.00	-0.01	0.00	0.00	0.01	-0.01	0.01	0.01	0.00	-0.01	0.00	0.00	0.01
Source: Model simulation																

Table 8. Estimated Change of Bilateral Export Volumes between Kazakhstan and China Under Various Scenarios (%)

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Sector	**ECK**	**EKC**	**ECK**	**EKC**	**ECK**	**EKC**	**ECK**	**EKC**
Kazakhstan								
Grains and Crops	63.18	95.54	95.20	63.03	62.73	96.08	95.37	62.91
Livestock and Meat Products	84.02	75.73	75.34	83.74	83.32	76.69	75.64	83.55
Mining and Extraction	55.60	-0.16	0.09	55.06	55.59	-0.08	0.10	55.08
Processed Food	52.98	31.46	31.37	52.64	52.48	31.84	31.49	52.52
Textiles and Clothing	18.19	217.56	217.23	17.75	17.76	218.06	217.39	17.64
Light Manufacturing	36.01	47.12	46.30	35.60	35.63	47.64	46.50	35.52
Heavy Manufacturing	34.86	21.64	21.29	34.48	34.60	22.12	21.45	34.43
Utilities and Construction	0.65	0.41	-0.03	0.37	0.28	0.92	0.14	0.28
Transport and Communication	0.57	0.40	-0.22	0.36	0.06	0.86	-0.06	0.23
Other Services	0.30	0.25	-0.15	0.16	-0.03	0.73	0.02	0.07

Note: EKC: Exports from Kazakhstan to China; ECK: Exports from China to Kazakhstan.

Source: Model Simulation

Table 9. Trade Creation and Diversion Effects of Kazakhstan-China Possible FTA (US$ Million)

	Kazakhstan Real Imports from							
	China				RoW			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Sector								
Grains and Crops	22.02	21.97	21.87	21.93	-13.28	-13.64	-14.48	-13.97
Livestock and Meat Products	1.96	1.95	1.94	1.95	-0.41	-0.79	-1.49	-1.09
Mining and Extraction	2.62	2.60	2.62	2.60	20.42	13.47	20.38	13.81
Processed Food	23.49	23.34	23.27	23.28	-7.33	-12.63	-15.30	-14.72
Textiles and Clothing	239.91	234.01	234.21	232.66	-148.48	-150.14	-150.14	-150.54
Light Manufacturing	386.81	382.48	382.78	381.56	-275.00	-299.46	-298.05	-304.98
Heavy Manufacturing	799.38	790.64	793.30	789.37	-470.05	-522.23	-506.96	-530.47
Utilities and Construction	1.77	1.01	0.75	0.75	32.92	20.37	15.86	15.93
Transport and Communication	0.22	0.14	0.02	0.09	7.75	5.24	1.70	3.59
Other Services	0.27	0.15	-0.03	0.07	16.84	10.96	1.94	6.77
	1478.45	1458.29	1460.73	1454.26	-836.62	-948.85	-946.54	-975.67

Source: Model Simulation

Table 10. Trade Creation and Diversion Effects of Kazakhstan-China Possible FTA (US$ Million)								
	China Real Imports from							
	Kazakhstan				RoW			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Sector								
Grains and Crops	3.15	3.14	3.17	3.15	10.95	11.74	10.70	11.24
Livestock and Meat Products	18.17	18.08	18.40	18.15	-5.44	-4.99	-5.70	-5.25
Mining and Extraction	-6.70	3.67	-3.27	4.25	36.30	33.80	36.35	35.60
Processed Food	1.38	1.38	1.40	1.38	6.50	6.68	6.26	6.22
Textiles and Clothing	11.03	11.02	11.06	11.02	10.05	9.87	9.49	9.45
Light Manufacturing	8.23	8.09	8.32	8.12	40.97	40.95	39.90	39.38
Heavy Manufacturing	577.04	567.73	589.92	572.04	-135.75	-129.78	-147.24	-137.37
Utilities and Construction	0.02	0.00	0.05	0.01	2.01	2.16	1.97	2.07
Transport and Communication	0.09	-0.05	0.19	-0.01	27.62	25.65	26.68	24.10
Other Services	0.05	-0.03	0.16	0.00	17.91	18.05	17.15	16.74
	612.46	613.03	629.40	618.11	11.12	14.13	-4.44	2.18
Source: Model Simulation								

5. Policy Implications

The proposed Free Trade Agreement (FTA) between China and Kazakhstan is strategically and economically significant, particularly in light of Kazakhstan's Nurly Zhol (Bright Path) infrastructure project and the larger Belt and Road Initiative (BRI). These two programs, which were formally aligned in 2015, are an intentional attempt to combine trade, transportation, and economic development strategies, making Kazakhstan a crucial Central Asian transit hub. Because of Kazakhstan's strategic location and China's increasing aspirations for regional connectivity, an FTA is a component of a larger geopolitical reorientation rather than just a change in trade policy.

