The Impact of Tariffs on China Dairy Production System: The Case of Twin Tariffs

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Abstract

The trade war was triggered by the U.S. concerns about the trade deficit and unfair trade practices. This paper examines how the "twin tariffs", concurrent import tariffs on dairy feed inputs and on dairy products, affected China's dairy production system and social welfare under different scenarios. Using a time series growth response model with fixed effects and large country twin tariff equilibrium model, we quantify tariff effects on input costs, import volumes, and farm-gate milk prices. The results show that twin tariffs curtailed feed import quantities, which in turn put upward pressure on Chinese dairy input cost and small farms face higher risk of being squeezed out. In the long term, tariff on alfalfa and dairy have opposite impacts on domestic milk price, as dairy import is more elastic than alfalfa in China. Chinese domestic milk prices rose by 9% during the initial trade war period (2018-22) due to the higher cost of alfalfa and lags in dairy import alternative. Following tariff adjustments and feed subsidy policies, China's farm-gate milk prices have begun to stabilize. Our findings carry important policy implications: tariff-induced cost shocks in a large import-dependent country, suggesting that trade policy should carefully weigh protectionist measures while considering critical food supply chains and social welfare changes.

Keywords: tariffs; alfalfa; dairy; China; trade policy

JEL Classification: F13; Q17; Q18

1. Introduction

Trade barriers, such as tariffs, are tools used by nations to address domestic political and economic objectives. China enacted retaliatory tariffs of more than 25% on agricultural goods from the U.S., which affected 86.3% HS 6-digit products in 2018 due trade war (Chor & Li, 2024; P. D. Fajgelbaum & Khandelwal, 2022). In the end of 2023, China's State Council Tariff Commission announced an extension of the Section 301 retaliatory tariff exclusions on 12 agricultural products, including alfalfa hay, through July 31, 2024 (Qian, 2023). Alfalfa production in China cannot meet the demands of growing animal husbandry in both yield and quality (Wan et al., 2022). China lacks a comparative advantage in land-intensive feed grains and protein sources such as alfalfa and soybean. Imports account for approximately 50% of China's total alfalfa demand in 2015, while by 2023, imports represented 89% of China's total alfalfa import volume (Hou et al., 2024; Wan et al., 2022). Therefore, trade in agricultural products holds strategic significance. After several rounds of countermeasures, tariffs on more than 90% of the U.S. agricultural exports to China reaching 25% on the U.S. exports like alfalfa and soybeans, which has significantly affected the cost of dairy feed (P. Fajgelbaum et al., 2024). The heightened tariffs led to increased cost of imported alfalfa, which are vital inputs for dairy farming. Policymakers should navigate the trade-offs between protecting domestic industries and fostering an open, liberalized trade environment that enhances global food systems (Interesse, 2024).

The central question arising from this situation is how these "twin tariffs" [1]. Free trade policies are widely viewed as contributing to improved food security by enabling countries to exploit their comparative advantages, reducing food insecurity by increasing a country's gross domestic product, per capita incomes, and funding for social safety net programs (Smith & Glauber, 2020). (Richman et al., 2014) generally sees tariffs as a legitimate tool to address chronic trade imbalances, as the Scaled Tariff (ST) brought trade toward balance, tariff revenue would be replaced by increased revenue from higher American incomes. Conceptually, long-run changes to trade barriers likely

[1]Twin tariff: tariffs imposed on both inputs (alfalfa) and outputs (dairy), tariffs imposed on alfalfa increased the dairy inputs cost, then the dairy supply curve shifts to the left.

affect not only farmers and producers in a region but also with consumption and even food security. The theoretical foundation posits tariffs distort market efficiencies and allocation of resources and highlights changes in productivity, input prices, and consumption patterns (Smith & Glauber, 2020). China's dependence on imported feed stocks, including alfalfa and soybeans underscores the vulnerability of its dairy sector to external shocks. (Bu & Liao, 2022) noted that China's rural revitalization initiatives aim to reduce reliance on imports by incentivizing domestic forage production. However, structural challenges, such as aging populations and high production costs, continue to hinder progress. Tariffs generally insulate producers from competitors, but their costs to domestic consumers can be an incentive for unilateral liberalization and loss of social welfare (Farrokhi & Pellegrina, 2023; Gaigné & Gouel, 2022; Ji et al., 2024). China and U.S. are likely to subsidize domestic agricultural production and have often done so in ways that expand domestic production and exports while reducing imports, leading to gains in self-sufficiency and productivity (Farrokhi & Pellegrina, 2023).

This study provides a novel analysis of the trade war's impact by focusing on a previously unexplored aspect – the simultaneous tariff shock on both input and output market of dairy industry. Besides, this study estimates the welfare changes under different tariffs scenarios (to compare results of single tariff, twin tariff, free trade and prohibit trade). Using time series data of dairy and alfalfa trade between China and U.S., and employing fixed-effects modeling, we isolate the effects of the 2018–2020 tariff increases on dairy production, feed imports, and farm input costs. Our approach captures the cascading effects of an input cost shock coupled with an output demand shock. The results illustrate how the twin tariffs impact Chinese dairy production and altered import patterns, while also indirectly affecting the U.S. dairy markets through supply and price fluctuations (as evidenced by the decline in the U.S. milk prices during the dispute). By shedding light on these dynamics, our paper contributes to the literature on trade policy and food systems in several ways. First, it offers a case study of how trade barriers on a feed commodity (alfalfa) ripple through to influence livestock output (dairy), highlighting the vulnerability of interlinked markets. Second, it provides empirical evidence from the Chinese context, enriching the understanding of how a major importer responds to sudden trade disruptions. Finally, the insights from this twin tariff case can inform global trade discussions, serving as a reference for other countries contemplating tariffs in sectors where imported inputs are crucial for domestic food production. In sum, our findings underscore the importance of carefully weighing the trade-offs of protectionist policies in agriculture, as these decisions have far-reaching implications for food security, producer livelihoods, and the overall efficiency of global food supply chains.

2. Background

China's rising demand for dairy products has made the tariff issue increasingly important, as shifting dietary patterns place greater emphasis on nutrient-rich foods, especially protein and calcium derived from milk (Gooch, 2017). Per capita dairy consumption in China has been on a steady upward trajectory, driven by urbanization, income growth, and government nutrition campaigns that highlight dairy's role in improving public health. However, domestic production has struggled to keep pace, particularly in the Golden Milk Source Belt, Inner Mongolia, where rising feed costs and land constraints hinder output growth. This widening gap between consumption and production has amplified reliance on imported dairy products and forage crops such as alfalfa, making the sector highly sensitive to trade disruptions.

According to USDA-National Agricultural Statistical Service (NASS), Alfalfa is the 3rd. most valuable cash crop in the U.S. and more than 50% of export forge is alfalfa (see appendix figure A2, A3), with an estimated economic value of $8.7 billion in 2023 (Felxi, 2024). The U.S. grows about 23 million acres of alfalfa each year. It is highly valued by organic and conventional farmers for its soil health-building characteristics and is the premiere forage for dairy cows. So alfalfa is a vital export cash crop in U.S. Consequently, tariffs imposed on both dairy and its critical inputs exacerbate cost pressures, undermine food security, and complicate China's efforts to meet its population's nutritional needs. The figure 1 demonstrated the dynamic impacts of the twin tariffs on the dairy supply chains in both countries. Dairy production declined from 2018 to 2020 due to increased input costs and tariffs restrictions in China. Following China's imposition of tariffs on primary feed ingredients and dairy products, the price of whole milk in the U.S. decreased, leading to varying degrees of economic losses across states because of retaliatory tariffs.

In response, China introduced producer subsidies for local forage growers and expanded support for regional dairy production to mitigate cost shocks and stabilize farm-gate milk prices. Besides, in response to the trade-war, China made efforts in trade diversification away from the U.S. PIIE research shows that China has sought out alternative markets for its agriculture imports, even while the U.S. remains reliant on Chinese import demand (Qian, 2023; Rose, 2024). China has also ratified its participation in the Regional Comprehensive Economic Partnership (RCEP), the world's largest free trade area by market size, and applied to join the Comprehensive and Progressive Trans-Pacific Partnership (CPTPP), neither of which includes the U.S. as a member (Li et al., 2020; Rose, 2024). China's diversification into alternative markets push future U.S. tariffs impacts to be smaller bite and weaker leverage. China's imports of alfalfa meal/pellets totaled 15.12 million kg in 2023, primarily sourced from Italy and Spain, with only 24,745 kg imported from the U.S., representing a decline of about 90% compared to 2022 (World Integrated Trade Solution). However, the U.S. remained China's principal supplier of imported alfalfa hay, providing 898,186 tons, accounting for 89.9% of the market (see appendix figure A5).

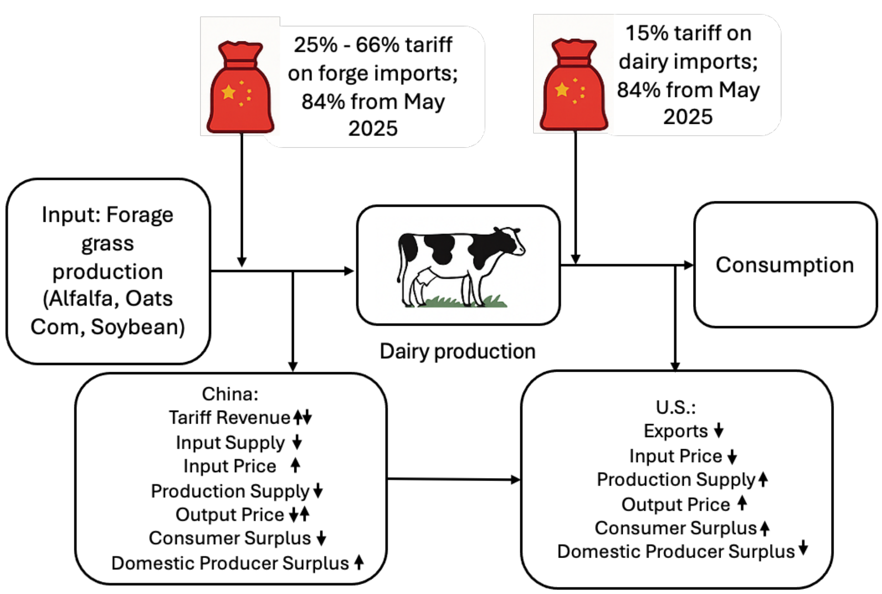

Figure 1: Framework of Chinese tariff on U.S. alfalfa and dairy impacts

3. Conceptual Framework

3.1 Large country single commodity trade

Trade barriers distort resource allocation, impacting not only producers but also consumers and food security. The U.S. remains a key supplier of alfalfa, which is a critical component of dairy feed. Tariff barriers have led to increased inputs costs for dairy production and thereby affecting productivity in China. Following China's imposition of tariffs on primary feed ingredients and dairy products, the price of whole milk in the U.S. decreased, leading to varying degrees of economic losses across states because of retaliatory tariffs. Chinese dairy price observed a significant increase, while production saw a slight decrease from 2018 to 2020 due to increased input costs and tariffs restrictions. Due to the rise in tariffs, the cost of forage increased, and domestic demand is partially reduced accordingly. In the short run, the supply of dairy cow feed decreased, and the average cost of dairy production rose in China. Chinese twin tariffs imposed on both alfalfa and dairy have profound and complex impacts. This policy redistributes welfare across stakeholders: Chinese consumers lose surplus due to the higher price (a Harberger triangle representing deadweight loss), domestic producers gain surplus from the price increase, and the government collects tariff revenue (Schmitz et al., 2022). The imposition of tariffs disrupted dairy inputs supply chains, leading to increased costs for China's dairy production and reduced competitiveness for U.S. exporters (Smith & Glauber, 2020; Unveren & Luckstead, 2020).

As shown in figure 2, given the supply S and demand D, the free trade price is P_f, for the tariff T_0 in the small country assumption, trade restricted import is Q' - D_s. For the large country case, this is no longer true, consider the effect of tariff T result in the change of the trade. The large country tariff shifts the price down. The result changes the size of tariff revenue is (cdef) in small country, however the lager country is (ehgf) (Schmitz et al., 2022). For example, The China import alfalfa CIF price from U.S. is $284.37 per ton in 2017, after the first round of tariff war, China imposed 20% tariff rate on alfalfa (284.37*1.2 = 355.46), but the real price in 2018 is $336.59 per ton. Dairy import price is $1491.44 per ton in 2017, theatrical price after tariff is $1789.72

per ton but real price is $1852.62 per ton in 2019, it indicated that twin tariff makes worse than single tariff. Because China is a large importer, the reduction in its import demand also depresses the world price of the good, meaning foreign exporters absorb part of the tariff by receiving a lower export price. This terms-of-trade effect allows China to capture some surplus from foreign producers, partially offsetting the domestic welfare loss relative to a small-country case. By contrast, in a small-country scenario the world price remains unchanged (no foreign price concession) and the entire tariff burden falls on importers, so any import tariff yields a net welfare loss equal to the classic dead-weight loss areas. We extend this framework to China's "twin tariff" policy of concurrently taxing a crucial input (alfalfa feed) and the final output (dairy products). A tariff on imported alfalfa raises dairy farmers' feed costs and shifts China's dairy supply curve (reflecting higher marginal costs), which pushes up the farm-gate milk price.

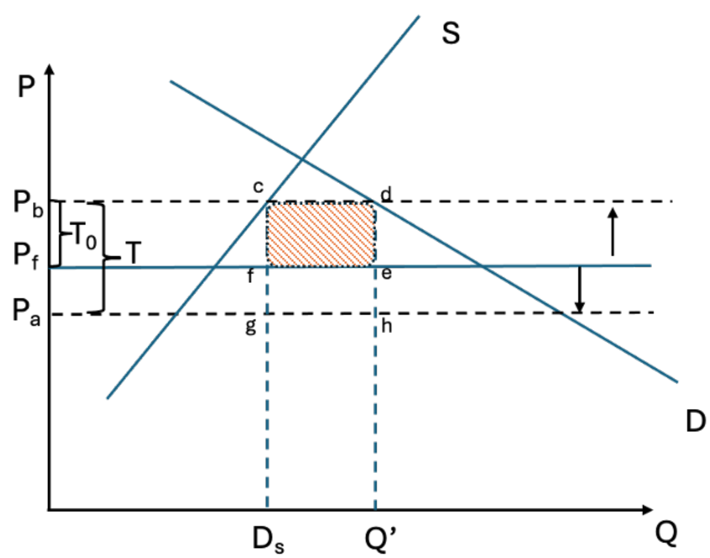

Figure 2: Effects of tariffs on terms of trade effects

3.2 Twin tariff model

The twin tariffs imposed on forage and dairy increased the dairy inputs cost, and supply prices due to trade war in China. The figure 3 use a simple model illustrated that input and output changes with twin tariffs on both of inputs and outputs by China. P1 is free trade price of alfalfa, Qd is domestic supply, (Fs – Qd) is import amount of alfalfa. After tariffs imposed on it, the price of alfalfa increased to P2 and import amount reduced to (Q2 – Q1), supply of alfalfa decreased to Q2. The dairy import amount decreased from (Fs - Qd) to (Q4 – Q3) due to tariffs and price increased to P4. The tariffs collected by China government on alfalfa is (abcd) green rectangle and (efgh) blue rectangle on dairy production. Besides, the dairy supply curve shift to the left due to supply of alfalfa decreasing and marginal input cost increased, so the price of dairy increased significant. Higher tariffs on alfalfa and oat hay resulted in a price surge of 20–25% for these inputs (Rose, 2024).

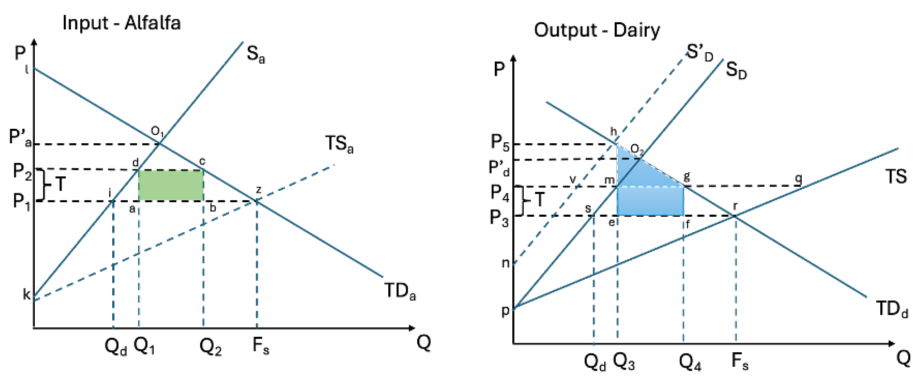

Figure 3: Twin tariffs impact on Chinese dairy industry

As a result, dairy farmers in Inner Mongolia (see appendix A1)faced increasing production costs, leading to a 10% rise in retail milk prices by 2021. But higher price of alfalfa hay simulates the productivity of Chinese domestic farmer. Before 2022, Chinese importers worried that potential future lockdowns would increase freight prices further and thus decided to expand and replenish their inventories. China imported 999,518 tons of alfalfa hay in 2023, a decrease of about 40% compared to 2022 (see appendix figure A3). According to the statistics of China Customs, alfalfa imports decreased 0.7% in the first quarter of 2024, but import value was US $164 million and declined 35.0%. The average CIF price of alfalfa peaked at $596.1/T, then declined to $383.60/T in 2024, driven by inventories and weakened demand in China, and preliminary data indicate an upward trend in 2025.

3.3 Follow-up policy: producer subsidy effects

Despite these challenges, policies introduced in 2020 included subsidies for local forage growers and investments leading to an expansion in dairy output by 2023. While China's dairy farming industry has been expanding, the purchase price of fresh milk decreased from 2022. In 2023, China produced 41.97 million tons of milk, an increase of 6.7 percent compared to 2022, marking the fourth consecutive year of a production increase of over 6% (Dokken, 2024) (Steinberg & Tan, 2024). Additionally, the alfalfa hay import price decreased from 596/$tonto$400/ton from 2022 to 2023 due to less demand of alfalfa import in China ("USDA ERS - Agricultural Trade," 2024).