The simulation results from the GTAP model reinforce the potential benefits of such an agreement. From a macroeconomic perspective, both countries are projected to experience gains in real GDP, equivalent variation (EV), and real consumption, with Kazakhstan reaping relatively larger benefits. These gains reflect trade creation effects, as both economies—particularly Kazakhstan—substitute away from higher-cost domestic production and third-country imports toward more efficient bilateral trade flows.

Trade pattern adjustments show clear evidence of comparative advantage-driven reallocation. Kazakhstan’s exports to China are projected to grow at a faster pace than China's exports to Kazakhstan, supporting the notion of asymmetric but mutually beneficial liberalization. Key sectors in Kazakhstan, such as heavy manufacturing, transport, and textiles, are poised for expansion, while China's gains are more modest and diffused across several sectors, including light manufacturing and textiles. This asymmetry is economically meaningful: it indicates that the smaller economy—Kazakhstan—may gain disproportionately more from improved market access and efficiency gains (consistent with classical trade theory).

Structural adjustment pressures, however, must be acknowledged. Kazakhstan, facing greater shifts in employment and resource allocation, will need to manage transitional costs. The anticipated contraction in some sectors, particularly textiles and livestock, implies a need for active labor market policies, retraining programs, and potentially targeted subsidies to ease the reallocation of labor and capital.

From a factor market perspective, the reallocation of land, labor, and capital is essential to realize the gains from trade. Kazakhstan's increased employment in growth sectors, alongside land-use changes, suggests the potential for rural-urban migration and sectoral labor mobility challenges. Similarly, while China experiences more muted adjustments, the data indicate positive employment effects in most sectors—albeit small—confirming a low-risk, high-reward scenario for China.

Finally, this FTA would complement Kazakhstan's multi-vector foreign policy, reinforcing its role as a strategic bridge between East and West. Improved trade infrastructure, reduced trade barriers, and deeper economic integration with China may enhance Kazakhstan's geopolitical leverage, investment attractiveness, and economic diversification. In summary, the proposed FTA offers a win-win scenario for the following reasons: i) It promotes efficiency and welfare through trade creation rather than diversion; ii) It supports macroeconomic growth and expands consumer and producer choices; iii) It enhances sectoral competitiveness in line with comparative advantage; iv) It strengthens the strategic trade and infrastructure partnership between China and Kazakhstan under the BRI framework.

Given these findings, policymakers should seriously consider bilateral tariff elimination, complemented by adjustment assistance for vulnerable sectors and institutional reforms to maximize the FTA's long-run developmental impact.

6. Conclusion

Empirical studies have long demonstrated that tariff liberalization—whether driven by multilateral or regional trade agreements—can enhance economic welfare when trade creation outweighs trade diversion (Robinson & Thierfelder, 2002; Turakulov, 2020). This paper sought to assess whether a bilateral free trade agreement (FTA) between Kazakhstan and China could yield similar economic benefits. Using the Global Trade Analysis Project (GTAP) Version 9 database, we simulated four counterfactual scenarios of full goods trade liberalization between the two countries, assuming the removal of all bilateral tariffs while keeping other distortions unchanged.

The use of both flexible and fixed current account closures allowed us to examine the sensitivity of the model results to alternative macroeconomic assumptions. Across all scenarios, Kazakhstan experienced higher gains in GDP, exports, and welfare relative to China. This outcome reflects Kazakhstan's relatively greater dependence on trade with China and its comparative advantage in certain sectors like textiles and grains. China, meanwhile, saw more modest but positive macroeconomic outcomes, primarily in manufactured goods and livestock.

Sectoral simulations revealed expected resource reallocations consistent with the theory of comparative advantage, with Kazakhstan expanding output and employment in export-oriented sectors while import-competing industries contracted. These shifts, while beneficial in aggregate imply transitional costs and labor mobility challenges, especially for displaced workers in import-competing sectors like textiles.

Furthermore, the analysis of bilateral and global trade patterns showed strong net trade-creating effects for both countries. For instance, Kazakhstan's increased imports from China exceeded the diversion from the rest of the world in nearly all sectors, indicating that the FTA would enhance trade efficiency.

From a welfare perspective, equivalent variation (EV) measures indicate positive welfare gains for both countries, largely driven by allocative efficiency and endowment effects. Notably, Kazakhstan gains more from terms-of-trade improvements, while China sees marginal declines. The decomposition of welfare effects underscores that structural adjustment, rather than external preference shocks or technical change, is the primary mechanism for welfare gains in this bilateral setting.

Notwithstanding the compelling quantitative data, this study faces several limitations. First, because the CGE model is comparative-static, it is unable to account for dynamic effects like increased productivity, capital accumulation, or innovation brought about by more intense trade integration. Second, the simulations' scope is restricted to the trade of goods; they did not model the liberalization of services or investment, which are growing in significance in both economies. Future research could build on this analysis with dynamic CGE frameworks or include FDI, trade-in services, and nontariff measures. Although there seems to be a strong economic case for a free trade agreement between China and Kazakhstan, practical implementation is not without challenges. Eurasia's trade routes and regional alliances have changed as a result of recent geopolitical events, most notably the conflict between Russia and Ukraine. Long-term trade agreements are complicated by Kazakhstan's strategic balancing act between China, Russia, and Western allies. Furthermore, although infrastructure investment is welcomed, China's growing economic clout in Central Asia also raises questions about economic dependency and asymmetry in bargaining power. The viability of an FTA may also be impacted by domestic political and economic factors. In Kazakhstan, public opposition to liberalization may be fueled by worries about growing Chinese imports and ingrained interests in protected industries like textiles. The Belt and Road Initiative (BRI) is actively promoted by the Chinese government, but FTA talks with smaller partners like Kazakhstan may be slowed down or limited by regional sensitivities and domestic policy priorities. The trade-offs between immediate adjustment costs and long-term economic benefits should be considered by policymakers in both nations. The transition for Kazakhstan might be facilitated by focusing on labor market policies such as retraining initiatives for displaced workers, and infrastructure spending to boost export-oriented industries. For China, the political acceptability of such an agreement would be enhanced by guaranteeing equitable benefits and taking into account regional sensitivities in Central Asia. Finally, regional cooperation frameworks that incorporate broader Central Asian countries could amplify the benefits and dilute the risks of bilateral asymmetries.

Declarations

Author Contributions

MD conceptualized the study framework and led the theoretical analysis. MD also played the primary role in designing the methodology, collecting data, and drafting the manuscript. MH supported the literature review, contributed to the interpretation of data, and provided critical revisions to the manuscript. MH and IA assisted in data analysis and contributed to editing the final version of the paper.

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Conflict of Interest

The authors have no relevant financial or non-financial interests to disclose.

Data Availability

The authors confirm that all data generated or analyzed during this study are included in this published article. Furthermore, primary and secondary sources and data supporting the findings of this study were all publicly available at the time of submission.

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Appendix A: Outline of the Standard CGE Model

A.1. Introduction

Figure *A*.1 provides an overview of the standard CGE model from the viewpoint of the flows of goods and factors in an economy. The flows of factors and goods at each stage where they are combined for either production or consumption are then explained. Assuming that there are two *goods* "1 and 2", the flows in Figure *A*.1 are explained from bottom to top.

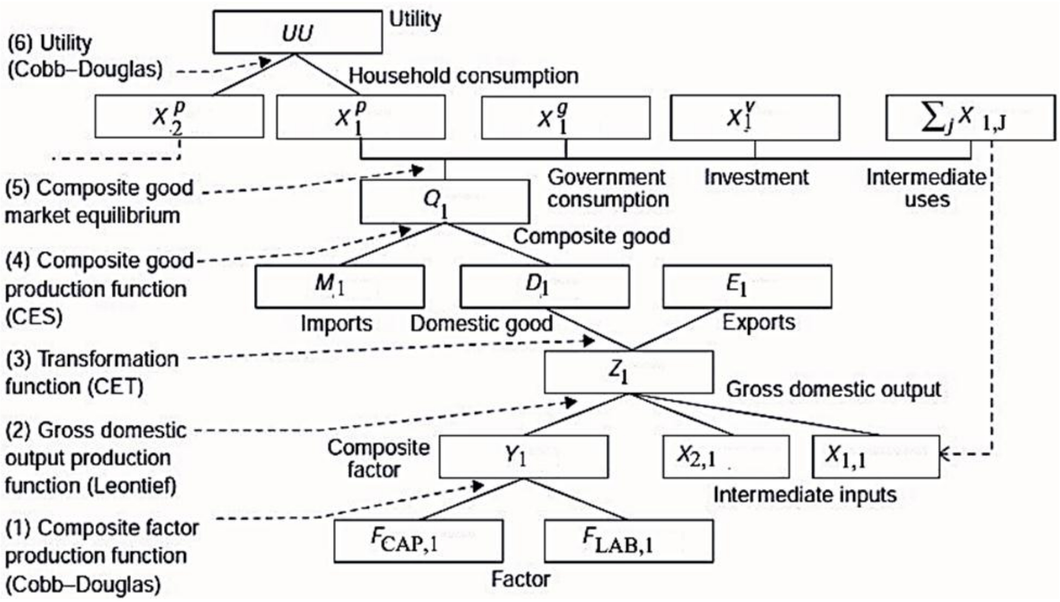

Figure A.1. Overview of the Standard CGE Model
* ***The functional Forms that are Assumed are Indicated by Parentheses***
** ***1, 2 Refer to Good 1 and Good 2 Respectively***

(1) Capital $F_{CAP,1}$ and labour $F_{LAB,1}$ are aggregated into the composite factor Y_1 using the composite factor production function.
(2) This composite factor Y_1 is combined with the intermediate inputs of commodity 1 which is $X_{1,2}$ and commodity 2 which is $X_{2,1}$ to produce the gross domestic output Z_1 using the gross domestic output production function.
(3) The gross domestic output Z_1 is transformed into the exports E_1 and the domestic good D_1 using the gross domestic output transformation function.
(4) The domestic good D_1 is combined with the imports M_1 to produce the composite good Q_1 with the composite good production function.
(5) The composite good Q_1 is distributed among household consumption X_1^p, government consumption X_1^g, investment X_1^v and intermediate uses by the 1 and 2 sectors $\sum_j X_{1,j}$
(6) Household utility UU is generated by consumption X_1^p and X_2^p as the utility function indicates.