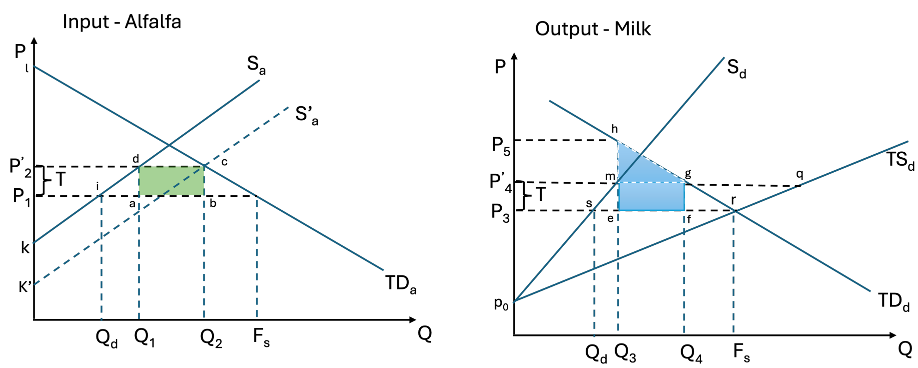

Figure 4: Implemented subsidies on alfalfa after tariff imposed

Following the Chinese government's implementation of a subsidy to alfalfa producers as a countermeasure, an alternative scenario emerges, depicted in figure 4. Under this scenario, the optimal subsidy provided to domestic alfalfa suppliers shifts the alfalfa supply curve from Sa to S'a, there will be no trade on alfalfa in extreme case period (other configuration would allow for trade alfalfa). Domestic alfalfa producer surplus will increase (k'kcd) and dairy producer surplus will increase (+P_4P_3em) relative to the unsubsidized scenario. Thus, alfalfa farmers are effectively protected without negatively affecting dairy producers, and consumer losses are mitigated compared to the twin-tariff scenario.

4. Empirical Framework

4.1 Data

This study combines multiple data sources to analyze the impacts of twin tariffs on China's dairy production system. The dataset is a panel constructed from USDA FAS – Global Agricultural Trade System (GATS), China Customs Statistics (GACC), USDA ERS, and the U.S. Census Bureau International Trade Data, covering the monthly data from 2005 to 2025. These data provide monthly import values, quantities for alfalfa hay (HS 1214) and major dairy products (HS 04), which represent the primary traded inputs and outputs in the dairy supply chain. Data from USDA including China imports of alfalfa and dairy quantity and value from U.S., which used to check changes of China imports. Data from GACC including Chinese domestic farm-gate milk price, which used for estimate tariff rates impacts on domestic dairy production cost. From these, unit import values (USD per metric ton) were calculated as value-to-quantity ratios to proxy for trade prices. Tariff rates are collected according to the statistics of China Customs, figure 5 shows the Chinese twin tariffs fluctuation from 2010 to 2025. And tariff revenue estimates were derived by multiplying observed tariff rates with corresponding import values. The appendix B table 3 shows overview of the data set.

The China farm-gate milk price and the world dairy price index series were collected from Food and Agriculture Organization (FAO), which composite cost indices for the milk and dairy basket were used to track input–output price transmission. This combination provides a consistent empirical foundation to examine how tariffs on both inputs and outputs—the twin tariff scenario—alter production costs, trade flows, and welfare outcomes. The empirical strategy integrates both descriptive trend analysis and econometric modeling. Trade volumes and price for alfalfa and dairy showing across key policy periods (pre-tariff, tariff shock, adjust period, second round tariff war). Percent changes relative to pre-tariff baselines quantify the magnitude of trade disruptions. China imports of alfalfa and dairy price and quantity from U,S. changes are shown in appendix figure A4, import dairy price increased and quantity decreased significantly during the first round of trade war (2019-2020), so this study will estimate average treatment effects (ATE) of interested periods, pre-trade war (2017-2018) as a control period.

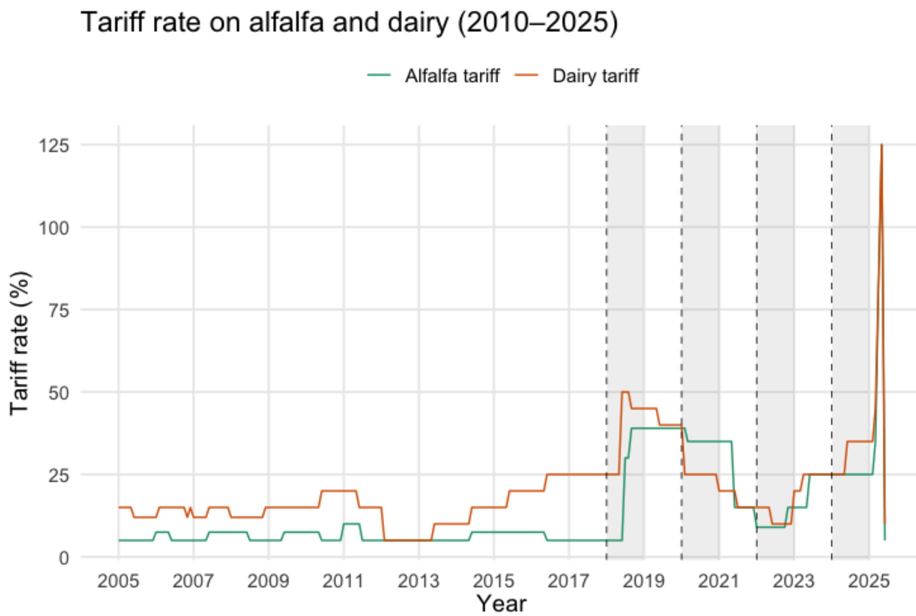

Figure 5: Chinese tariffs rate on U.S. dairy and alfalfa

4.2 Assumptions

In the large-country trade framework, China is modeled as a large importer of alfalfa and dairy products, while the U.S. is treated as the primary exporter. It is implying its tariff policies influence not only domestic prices but also global prices. Evidence of falling unit import values during sustained high tariffs supports this terms-of-trade mechanism. Thus, when China imposes tariffs, part of the burden is shifted back onto foreign exporters through price concessions, consistent with the terms-of-trade effect (Grant et al., 2021; Smith & Glauber, 2020). The twin tariff case was simulated using partial equilibrium diagrams to illustrate the compounding effects on dairy supply chains (Schmitz et al., 2022). By combining empirical evidence with theoretical modeling, this approach captures both the immediate quantity-price adjustments and welfare implications of China's tariff policies in the dairy sector (P. Fajgelbaum et al., 2024).

Key assumptions in this application: 1. China as a large-country importer: China's demand for alfalfa is dominant in global trade, accounting for largest U.S. alfalfa importer. Consequently, tariff impositions in China are assumed to lower the world price of alfalfa and dairy products. 2. Other exporters are small: Competing suppliers (e.g., Spain, Italy, or Australia) are treated as small countries and price taker. Their market shares are marginal relative to U.S. exports, so the third-country effects are ignored. 3. Imperfect substitutes: Alfalfa is modeled as a critical and non-substitutable forage input in China's dairy production. While some substitution across forage crops (e.g., corn silage, oats) is possible in practice, this framework assumes inelastic substitution to isolate the impact of alfalfa tariffs. 4. Parelle trend: Alfalfa is seasonal agricultural product, this study assumes import trends are the same across different years, so all impacts come from exogenous variables. We fit the time series data in auto-regressive integrated moving average (ARIMA) checked the assumption. As shown in appendix A13, the forecast trend accuracy reached 99%, which aligned the test data well. So use Δlog formation can remove undeserved trends (e.g. inflation and CPI), because it expresses percentage change responses to tariff shocks in a way that is statistically robust (stationary) and economically interpretable (elasticities).

4.3 Regression model

The Chinese "twin tariffs" on dairy imports (output) and on alfalfa feed (input) create simultaneous supply and demand side shocks to the Chinese dairy production system. Import quantities respond strongly and immediately to tariffs, while domestic milk prices adjust with a delay as feed costs and dairy import availability change. The retaliatory tariffs were imposed as part of geopolitical negotiations rather than in response to dairy market fundamentals. Following Amiti et al. (2019) and Chor and Li (2024), we treat month-to-month tariff variation as predetermined with respect to unobserved shocks to Chinese import quantities or milk prices. Import quantity is an endogenous mediator between tariffs and domestic milk price. Tariffs directly affect import quantities, and import quantities in turn affect domestic milk supply conditions and prices. Because dairy imports may endogenously respond to domestic prices, we instrument $\Delta \ln Q_{D,t}$ with lagged tariff changes, which isolated the causal pathway from tariff to domestic milk production and price. Lag structures and fixed effects account for dynamic adjustment and confounding shocks. Unlike gravity models, which explain the cross-partner allocation of trade flows, our empirical framework focuses on the time-series adjustment of aggregate import quantities and domestic prices to tariff shocks, which is more appropriate for identifying input-cost transmission and farm-gate price effects (Jeff Luckstead & Stephen Devadoss, 2025).

With satisfied above assumption (removed undeserved trend trends), this study used time series growth response model with fixed effects to identify elasticities to tariff shocks and lag periods effects of tariff rate changes on import and domestic milk price. We treat the tariff changes as exogenous and assume that are uncorrelated with unobserved shocks to import value (Amiti et al., 2019; Nunn & Trefler, 2010). In this way, we can capture month-to-month variations caused by tariff shocks. Besides, the tariff primarily operates through the feed-cost channel (tightening alfalfa supply), rather than directly altering milk markets. Therefore, the tariff shock satisfies the instrument variable (IV) conditions (Relevance and Endogeneity). It is largely excluded from the second-stage equation (no direct milk-price effect), supporting its use as a valid external instrument for identifying the causal effect of import quantity on domestic milk prices and reveal the causal transmission mechanism (Bohara & Kaempfer, 1991).