A.2. Intermediate Inputs

By assuming that businesses use intermediate inputs in their production process, we are able to make the model more realistic. The behavior of firms becomes more complex after this extension, and we can categorize the production process (or firms) into two stages. Labor and capital are employed in the first stage to produce a composite factor, also known as value-added. The behavior of a virtual factory can be compared to the production process of the composite factor. This factory chooses its level of output (composite factor) and uses inputs (labor and capital) based on their relative prices,

taking into account technological limitations. The goal is to maximize profit. The gross domestic output production function indicates that in the second stage, the composite factor is combined with intermediates to produce the gross domestic output. We assume a Leontief-type production function for the second stage and a Cobb-Douglas-type production function for the first in this two-stage production process. Both of them are homogenous to the first degree, and as a result, are described as having constant returns to scale. In contrast to the Leontief-type production function, the Cobb-Douglas-type production function enables us to describe substitution between inputs. The number of endogenous variables, especially for intermediate inputs, rises in proportion to the square of the number of sectors/goods as empirical CGE models are created based on the input–output (IO) tables that differentiate dozens of sectors/goods. In this sense, the computational load is greatly decreased by the Leontief-type production function, which also greatly reduces the model's complexity. The profit-maximization problems for the j^{th} firm can be written as follows:
For the first stage:

$$maximize_{\;Y_j F_{h,j}} \; \pi_j^y = p_j^y Y_j - \sum_h p_h^f F_{h,j}$$

Subject to

$$Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \qquad (A.1)$$

For the Second Stage:

$$maximize_{\;Z_j, Y_j, X_{i,j}} \; \pi_j^z = p_j^z Z_j - \left(p_j^y Y_j + \sum_i p_i^q X_{i,j} \right)$$

Subject to

$$Z_j = min\left(\frac{X_{1,j}}{\alpha x_{1,j}}, \frac{X_{2,j}}{\alpha x_{2,j}}, \frac{Y_j}{\alpha y_j} \right) \qquad (A.5')$$

Where:

π_j^y	profit of the j-th firm producing composite factor Y_j in the first stage,
π_j^z	profit of the j-th firm producing gross domestic output Z_j in the second stage
Y_j	composite factor, produced in the first stage and used in the second stage by the j-th firm
$F_{h,j}$	the h-th factor used by the j-th firm in the first stage
Z_j	gross domestic output of the j-th firm
$X_{i,j}$	intermediate input of the i-th good used by the j-th firm
p_j^y	price of the j-th composite factor
p_h^f	price of the h-th factor
p_j^z	price of the j-th gross domestic output
p_i^q	price of the i-th composite good
$\beta_{h,j}$	share coefficient in the composite factor production function
b_j	scaling coefficient in the composite factor production function
$\alpha x_{i,j}$	input requirement coefficient of the i-th intermediate input for a unit output of the j-th good
αy_j	input requirement coefficient of the j-th composite good for a unit output of the j-th good

The firm's profits are the objective value at every stage of production. The sales of the composite factor are represented by the first term on the right-hand side of the first-stage profit function, and the second term the labor and capital input costs incurred during production. A Cobb-Douglas-type production function describes the technology of the composite factor production, which is represented by the constraint $(A.1)$. The sales of the gross domestic output, which in this model consists of common goods like 1 and 2, are the first term on the right-hand side of the second-stage profit function. The costs of the intermediate inputs used in the second-stage production and the composite factor input are the second and third terms, respectively. With the composite factor and intermediate inputs, the production function for the gross domestic output under constraint (A.5') is Leontief-type. When these two problems are resolved, we obtain:

	$Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \ \forall j$	***(A.1)***
	$F_{h,j} = \frac{\beta_{h,j} p_j^y}{p_h^f} Y_j \forall h, j$	***(A.2)***
	$X_{i,j} = \alpha x_{i,j} Z_j \forall i, j$	***(A.3)***
	$Y_j = \alpha y_j Z_j \forall j$	***(A.4)***
	$Z_j = min\left(\frac{X_{1,j}}{\alpha x_{1,j}}, \frac{X_{2,j}}{\alpha x_{2,j}}, \frac{Y_j}{\alpha y_j}\right)$	***(A.5′)***

Isomput curves, also known as rectangular isoquants, are produced by the production function (A.5'). A common source of difficulty in numerical computations is the kinks in the isoquants. In order to avoid this computational issue, we substitute a zero-profit condition—which ought to hold—for (A.5').

$$\pi_j^z = p_j^z Z_j - \left(p_j^y Y_j + \sum_i p_i^q X_{i,j}\right) = 0 \ \ \forall j$$

Although we can incorporate this zero-profit condition into the model, it would be more practical to simplify it and express it as a unit cost function. By removing
$X_{i,j}$, and Y_j using (A.3) and (A.4), we can obtain:

$$p_j^z Z_j - \left(\alpha y_j p_j^y Y_j + \sum_i \alpha x_{i,j} p_i^q Z_j\right) = 0 \ \ \forall j$$

and again by eliminating Z_j, we get the following unit cost function:

$p_j^z = \alpha y_J p_J^y Y_j \ + \sum_i \alpha x_{I,J} p_I^q \ \ \forall j$	***(A.5)***

Replacing (A.5′) with (A.5), we can describe the firms' behavior with (A.1) to (A.5).