Log-linear regressions were estimated to test the sensitivity of import quantities and unit values to tariff rates, with fixed effects capturing the tariff shock. The model included lag of tariff shocks on the right-hand side by 2 periods to accommodate lagged effects (Chor & Li, 2024). $\Delta \ln Q_{d,it}$ = log-difference of dairy import quantity (tons); $\Delta \ln Q_{a,it}$ = log-difference of alfalfa import quantity (tons); $\Delta \ln P_{it}^{milk}$ = log-difference of farm-gate milk price; $\Delta \ln \mathrm{tr}_{i,t-k}^{A}$ and $\Delta \ln \mathrm{tr}_{i,t-k}^{D}$ = k-lagged log-differences of alfalfa and dairy tariff rates, respectively. μ_m are monthly fixed effects that absorb seasonal patterns (e.g. Chinese New Year, production cycles), while year fixed effects - λ_y absorb slow-moving macroeconomic shocks (e.g. inflation, recovery from melamine crisis). u_t, ε_t, v_t = idiosyncratic error terms. The parameters γ in function (1) represent the import dairy production elasticities to tariff changes. The parameter β in (2) are farm-gate milk price elasticities to import amount and price. The θ_k in (3)are the impact effects of tariff rate changes on farm-gate milk price.

$$\text{First stage:}\quad \Delta\ln Q_{D,t} = \alpha_0 + \sum_{k=0}^{2}\Big(\gamma_k^D\,\Delta\ln(\mathrm{tr}_{t-k}^D+1) + \gamma_k^A\,\Delta(\mathrm{tr}_{t-k}^A+1)\Big) + \mu_m + \lambda_y + u_t, \tag{1}$$

$$\text{2SLS:}\quad \Delta\ln P_t^{mi} = \beta_0 + \sum_{k=0}^{2}\big(\beta_{1,k}\,\Delta\widehat{\ln Q_{D,t}}_{-k} + \beta_{2,k}\,\Delta\ln(\mathrm{P}_{t-k}^D) + \beta_{3,k}\,\Delta\ln(\mathrm{P}_{t-k}^A)\big) + \mu_m + \lambda_y + \varepsilon_t, \tag{2}$$

$$\text{Reduced form:}\quad \Delta P_t^{milk} = \theta_0 + \sum_{k=0}^{2}\Big(\theta_k^A\,\Delta(\mathrm{tr}_{t-k}^A+1) + \theta_k^D\,\Delta(\mathrm{tr}_{t-k}^D+1)\Big) + \mu_m + \lambda_y + \nu_t. \tag{3}$$

4.4 Tariff revenue and social welfare

We perform a counterfactual analysis to calculate social welfare and tariff revenue under different tariff scenarios as following. P_i^{*0} is the pre-tariff benchmark CIF price and P_i^{*1} the post-tariff CIF price. $P_i = (1+\tau_i)P_i^*$ is import price after tariff., V_i is the trade value, and Q_i is the import volume. TR denotes the tariff revenue, and the deadweight loss (DWL) is computed from the domestic price change (areas depending on demand and supply slopes or elasticities). TOT gain is terms-of-trade gain; domestic transfer is tariff-induced transfer from consumers to government/producers. M_i^1 is post-tariff imports.

$$V_i = Q_i P_i^* \tag{4}$$

$$TR_i = \tau_i Q_i P_i^* \tag{5}$$

$$TR = TR_a + TR_d \;=\; \text{TOT gain} \;+\; \text{domestic transfer} \tag{6}$$

Welfare change:

$$\Delta W = \big(P_a^{*0} - P_a^{*1}\big)M_a^1 \;+\; \big(P_d^{*0} - P_d^{*1}\big)M_d^1 \;-\; \big(DWL_a\cdot P_a \;+\; DWL_d\cdot P_d\big) \tag{7}$$

Figure 6 shows the Chinese tariff revenue on alfalfa and dairy from U.S., after 1 round of retaliatory tariff, the tariff revenue boost temporary and following decrease. The China import alfalfa from U.S. totaled 2.8 million tons in 2022 and decreased to 0.89 million tons in 2023 due tariff barriers ("FAS," 2023; Wang & Zou, 2020). The new tariffs are measured affects more than $18 billion in trade coverage, as compared with total U.S. merchandise imports of $3.826 trillion in 2023 (Steinberg & Tan, 2024; Wolff, 2024). U.S. export to China is forecaster to be down by over 1 billion dollars from 2023 ("China," 2023; Hanrahan, 2024; Tucker et al., 2024). Tariffs can temporarily boost tariff revenue when the targeted good is inelastic, since import volumes do not immediately contract in proportion to the tariff increase. In the short run, this inelastic response allows tariff revenue to rise despite higher duties (Hanrahan, 2024). However, the increase is not sustained: over time, higher costs reduce import demand, especially for feed inputs such as alfalfa, where substitution and domestic policy adjustments occur. The result is a sharp decline in both import volumes and tariff revenue after the initial spike, consistent with the theory that tariff incidence on inelastic goods is temporary and erodes once importers adjust (Amiti et al., 2019).

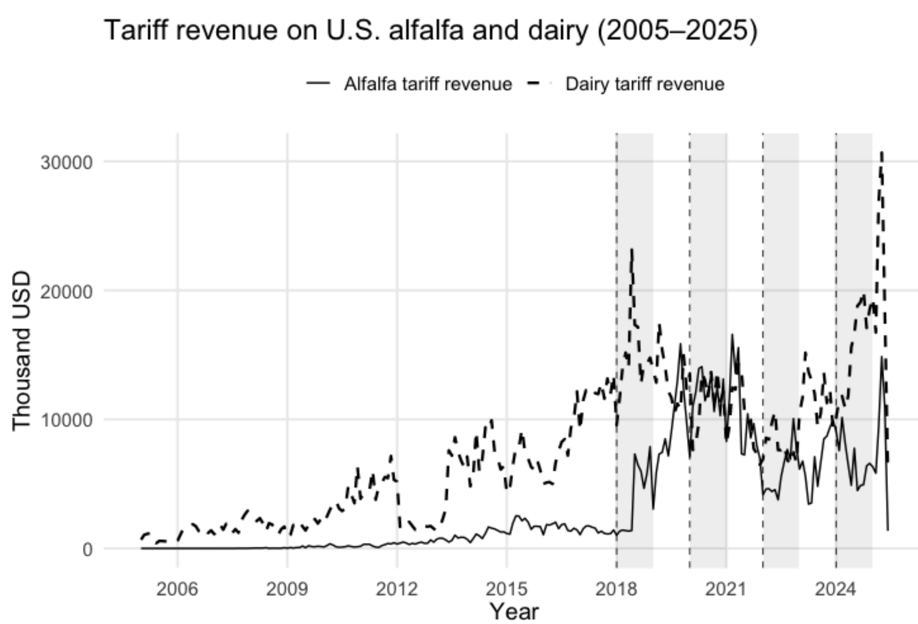

Figure 6: China's tariff revenue on U.S. dairy and alfalfa from 2005 to 2025

5. Results

5.1 Twin tariff impacts

From 2018 to 2022, the average prices for alfalfa increased by 15%, per capita milk output in Inner Mongolia declined by 9.2%. The 2022 alfalfa hay price represented a 35.6% increase from 2021. Demand for dairy products has been increasing in China over the past few decades, but imports of dairy products from U.S. have declined significantly since the tariff war in 2018 and continue to show a downward trend (see appendix figure A7-A9). On the other hand, the rise in input costs pushed the Chinese dairy farmlands facing higher pressure. Though there is a reduction in China import dairy from U.S., dairy imports demand gap can be alternative by EU or Australia exports. However, the Chinese alfalfa imports demand are mainly depends on U.S. Besides, China's retaliatory tariffs on alfalfa and soybeans led to an oversupply in the U.S. market leading to a decline in feed costs (Unveren & Luckstead, 2020). Meanwhile, the average price of milk decreased 8.5% from 2022 to 2024 in U.S. city due to export decline (see appendix figure A9). The profitability of dairy farming continued to decline, with the price-cost ratio falling from 1.07 in January to 0.98 in December of 2023. According to the National Dairy Cattle Industry Technology System, the average production cost of raw milk on farms was $0.546/kg. The 2023 Dairy Cattle Industry and Technology Development Report released by China National Dairy System predicts that raw milk production is expected to continue to increase as average cost increasing.

Table 1 distributed model estimations results, the estimated coefficient in this regression captures the impact of the tariffs on the import quantity and China domestic farm-gate milk price. We regress the change in the log import quantity, and domestic farm-gate milk price on the change in log one plus the applied tariff on imports over the period with 2 months lag effects. The model (1) estimates how changes in tariffs affect import quantities of dairy and alfalfa. The model (2) then relates relative milk price changes to the instrumented quantity shocks from (1), identifying the causal elasticity (Amiti et al., 2019; Chor & Li, 2024). The model (3) captures the direct effect of tariff to price changes pass-through without isolating the quantity channel. The tariff has significant negative effects on import quantity instead of CIF price. It suggests that the tariff changes had little to no impact on the prices received by exporters. Because most of tariff on alfalfa transfer the cost pressure to dairy producers and importers, and import dairy source is more diverse than alfalfa. These results confirm the first stage strength and the exclusion restriction: the tariff significantly shifts imported quantities (relevance), but has little direct influence on milk prices (exclusion). Imports, in turn, significantly predict milk prices, indicating that feed-cost shocks are an important determinant of dairy market outcomes.