A.3. Government

It is assumed that the government imposes an ad valorem import tariff at a rate τ^d on imports, an ad valorem production tax (an indirect tax) at tax rate τ_j^z on gross domestic output, and a direct tax at a rate τ_i^z on household income. Concurrently, we assume that (1) the government uses all tax revenues for its own consumption and (2) the government consumes all goods (such as goods 1 and 2) in fixed proportions to the total amount of government spending. For instance, 40% of the government's total revenue goes toward buying good 1, and 60% goes toward buying good 2. Therefore, the aforementioned assumptions can be formulated as follows:

	$T^d = \tau^d \sum_h p_h^f FF_h$	***(A.6)***
	$T_j^z = \tau_j^z p_j^z Z_j \ \ \forall j$	***(A.7)***
	$T_i^m = \tau_i^m p_i^m M_i \ \ \forall i$	***(A.8)***
	$X_i^g = \frac{\mu_i}{p_i^q}\left(T^d + \sum_j T_j^z + \sum_j T_j^m\right) \forall i$	***(A.9′)***

Where:

T^d	direct tax
T_j^z	production tax on the j-th good
T_i^m	import tariff on the i-th good
τ^d	direct tax rate
τ_j^z	production tax rate on the j-th good
τ_i^m	import tariff rate on the i-th good
FF_h	endowments of the h-th factor for the household
Z_j	gross domestic output of the j-th firm
M_i	imports of the i-th good
X_i^g	government consumption of the i-th good
p_j^z	price of the j-th gross domestic output
p_h^f	price of the h-th factor
p_i^m	price of the i-th imported good
p_i^q	price of the i-th composite good
μ_i	share of the i-th good in government expenditure $(0 \leq \mu_i \leq 1, \sum_i \mu_i = 1)$

We can make different assumptions, even though we assume that government spending is distributed proportionately among goods for consumption, as shown in this example by (A.9'). As an illustration, we can further simplify government action by limiting consumption to the point of an initial equilibrium level X_i^{g0}:

$$X_i^g = X_i^{g0} \quad \forall i$$

When the government sells its assets, it shows up in statistical databases such as the IO tables as negative consumption. (An analogous finding may also be made in the investment account, where a decline in stocks takes place.) In a situation like this, applying the previously recommended proportionate government spending behavior might not be appropriate. Alternatively, we could create a model that permits negative values for specific government uses. In other words, we can assume positive proportionate expenditure for some goods and set a negative value for their consumption for others.

A.4. Investment and Savings

A.4.1. Introduction of Investment and Savings

Funds from the government, the household, and the external sector are collected by the investment agent, who then uses them to buy investment goods. While both the government and households are free to choose how much to save and invest, the current model assumes that a virtual agent takes all of an economy's savings and uses it to buy goods in a proportionate amount, with a constant share λ_i. We can use the investment demand function (A.10) to explain its behavior. This is comparable to the notion regarding the government's function of demand for goods.

$$X_i^v = \frac{\lambda_i}{p_i^q}\left(S^p + S^g + \varepsilon S^f\right)\forall i \qquad (A.10)$$

Where:

S^p	household savings
S^g	government savings
S^f	current account deficits in foreign currency terms (or equivalently foreign savings),
X_i^v	demand for the i-th investment good
ε	foreign exchange rate (domestic currency/foreign currency),

p_i^q	price of the i-th composite good
λ_i	expenditure share of the i-th good in total investment $(0 \leq \lambda_i \leq 1, \sum_i \lambda_i = 1)$

The Variables on the Right Side of $(A.10)$, Enclosed in Parenthesis, Represent The Total Savings That Come from Savings Made by The Government, The Household, and The External Sector. It Should Be Noted That $(A.10)$ Suggests That the Total Savings And Total Investment in an Economy are Always Equal Because The Share Parameter λ_i Sum Equals Unity. Then, Let Us Assume That the Following Constant Average Propensities for Saving Determine Household and Government Savings:

$$S^p = ss^p \sum_h p_h^f FF_h \quad (A.11)$$

$$S^g = ss^g \left(T^d + \sum_j T_j^z + \sum_j T_j^m \right) \quad (A.12)$$

Where:

ss^p	average propensity for savings by the household
ss^g	average propensity for savings by the government

It should be highlighted that the investment determined by $(A.10)$ necessitates giving up goods, which neither improves household utility nor increases firm output. In reality, the utility function is independent of investment magnitude X_i^v. Moreover, the investment X_i^v in this static model cannot raise the endowments of capital FF_{CAP} because they are predetermined in this economy.