Table 1: Twin Tariff Impacts on China's Dairy Production System (One-way Fixed Effects)

		(1)	(2)	(3)
		$\Delta\log(\textit{dairy import qty})$	$\Delta\log(\textit{milk price})$	$\Delta\log(\textit{milk price})$
		(First stage)	*(2SLS)*	*(Direct)*
Tariff on dairy $\Delta\log(\cdot)$	$t=0$	0.086	0.011	0.010
	$t-1$	0.046	0.009	-0.008
	$t-2$	0.25^{***}	0.03^{***}	-0.009
Tariff on alfalfa $\Delta\log(\cdot)$	$t=0$	-0.155^{**}	-0.022^{**}	-0.013
	$t-1$	0.008	0.002	0.003
	$t-2$	-0.124^{**}	-0.017^{***}	0.006
Observations		243	243	243
Adj. R^2		0.414	0.998	0.998

Notes: One-way fixed effects (month and year) included. Heteroskedasticity-robust standard errors. Dependent variables as labeled in column headings. Significance levels: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$, $^{\cdot}p < 0.15$.

The immediate effect (t=0) of tariff on alfalfa is 2.2% more pronounced than the delayed effects, which means 1% increase of tariff on alfalfa can decrease farm-gate milk price 2.2% in 1 month, and 1% tariff on dairy can push it increase 3% with lag 2 month. In columns (2), tariff on dairy does not post significant effects on farm-gate milk price, but tariff on alfalfa has more pronounced effects on farm-gate price. Such an outcome is unfavorable for dairy farms, as they face higher input costs while simultaneously receiving the same or lower output prices. And it is a notice that here tariff changes are relative changes percentage. For example, if tariff increase from 10% to 11%, the $\Delta\log(\textit{tariff on alfalfa}) = \textit{10\%}$ instead of 1%, which means relative changes is 10%, so the $\Delta\log(\textit{milk price})$ will decrease 22%. The tariff does not have significant direct effects on farm-gate milk price in the long run. So the importer and producer swallowed most tariff cost. Tariffs on feed inputs (alfalfa) are more trade-distorting than direct product tariffs (dairy), we analyzed the trade war period effects following.

5.2 Twin tariff ATE on domestic farm-gate milk price

We set initial trade war period is contrast period, and calculated treatment periods' relative price changes miners contrast period changes as average treatment effects (ATE). Figure 8 shows that tariff shocks raise alfalfa CIF prices and dairy input costs in all windows. With limited short-run substitution and incomplete foreign price offsets, feed costs rise and push up the dairy sector's marginal cost, so the ATEs on alfalfa price and input cost are uniformly positive.

Over the period, milk prices rose by approximately 9% during the initial trade war period (2018-22) (figure 7), and logistic was tighten in 2020 due to COVID-19. Following tariff adjustments period and Chinese subsidy policies, China's relative milk prices have begun to stabilize. The adjust (2022–23) exhibits the less ATE because China adjusted temporal tariff rate temporal, alfalfa subside and import tariff tax refund programs for agricultural business. By contrast, the second-round trade war (2023–25) yield much smaller ATEs than the first round (2018–22), due to higher domestic production and a series counter measures (subsidy and import alternative). Importers and processors had time to adapt—diversifying origins and grades, expanding domestic forage, renegotiating contracts, and making selective use of tariff-exclusion channels—so the effective price impact per tariff point fell. This pattern suggests domestic producer subsidies and market segmentation, which prevent global trade policy shocks from destabilizing Chinese dairy farmers' returns. By the second trade war (2023-25) window, price ATEs it attenuate, and import dairy and alfalfa quantity from U.S. decreasing, reflecting adaptation—tariff exclusions, renegotiated contracts, inventory smoothing, and diversification to non-U.S. origins and domestic forage. Both effects moderate further, consistent with a large-country terms-of-trade channel in which foreign exporters concede part of the tariff via lower prices while Chinese buyers improve sourcing elasticity over time. Retaliatory tariffs can boost tariff revenue in short term, but result in extraordinary welfare losses in long term. So, the cost of dairy production in China may continue increase in the future. Overall, the "twin-tariff" regime transferred the pressure to dairy farmer and increased the marginal cost of milk, with the strongest effects when global shipping and energy markets were tight.

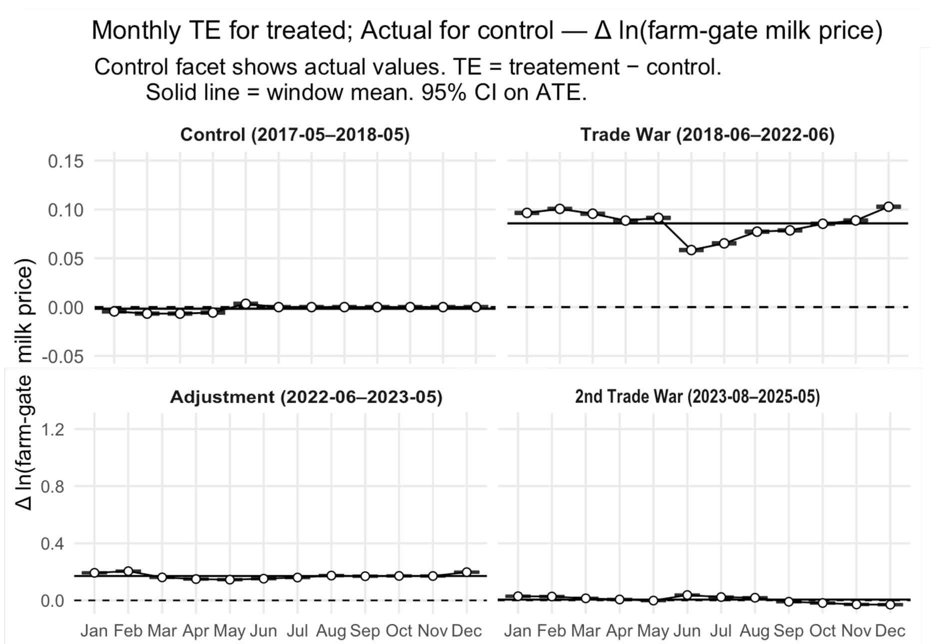

Figure 7: Treatment effects on China domestic farm-gate milk price

In the short term, the tariff war has led to a significant and pronounced increase in Chinese farm milk prices, but decrease in the long term. owever, milk producers (especially dairy farmers) face reduced profit margins because the proportionate rise in alfalfa feed prices far exceeds the increase in dairy product prices. Over the long term, China's dairy import sources have diversified toward Australia, New Zealand, and the European Union, whose competitive pricing and product quality have intensified price pressure on domestic producers. As shown in appendix figure A11, the import alfalfa price increased 38%in 2022, but the farm-gate milk price increased less than 10% in this period (see appendix figure A8). Consequently, the twin tariffs impose short-run burdens on both dairy producers and consumers, but in the long run the pressure falls disproportionately on producers.

5.3 Subsidy effects and Tariff Revenue

Different tariff scenario impacts on consumer, producer and tariff revenue are illustrated in table 2. We assume the 2017 price as the global price without tariffs, since it was one year before the tariff war and thus closer to the true world market level. According to the China Grass Industry Statistics (CGIS), China produced about 39.3 million tons of alfalfa hay in 2017 and 47.4 million tons in 2019, with only 0.18% exported. Because exports represent a very small share of total production, we do not consider them in the analysis. Government subsidies were implemented at the end of 2019, so we use 2020 prices to calculate subsidy effects. China's alfalfa imports account for about 50% of total demand, and in 2018, 96% of those imports came from the United States (Wang & Zou, 2020). If tariffs were imposed only on alfalfa, tariff revenue would decline, dairy producers would earn less, and consumers would lose more compared with the twin-tariff case. By contrast, if tariffs were imposed only on dairy products, alfalfa farmers would not incur losses, while dairy producers would experience relatively smaller gains, but overall social welfare losses would be greater. According to the USDA–FAS report, China produced 35.45 and 33 million tons of dairy in 2017 and 2019, respectively, consistent with our theoretical framework that higher tariffs decrease domestic dairy production by increasing input costs. The CIF price of U.S. alfalfa imports was $284.37 per ton in 2017. After the first round of tariffs, China imposed a 20% tariff on alfalfa (284.37×1.2 =355.46), but the observed price in 2018 was $336.59 per ton. For dairy, the import price was $1,491.44 per ton in 2017, with a theoretical post-tariff price of $1,789.72 per ton, while the actual observed price in 2019 was $1,852.62 per ton. This indicates that the combined (twin) tariffs had a more severe impact than a single tariff alone.

Table 2: Impacts estimation of different scenarios of tariff imposed on alfalfa and dairy

Case scenario	Production surplus changes		Consumer surplus changes	Tariff revenue	Net loss
	Alfalfa	Dairy			
Twin tariff	+P1P2di (+$2263.7 M)	P5hn – P3sp (+$4878.2 M)	–P5P3rh (–$23035.9 M)	abcd + efgh ($185.9 M)	–$15708.1 M
Tariff on alfalfa	+P1P2di (+$2263.7 M)	P4vn – P3sp (+$1268.2 M)	–P'dP3rg (–$4011.2 M)	abcd ($64.6 M)	–$414.7 M
Tariff on dairy	0	+P3P4ms (+$10208.6 M)	–P4P3rg (–$19003.5 M)	efgm ($68 M)	–$8726.9 M
Prohibit tariff	+$\mathrm{P}_1 P_a' O_1 i$ (+$2021.5 M)	P5hn – P3sp (+$4878.2 M)	–P5P3rh (–$23035.9 M)	No trade	–$15894 M
Subsidy on alfalfa	+k'kcd (+$3520.1 M)	+P'4P3sm (+$7487.8 M)	–P'4P3rg (–$13953.9 M)	efgm ($167.8 M)	–$2797.8 M

Tariff revenue is an endogenous fiscal outcome because both the tariff wedge and the import quantity adjust in equilibrium. Consistent with our comparative statics, retaliatory tariffs can generate a short-term increase in revenue when import demand is initially inelastic, but revenue declines as quantities contract and substitution/trade diversion intensifies (see figure 6). The subsidy on alfalfa counterfactual highlights this linkage: by shifting domestic alfalfa supply outward (figure 4), the policy compresses alfalfa import demand and therefore reduces the scope for collecting alfalfa-tariff revenue, effectively replacing fiscal receipts with higher domestic surplus in the upstream feed market. At the same time, tariff revenue from the remaining taxed segment (dairy imports: $efgm$) can persist (table 2 reports $efgm = \$167.8$M), while total welfare losses fall sharply relative to the twin-tariff benchmark (net loss $-\$2{,}797.8$M vs. $-\$15{,}708.1$M). This highlights an important policy implication: maximizing tariff revenue is not equivalent to maximizing welfare, and a subsidy that relaxes the binding feed-cost channel can improve aggregate outcomes even if it reduces the government's short-run tariff revenue.

Importing companies pay tariffs and decide whether to pass on any portion of the cost to consumers through higher prices in China (Schmitz et al., 2022). The tariffs that China imposed on U.S. exports were calculated to broadly match the value of U.S. tariffs, avoiding a spiral of escalation, but they were economically costly for the U.S. agricultural exports to China suffered, compelling U.S. to channel tens of millions of dollars' worth of subsidies to farmers (Steinberg & Tan, 2024). The revenue generated by tariffs for China during the trade-war would have been a temporary boost, but it came at the cost of higher prices for Chinese consumers. Small countries are price taker, but large country can influence the world prices through trade policy. For example, China impose tariffs on dairy can shift lower the world price from due to reduced demand and increased domestic supply (see appendix figure A8-A10). To generate the same level of tariff revenue (cdef) in a large country as that produced by the initial tariff T0 in a small country, the tariff should be higher (see figure 2) (Gaigné & Gouel, 2022; Schmitz et al., 2022).

6. Discussion

China is the largest importer of alfalfa, soybeans, and corn from the U.S, and the U.S. has immense potential advantage in alfalfa trade with China because alfalfa is a land intensive crop ("China," 2021; Hou et al., 2024). And China's demand for U.S. alfalfa remains strong because per capita farmland scarcity and diet structure changes determines the import demand for dairy products and forage (China, 2021). But ongoing tariffs, non-tariff barriers, and currency fluctuations continue to create headwinds for U.S. exporters. From 2020 to 2022, there is a sharp increase in U.S. forage exports due to China's limited resources for high quality alfalfa, and Chinese dairy consumption demand increased significantly (see appendix figure A6). The U.S. dairy prices experienced a significant decrease after 2022, due to alfalfa export reduced and inputs cost decreased (see appendix A9-A11). Changes in China's dietary structure, especially the growing demand for dairy products, highlight the growing importance of the alfalfa trade.

Tariffs imposed on higher elastic commodity have lower welfare effects on trade (Steinberg & Tan, 2024). An alfalfa tariff pushed up dairy marginal costs, shifting the dairy supply curve inward. Tariff impacts on dairy import quantities are greater than those on alfalfa, as China's demand for U.S. alfalfa is relatively more inelastic, whereas dairy imports are sourced from a more diverse set of countries. This upstream tax therefore propagates downstream, cutting dairy supply and raising dead-weight loss, while also harming alfalfa growers and consumers via higher effective costs. In short, given dairy's inelastic demand and scale, we must pay special attention to alfalfa tariff pass-through, as it depresses dairy output and lowers social welfare. Because the U.S. is not a major dairy supplier to China, tariffs on U.S. dairy can be largely offset by switching to Australia, New Zealand and EU sources, whereas China remains highly dependent on U.S. alfalfa, limiting substitution on the feed side.

Empirical results align with the large-country model's terms-of-trade channel in the context of the U.S.–China dairy–forage trade. Tariffs on both inputs (alfalfa) and outputs (dairy) compound cost pressures. Input tariffs increase the marginal cost of production, shifting the Chinese dairy supply curve upward, while output tariffs lower the effective demand for U.S. dairy, shifting down the world prices. So Chinese small dairy farms faced higher risk of costs exceeding prices. These findings align with Unveren and Luckstead (2020) and Farrokhi and Pellegrina (2023), who demonstrated that tariffs on agricultural inputs lead to reduced productivity, particularly in sectors reliant on imported resources. As table 1 and 2 illustration, it indicated that alfalfa and dairy elasticity of imports is inelastic in the short run, almost all cost of the tariffs was transferred to Chinese consumers, importers and dairy farms,. This is aligned with Amiti et al. (2019) study results of U.S. 2018 tariff impacts on price and welfare. Trump's tariff policy failed to account for the differing terms-of-trade effects that tariffs have on large versus small countries. The imposition of tariffs led to increased input costs, which initially threatened the stability of dairy and livestock production.

The gap of high quality alfalfa production between China and the U.S. The production of high-quality alfalfa hay reached 52.60 million tons in USA, but China only 1.8 million tons in 2015 (Wang & Zou, 2020). One of the important reasons for this discrepancy is that alfalfa must be sown in marginal land, which usually has poor soil fertility and suboptimal climate conditions (Wan et al., 2022). We find that producer subsidies (e.g., support for domestic alfalfa production) partially offset these cost pressures by lowering input prices, thereby cushioning dairy producers. Aligning trade policies with domestic agricultural strategies is critical for sustainable growth. So policy responses should consider following points: 1. Expanding trade partnerships can reduce dependence on single suppliers. 2. Using better land, seeds, irrigation practices and fertilizer can be an effective management strategy to improve the yield and quality of alfalfa (Wan et al., 2022). 3.

Subsidies for inelastic inputs factor of output can help to mitigate twin tariff impacts.

However, we caution against over interpreting this result because this study provides a narrow view of the twin tariff. And the empirical estimation of twin tariff impacts take many ideal assumptions, it is rough estimation but provided comparation and direction. Alfalfa account largest share of dairy farm feeds cost, but dairy feed usually mixed with alfalfa, corn, soybean and silage, which are all major agricultural exports from the U.S. to China. Our study did not calculate integrative feed cost, so actual of tariff impacts on dairy inputs were higher than our empirical results.The insights of this study are applicable to similar trade and agricultural policy contexts. In particular, under twin-tariff regimes where inputs exhibit lower elasticity (owing to scarce substitutes and structural supply-chain rigidities), while import demand for output is elastic (as alternative foreign suppliers are comparatively accessible), analogous adjustment patterns and policy transmission effects may be expected (Wang & Zou, 2020; Wang et al., 2010).

7. Conclusion

The U.S.-China trade-war imposed tariffs on alfalfa imports increased dairy production costs and disrupted supply chains, and spurred policy innovations aimed at enhancing self-sufficiency. This paper provides a study of the impacts of trade-war on livestock feed and dairy industries. The findings of this study illuminate the multifaceted impacts of the U.S.-China trade war on China's dairy sector. Increased tariffs on alfalfa and other feeds disrupted the input supply chain for dairy farmers in China. These challenges initially increased the marginal input cost of dairy production, and consequently, small-scale farms faced a higher risk of being squeezed out of the market because they are price takers. Subsidies for local forage and investment support for regional dairy have collectively improved the sector's resilience. Furthermore, increased tariffs and rising import costs also led China to ramp up policies supporting local production. These policies provide financial incentives for dairy production and forage production and improving breeding practices to boost output and quality standards.

Retaliatory tariffs make U.S. alfalfa and soybean exports to fall to a three-year low, although exports to other countries are increasing, those markets cannot compensate the loss (Adjemian et al., 2019; Morgan et al., 2022). The Chinese government implemented a series of measures aimed at bolstering domestic production and reducing reliance on U.S. imports. These measures included subsidies for alfalfa farmers, and identification of alternative sources of alfalfa and other hay imports, all of which contributed to mitigating some of these adverse impacts and improving the resilience of the dairy industry. The study provides valuable insights for other markets navigating similar trade challenges. When twin tariffs are imposed on inelastic production, a larger share of the cost increase is passed through to consumers in the short run, while small scale producer face higher exit risk. Twin tariffs generate higher dead-weight loss, redistribute surplus away from consumers and small producers, and can reduce long-run productive capacity through selection effects and import shift to other country. In short, with inelastic input factor demand, twin tariffs raise input cost, squeeze small producers, and increase social-welfare losses more than a comparable single-tariff regime. In addition, frequent changes in tariff policy generate uncertainty and alter expectations for domestic forage traders and dairy producers, often triggering large-scale stockpiling or abrupt adjustments to production plans, which ultimately undermine the intended policy objectives. These unanticipated shifts are difficult to quantify and may disrupt supply chains, leading to pronounced price volatility driven by supply–demand imbalances. Moving forward, optimal tariff policies will be pivotal in ensuring the comparative competitiveness of agricultural trade.