A.4.2. Modification of Household and Government Behavior

The household budget constraint needs to be slightly adjusted, but otherwise, the original model equations describing the behavior of the household and the government must be modified in order to include the government, investments, and savings. Put differently, the amount of household savings and direct tax payments now lowers the amount of funds available for household consumption of goods; as a result, the household problem is updated as follows.

$$\text{maximize}_{X_i^p} \; UU = \prod_i X_i^{p^{\alpha_i}}$$

Subject to

$$\sum_i p_i^q X_i^p = \sum_i p_h^f FF_h - S^p - T^d$$

Where:

UU	The utility
X_i^p	household consumption of the i-th good
FF_h	endowments of the h-th factor for the household
S^p	household savings
T^d	direct tax
p_i^q	price of the i-th composite good
p_h^f	price of the h-th factor
α_i	share parameter in the utility function $0 \leq \alpha_i \leq 1, \sum_i \alpha_i = 1)$

Solving This Modified Household Problem, We Obtain the Household Demand Function for The I-Th Good:

$$X_i^p = \frac{\alpha_i}{p_i^q}\left(\sum_h p_h^f FF_h - S^p - T^d\right) \forall i \qquad (A.13)$$

Similar modifications are made to the government demand function for the i-th good by incorporating government savings:

$$X_i^g = \frac{\mu_i}{p_i^q}\left(T^d + \sum_j T_j^z + \sum_j T_j^m - S^g\right) \forall i \qquad (A.9)$$

A.5. International Trade

A.5.1. Small-Country Assumption and Balance of Payments

The conversion of the initial closed economy model to an open economy model is the third key component of the standard CGE model. To keep things simple, we'll assume that this economy is so small that it lacks a significant impact on the rest of the world – even with extreme activity such as export dumping. The fundamental premise of the small-country assumption is that this economy's export and import prices, expressed in terms of foreign currency, are provided by external sources.

In this context, we need to differentiate between two categories of price factors. Prices expressed in local currency p_i^e and p_i^m, and prices expressed in terms of foreign currency p_i^{We} and p_i^{Wm}. They have the following connections to one another:

$$p_i^e = \varepsilon p_i^{We} \ \forall i \qquad (A.14)$$

$$p_i^m = \varepsilon p_i^{Wm} \ \forall i \qquad (A.15)$$

Additionally, it is assumed that the economy has balance of payments constraints, which are characterized by the foreign currency prices of imports and exports:

$$\sum_i p_i^{We} E_i + S^f = \sum_i p_i^{Wm} M_i \qquad (A.16)$$

Where:

p_i^{We}	**export price in terms of foreign currency (exogenous)**
p_i^e	export price in terms of domestic currency
ε	foreign exchange rate (domestic currency/foreign currency)
E_i	exports of the i-th good
p_i^{Wm}	import price in terms of foreign currency (exogenous)
p_i^m	import price in terms of domestic currency
M_i	imports of the i-th good
S^f	current account deficit in terms of foreign currency (or equivalently foreign savings; exogenous)

The current account deficit expressed in foreign currency terms
S^f is an exogenous variable, as was indicated in Subsection A.4.1. Although the balance of payments constraints in the current model are stated in terms of foreign currency, that restriction can also be stated in terms of domestic currency by substituting p_i^{We}, p_i^{We} with p_i^e, p_i^m
using (A.14) and (A.15).

A.5.2. Armington's Assumption and Substitution between Imports and Domestic Goods

We Assume Pairwise Substitution in CGE Models Between Imports and Domestic Goods as Well as Between Exports and Domestic Goods. Armington's (1969) Assumption Describes the Imperfect Substitution Between Domestic and Imported Goods. The Optimization Problem for The I-Th Armington-Composite-Good-Producing Firm Can Be Written as Follows:

$$\text{maximize}_{\,Q_i M_i D_i}\ \pi_i^q = p_i^q Q_i - \left[(1+\tau_i^m)p_i^m M_i + p_i^d D_i\right]$$

Subject to

$$Q_i = \gamma_i\left(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i}\right)^{\frac{1}{\eta_i}} \qquad (A.17)$$

Where:

π_i^q	**profit of the firm producing the i-th Armington composite good**
p_i^q	price of the i-th Armington composite good
p_i^m	price of the i-th imported good in terms of domestic currency
p_i^d	price of the i-th domestic good
Q_i	the i-th Armington composite good
M_i	the i-th imported good
D_i	the i-th domestic good
τ_i^m	import tariff rate on the i-th good
γ_i	scaling coefficient in the Armington composite good production function
δm_i , δd_i	input share coefficients in the Armington composite good production function ($0 \le \delta m_i \le 1,\ 0 \le \delta d_i \le 1,\ \delta m_i + \delta d_i = 1$)
η_i	parameter defined by the elasticity of substitution ($\eta_i = \frac{\sigma_i - 1}{\sigma_i}, \eta_i \le 1$)
σ_i	elasticity of substitution in the Armington composite good production function $\left(\sigma_i = -\frac{d(M_i/D_i)}{M_i/D_i} \Big/ \frac{d\left(p_i^m/p_i^d\right)}{p_i^m/p_i^d}\right)$

The Following Demand Functions for Imports and the Domestic Goods are Implied by the First-Order Conditions for the above Problem's Optimality:

$$M_i = \left[\frac{\gamma_i{}^{\eta_i}\delta m_i p_i^q}{(1+\tau_i^m)p_i^m}\right]^{\frac{1}{1-\eta_i}} Q_i \quad \forall i \qquad (A.18)$$

$$D_i = \left[\frac{\gamma_i{}^{\eta_i}\delta d_i p_i^q}{p_i^d}\right]^{\frac{1}{1-\eta_i}} Q_i \quad \forall i \qquad (A.19)$$

Notably, a firm that produces Armington composite goods must contend with tariff-inclusive import prices $(1+\tau_i^m)p_i^m$ rather than tariff-exclusive import prices p_i^m; as a result, the tariff rate τ_i^m is included in the calculation of its profit π_i^q. Accordingly, $(1+\tau_i^m)p_i^m$ is included in the derived import demand function as well (A.18).

A.5.3. Transformation between Exports and Domestic Goods

When the i-th firm converts its gross domestic output into exports and domestic goods, the profit-maximization problem can be expressed as follows:

$$maximize_{Z_iE_iD_i}\ \pi_i = \left(p_i^e E_i + p_i^d D_i\right) - (1+\tau_i^z)p_i^z Z_i$$

Subject to

$$Z_i = \theta_i\left(\xi e_i E_i^{\phi_i} + \xi d_i D_i^{\phi_i}\right)^{\frac{1}{\phi_i}} \quad (A.20)$$

Where:

π_i	profit of the firm engaged in the i-th transformation
p_i^e	price of the i-th export good in terms of domestic currency
p_i^d	price of the i-th domestic good
p_i^z	price of the i-th gross domestic output
E_i	exports of the i-th good
D_i	supply of the i-th domestic good
Z_i	gross domestic output of the i-th good
τ_i^z	production tax on the i-th gross domestic output
θ_i	scaling coefficient of the i-th transformation
ξe_i , ξd_i	share coefficients for the i-th good transformation $(0 \le \xi e_i \le 1,\ 0 \le \xi d_i \le 1,\ \xi e_i + \ \xi d_i = 1)$
ϕ_i	parameter defined by the elasticity of transformation ($\phi_i = \frac{\psi_i + 1}{\psi_i}, \psi_i \ge 1)$
ψ_i	elasticity of transformation of the i-th good transformation $\left(\psi_i = \frac{d(E_i/D_i)}{E_i/D_i} / \frac{d\left(p_i^e/p_i^d\right)}{p_i^e/p_i^d}\right)$

We obtain the Following Supply Functions for Exports and Domestic Goods by Resolving this Maximization Problem:

$$E_i = \left[\frac{\theta_i^{\phi_i}\xi e_i(1+\tau_i^z)p_i^z}{p_i^e}\right]^{\frac{1}{1-\phi_i}} Z_i \quad (A.21)$$

$$D_i = \left[\frac{\theta_i^{\phi_i}\xi d_i(1+\tau_i^z)p_i^z}{p_i^d}\right]^{\frac{1}{1-\phi_i}} Z_i \quad (A.22)$$

Due to the fact that the production tax τ_i^z is levied on the gross domestic output Z_i—which serves as the input in this transformation process—τ_i^z can be found in both the numerators of the two supply functions mentioned above as well as in the equation defining profit
π_i.

A.6. Market-Clearing Conditions

Equations have been utilized to characterize the actions of economic agents, including households, firms, governments, investment agents, and the external sector. The last action we take in this modeling process is putting in place the following market-clearing requirements to ensure that supply and demand are met in every market:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_i X_{i,j} \quad \forall i \quad (A.23)$$

	$\sum_i F_{h,j} = FF_h \ \forall h$	***(A.24)***

Equation (A.23) describes the market-clearing condition for the Armington composite goods. The government, the investment agent, and households all use the composite good Q_i, as covered in Subsection A.5.3 as well as for intermediate input; we give each one the same price, p_i^q. The market-clearing condition factor is represented by equation (A.24). However, under the current model, the price that the household must pay p_i^q is unrelated to the price p_i^z that the firm must pay.

Although they do not establish a direct connection between p_i^q and p_i^z, the CES and CET structures, which stand for substitution between imports and domestic goods and transformation between exports and domestic goods, respectively, equalize the supply and demand of goods by these agents. Consequently, we do not impose restrictions on price equality between p_i^q and p_i^z.

A.7. Model System

As was previously mentioned, we have created a system of simultaneous equations, (A.1)–(A.24), for the standard CGE model which was the foundation block that was utilized in developing the model presented in this study.