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A. Appendix-Support Information

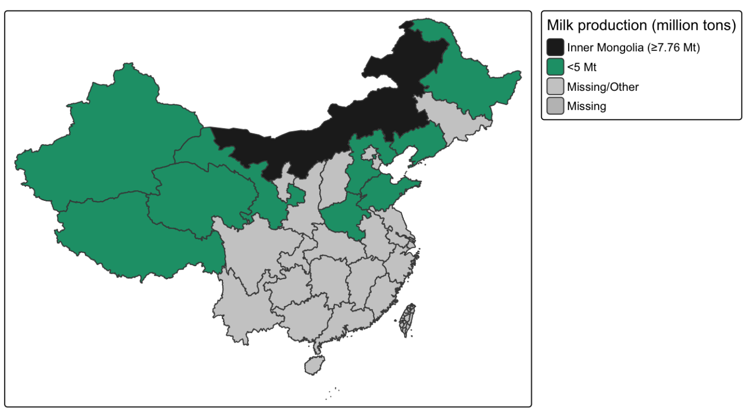

Figure A1: Chinese dairy production distribution

Source: China Food Consumption Report 2022

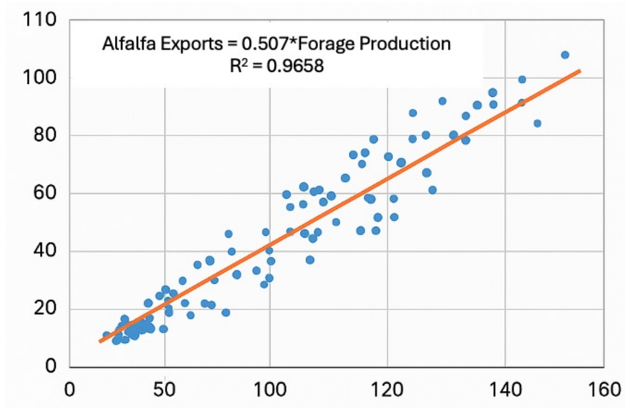

Figure A2: Relationship of U.S. alfalfa exports to all states to forage production exports (Million $)

Source: (Sall et al., 2023)

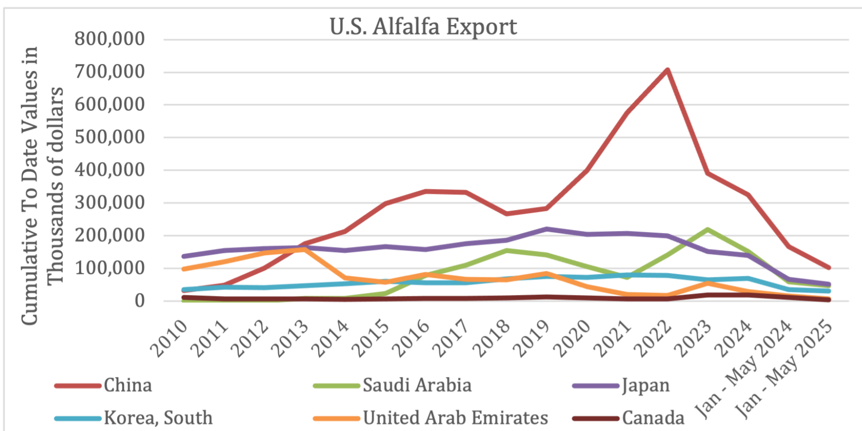

Figure A3: U.S. alfalfa export value from 2010 to 2025

Source: U.S. Census Bureau Trade Data

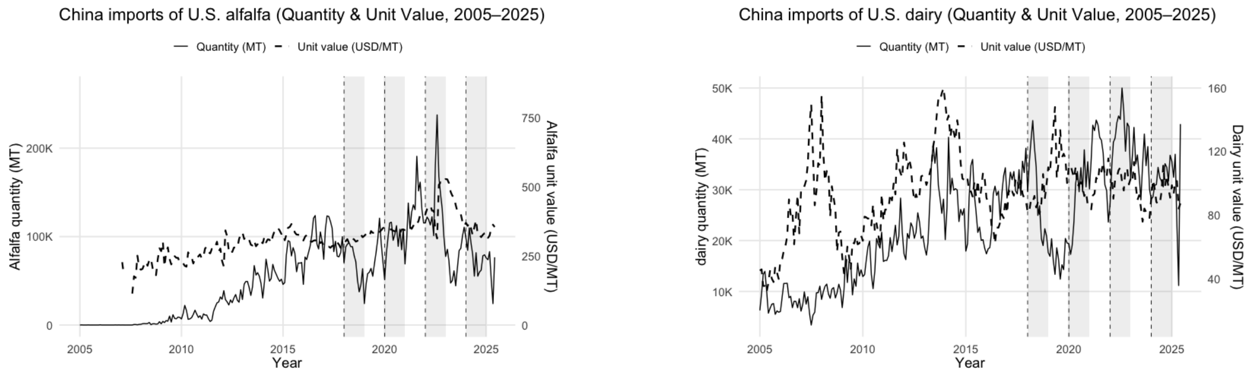

Figure A4: China import alfalfa (left) and dairy (right) quantity and price from U.S.

Source: GACC Statistics; USDA-FAS-GATS

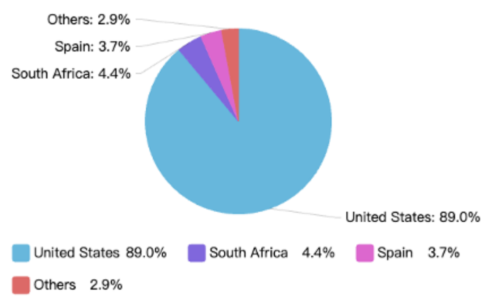

Figure A5: Chinese alfalfa hay imports source in 2023 (tons)

Source: 2024 Market Overview - Alfalfa Hay and Other Forages in People's Republic of China

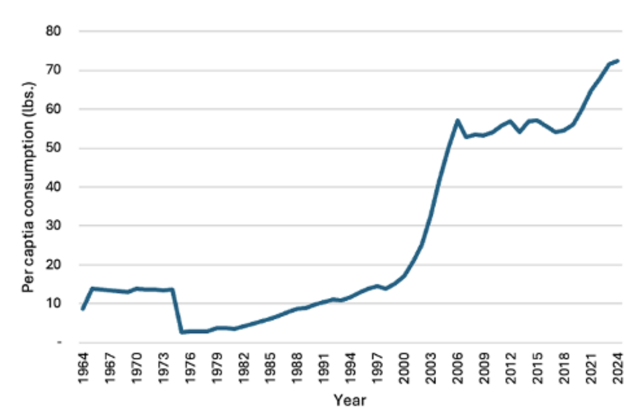

Figure A6: China per capital dairy consumption from 1964 to 2024

Source: Hoard's Dairyman Intel

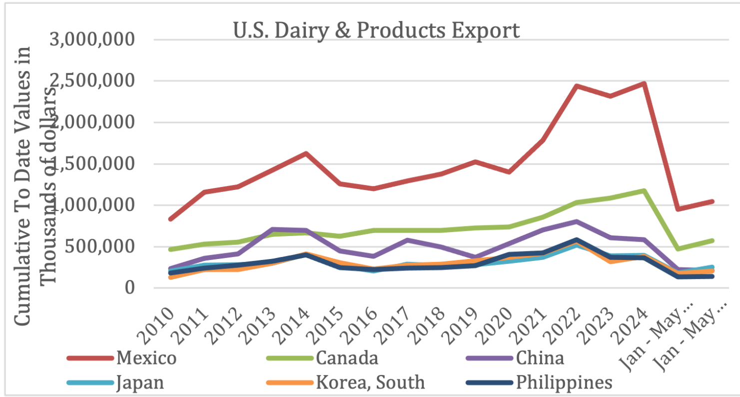

Figure A7: U.S. dairy & products export value from 2010 to 2025

Source: U.S. Census Bureau Trade Data

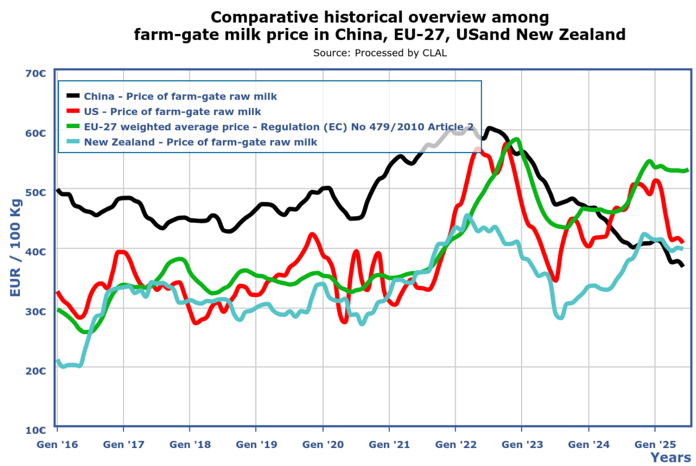

Figure A8: Farm gate milk price from 2016 to 2025

Source: Processed by CLAL, National Bureau Statistic

Figure A9: Distribution of estimated annualized losses due to retaliatory tariffs U.S. dollars (Million)

Source: (Morgan et al., 2022)