Domestic Production:

	$\boldsymbol{Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \ \forall j}$	***(A.1)***
	$F_{h,j} = \frac{\beta_{h,j} p_j^y}{p_h^f} Y_j \forall h, j$	***(A.2)***
	$X_{i,j} = \alpha x_{i,j} Z_j \forall i, j$	***(A.3)***
	$Y_j = \alpha y_j Z_j \forall j$	***(A.4)***
	$p_j^z = \alpha y_j p_j^y Y_j + \sum_i \alpha x_{I,J} p_I^q \ \ \forall j$	***(A.5)***

Government:

	$\boldsymbol{T^d = \tau^d \sum_h p_h^f FF_h}$	***(A.6)***
	$T_j^z = \tau_j^z p_j^z Z_j \ \ \forall j$	***(A.7)***
	$T_i^m = \tau_i^m p_i^m M_i \ \ \forall i$	***(A.8)***
	$X_i^g = \frac{\mu_i}{p_i^q} \left(T^d + \sum_j T_j^z + \sum_j T_j^m - S^g \right) \forall i$	***(A.9)***

Investment and Savings:

	$\boldsymbol{X_i^v = \frac{\lambda_i}{p_i^q} (S^p + S^g + \varepsilon S^f) \forall i}$	***(A.10)***
	$S^p = ss^p \sum_h p_h^f FF_h$	***(A.11)***

	$S^g = ss^g\left(T^d + \sum_j T_j^z + \sum_j T_j^m\right)$	***(A.12)***

Households:

	$\boldsymbol{X_i^p = \frac{\alpha_i}{p_i^q}\left(\sum_h p_h^f FF_h - S^p - T^d\right) \forall i}$	***(A.13)***

Export and Import Prices and the Balance of Payments Constraint:

	$\boldsymbol{p_i^e = \varepsilon p_i^{We} \ \ \forall i}$	***(A.14)***
	$p_i^m = \varepsilon p_i^{Wm} \ \ \forall i$	***(A.15)***
	$\sum_i p_i^{We} E_i + S^f = \sum_i p_i^{Wm} M_i$	***(A.16)***

Substitution between Imports and Domestic Goods (Armington Composite):

	$\boldsymbol{Q_i = \gamma_i\left(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i}\right)^{\frac{1}{\eta_i}}}$	***(A.17)***
	$M_i = \left[\frac{\gamma_i{}^{\eta_i}\delta m_i p_i^q}{(1+\tau_i^m)p_i^m}\right]^{\frac{1}{1-\eta_i}} Q_i \ \ \forall i$	***(A.18)***
	$D_i = \left[\frac{\gamma_i{}^{\eta_i}\delta d_i p_i^q}{p_i^d}\right]^{\frac{1}{1-\eta_i}} \quad Q_i \ \ \forall i$	***(A.19)***

Transformation between Exports and Domestic Goods:

	$\boldsymbol{Z_i = \theta_i\left(\xi e_i E_i^{\phi_i} + \xi d_i D_i^{\phi_i}\right)^{\frac{1}{\phi_i}}}$	***(A.20)***
	$E_i = \left[\frac{\theta_i^{\phi_i}\xi e_i(1+\tau_i^z)p_i^z}{p_i^e}\right]^{\frac{1}{1-\phi_i}} \quad Z_i$	***(A.21)***
	$D_i = \left[\frac{\theta_i^{\phi_i}\xi d_i(1+\tau_i^z)p_i^z}{p_i^d}\right]^{\frac{1}{1-\phi_i}} \quad Z_i$	***(A.22)***

Market-Clearing Conditions:

	$\boldsymbol{Q_i = X_i^p + X_i^g + X_i^v + \sum_i X_{i,j} \ \ \forall i}$	***(A.23)***
	$\sum_i F_{h,j} = FF_h \ \ \forall h$	***(A.24)***

Appendix B: Aggregation of the Sectors:

Table B1. Aggregation of regions and commodities

region	GTAP region	Aggregated sector	GTAP commodity in each sector
Rest of the World (RoW)	All other Regions		
China	China	*Livestock and Meat Products*	Bovine cattle, sheep and goats, horses; Animal products; Raw milk; Wool, silk-worm cocoons; Bovine meat products; Meat products
India	India	*Mining and Extraction*	Forestry; Fishing; Coal; Oil; Gas; Minerals
East Asia	Hong Kong; Korea; Japan; Mongolia; Taiwan; Rest of East Asia	*Processed Food*	Vegetable oils and fats; Dairy products; Sugar; Food products; Beverages and tobacco
Southeast Asia	Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Philippines; Singapore; Thailand; Viet Nam; Rest of Southeast Asia	*Textiles and Clothing*	Textiles; Wearing apparel
South Asia	Bangladesh	*Light Manufacturing*	Leather products; Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment; Manufactures
South Asia	Nepal; Pakistan; Sri Lanka; Rest of South Asia	*Heavy Manufacturing*	Petroleum, coal products; Chemical, rubber, plastic products; Mineral products; Ferrous metals; Metals; Electronic equipment; Machinery and equipment
North America	Canada; United States of America; Mexico; Rest of North America	*Utilities and Construction*	Electricity; Gas manufacture, distribution; Water; Construction
Kazakhstan	Kazakhstan	*Transport and Communication*	Trade; Transport ; Water transport; Air transport; Communication
EU 25	Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom	*Other Services*	Financial services ; Insurance; Business services; Recreational and other services; Public Administration, Defense, Education, Health; Dwellings

Source : GTAP database version 9; Refernce Year: 2011