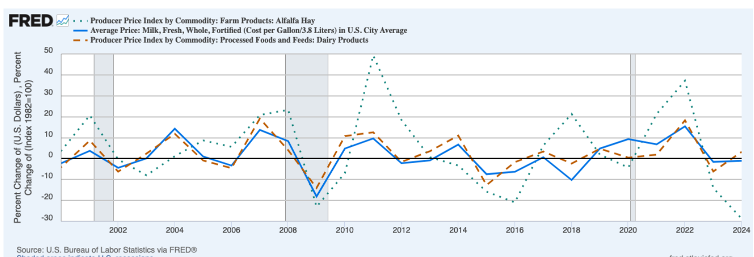

Figure A10: Average price of milk, fresh, whole, fortified in U.S. city (US$/gallon)

Source: U.S. Census Bureau Trade Data

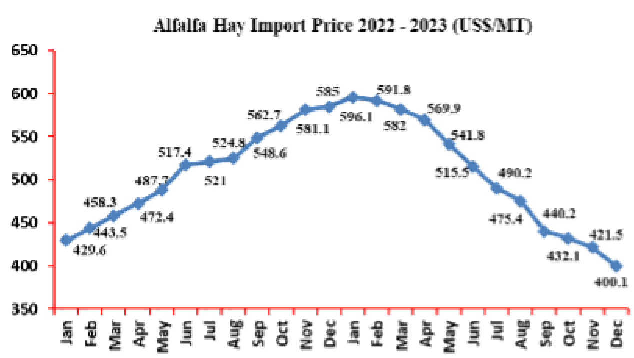

Figure A11: The price of China import alfalfa from U.S.

Source: USDA-FAS

Prices Received for Premium and Supreme Alfalfa Hay – States and 5-State Total: July 2023

State	July 2022	June 2023	July 2023
	(dollars per ton)	(dollars per ton)	(dollars per ton)
California	370.00	340.00	300.00
Idaho	320.00	290.00	280.00
Michigan	205.00	225.00	220.00
Minnesota	195.00	221.00	222.00
New York	320.00	312.00	314.00
Pennsylvania	330.00	322.00	325.00
Texas	309.00	330.00	326.00
Wisconsin	168.00	188.00	185.00
5-State Total [1 2]	335.00	310.00	288.00

[1] 5-State total represents a weighted (hay purchases) average price for the five largest milk producing States (based on the pounds of milk produced during the previous month).
[2] For July 2022, includes California, Idaho, New York, Texas, and Wisconsin. For June 2023, includes California, Idaho, New York, Texas, and Wisconsin. For July 2023, includes California, Idaho, New York, Texas, and Wisconsin.

Figure A12: U.S. alfalfa price

Source: USDA-NASS

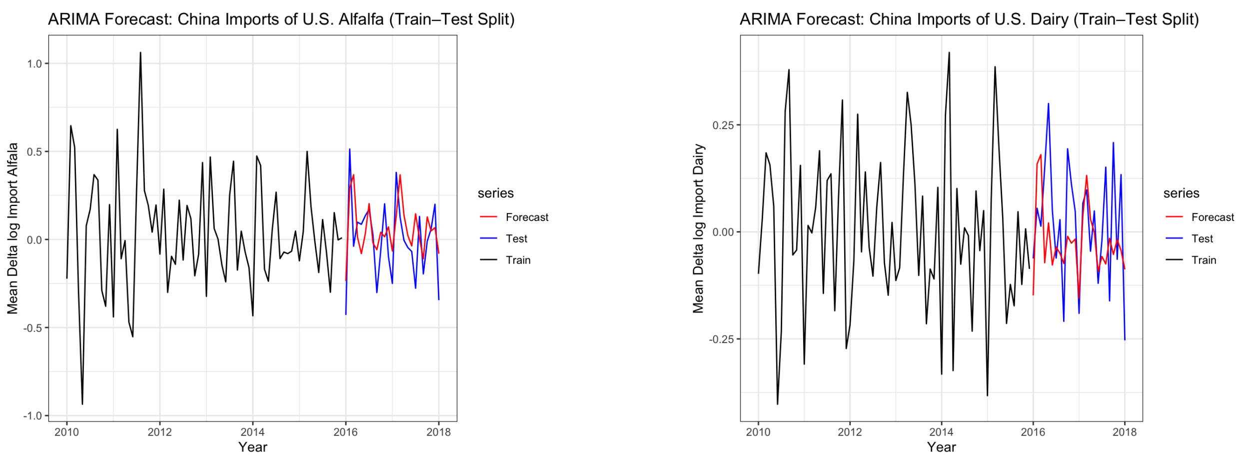

Figure A13: China import alfalfa (left) and dairy (right) quantity from U.S. stationary check

B. Data Replication

All datasets and coding are open access on author's GitHub and sole responsibility of the authors. Data clean: https://github.com/liyoumin/Trade-tarrifs-impacts-on_Chinnese_dairy/blob/main/clean%20data.R Estimations: https://github.com/liyoumin/Trade-tarrifs-impacts-on_Chinnese_dairy/blob/main/estimation.R

Table 3: Data sources and variable descriptions.

Variable	**Source**	**Code**	**Notes**	**Time**
U.S. export dairy value	USDA FAS (GATS)	HS04	$ Thousand	01/2005–06/2025
U.S. export alfalfa value	USDA FAS (GATS)	HS1214	$ Thousand	01/2005–06/2025
U.S. export alfalfa quantity	USDA FAS (GATS)	HS1214	Metric ton	01/2005–06/2025
U.S. export dairy quantity	USDA FAS (GATS)	HS04	Metric ton	01/2005–06/2025
FAO dairy price index	FAO (weighted avg. 2014–2016)	HS04	Index	01/2005–07/2025
China farm-gate milk price	CLAL.it	—	CNY / kg	01/2009–06/2025
China imports forage grass	GACC (China Customs)	HS12	Metric ton	01/2010–06/2024
Feed & fodder quantity	USDA FAS (GATS)	0120AT	Metric ton	01/2010–06/2024
U.S. alfalfa price	USDA NASS	—	$ / ton	2010–2024
U.S. dairy price	BLS via FRED	—	% change	1995–2025
U.S. grazing fee	USDA NASS	—	$ / animal / month	2010–2024
Tariff rate	Chad P. Bown (2025 Chart)	—	—	06/2018–03/2025
Tax revenue (state/local)	U.S. Census Bureau	—	Million $	01/2005–12/2024
Tariff rate (ISIC)	ISIC	—	%	01/2005–12/2024
Ag. export value	USDA ERS	HS04, HS1214	$ Thousand	01/2005–06/2025

B.1 Robustness Checks

Placebo Tests

First, we implement two placebo exercises to evaluate whether tariff shocks capture pre-existing trends. (i) We construct a placebo tariff series by shifting actual tariff changes three years earlier:

$$\mathrm{tr}_t^{\mathrm{placebo}} = \mathrm{tr}_{t+36}.$$

Re-estimating both the first-stage and second-stage equations with placebo tariffs yields coefficients that are statistically close to zero, suggesting that tariff shocks do not proxy for underlying trends. (ii) We augment the model by including *lead* tariff changes, $\Delta \ln(1+\mathrm{tr}_{t+1})$ and $\Delta \ln(1+\mathrm{tr}_{t+2})$. Consistent with exogeneity, the lead coefficients are near zero, indicating that future policy announcements do not predict past import volumes or domestic milk prices.

Alternative Lag Structures

To examine sensitivity to dynamic adjustment assumptions, we estimate variants of the baseline model with alternative lag lengths: (i) a shorter window (lags 0–1), (ii) a longer window (0–3 and 0–4), (iii) a geometric distributed lag, and (iv) a three-month average tariff index. Magnitude varies modestly across specifications, but the qualitative conclusions remain the same: tariff increases consistently reduce import quantities, with effects accumulating over the first two months.

Tariff-Quantity Decomposition

We further test robustness by decomposing tariff transmission into quantity and price channels. (i) We replace tariff rates with import unit values for dairy and alfalfa, $\Delta \ln P_t^D$ and $\Delta \ln P_t^A$, to isolate price pass-through. (ii) We include both tariff rates and CIF prices jointly in the first stage to test whether tariffs retain predictive power for import quantities after controlling for unit-value movements. Across all decompositions, tariff coefficients remain stable in sign and direction, confirming that results are not artifacts.

Additional Sensitivity Analyses

We also conduct supplemental checks, including excluding the melamine crisis years (2007–2009) and the COVID-19 period (2020–2021), and estimating models in levels rather than log-differences. All robustness exercises yield consistent qualitative patterns, strengthening confidence in the identification strategy.

Table 4: Summary of Robustness Checks

Robustness Exercise	**Description and Expected Outcome**
Placebo Tariff Shocks	Shift tariff series three years earlier; placebo coefficients close zero when tariffs are exogenous.
Lead Tariff Tests	Include future tariff changes; leads have no predictive power for past outcomes.
Short Lag Window (0–1)	Tests immediate adjustment; results align with baseline direction.
Long Lag Window (0–3, 0–4)	Captures delayed contracting/shipping effects; cumulative effects remain similar.
Geometric Distributed Lag	Smooth decay in tariff effects; sign and significance match baseline.
Averaged Tariff Index	Three-month tariff average; stabilizes noise, but effects remain consistent.
Tariff vs. CIF Price Decomposition	Replace tariffs with import prices; tests price pass-through robustness.
Excluding Crisis Years	Removes 2007–2009 and 2020–2021; results remain stable.