NDSU AGRICULTURAL RISK POLICY CENTER

Quantifying the Price Effects of Over-Quota Sugar Imports on the U.S. Domestic Market

ARPC White Paper 2026–07

Shawn Arita, Ming Wang, and Sandro Steinbach

Agricultural Risk Policy Center, North Dakota State University

April 24, 2026

Executive Summary

U.S. Senator John Hoeven (ND) requested that the Agricultural Risk Policy Center at North Dakota State University prepare an analysis of the effects of over-quota sugar imports on the U.S. sugar market. This study quantifies those effects using two separate methods: a partial equilibrium trade model calibrated to the USDA Needs Formula, and a reduced-form stocks-to-use regression estimated using WASDE data.

Central Finding: Our central estimates imply that Tier 2 (over-quota) imports depressed U.S. domestic raw sugar prices by approximately 5–8 cents/lb during FY2025–FY2026, the core injury window in which cumulative Tier 2 inflows had generated the largest import displacement and stock overhang. The mechanism is a compositional shift in which administered, price-stabilizing supply from Mexico was displaced by arbitrage-driven supply that imposes a price ceiling on the domestic market. Total import volumes remained roughly stable; however, the source of those imports changed in ways that undermined the managed supply system.

Key Insights

- **The tariff protection has eroded.** The Tier 2 tariff of 15.36 cents/lb has lost approximately 49% of its real value to inflation since 2000. Tier 2 imports rose from roughly 10,000 STRV per year before FY2018 to a record 1,231,000 STRV in FY2024, a more than 700% increase in five-year averages.
- **The Needs Formula can no longer maintain its target.** The Suspension Agreement formula targets a 13.5% ending stocks-to-use ratio by adjusting Mexico's import allocation, reduced by projected Tier 2 imports. As Tier 2 grew, the formula compressed Mexico's share to near zero, and excess supply accumulated above the policy target.
- **Revenue losses to domestic producers are substantial.** Our central estimate, anchored to the ICE No. 16 raw sugar benchmark, is an annual revenue loss of $0.9 to $1.5 billion. A refined-adjusted estimate that applies amplified raw-to-refined pass-through to both the beet and cane segments implies an industry-wide loss of $1.3 to $1.8 billion, with the sugar beet segment absorbing the majority.
- **The stock overhang is attributable to Tier 2 imports.** A stock-adjusted dynamic extension decomposes the total price effect into a within-year flow component and an across-year stock-accumulation

component. By FY2025–FY2026, the stock component explains most of the price depression, indicating that current excess inventories reflect cumulative Tier 2 inflows from FY2021–FY2024.

- **Conditions support continued Tier 2 pressure.** The Supreme Court's February 2026 invalidation of IEEPA tariff authority removed the overlay that had partially suppressed Tier 2 flows. The Section 122 replacement (10% ad valorem) expires in July 2026. After that date, the only barrier to over-quota imports is the 15.36-cent rate already in effect during FY2024. Absent a tariff adjustment, the estimated price effects would be expected to persist.

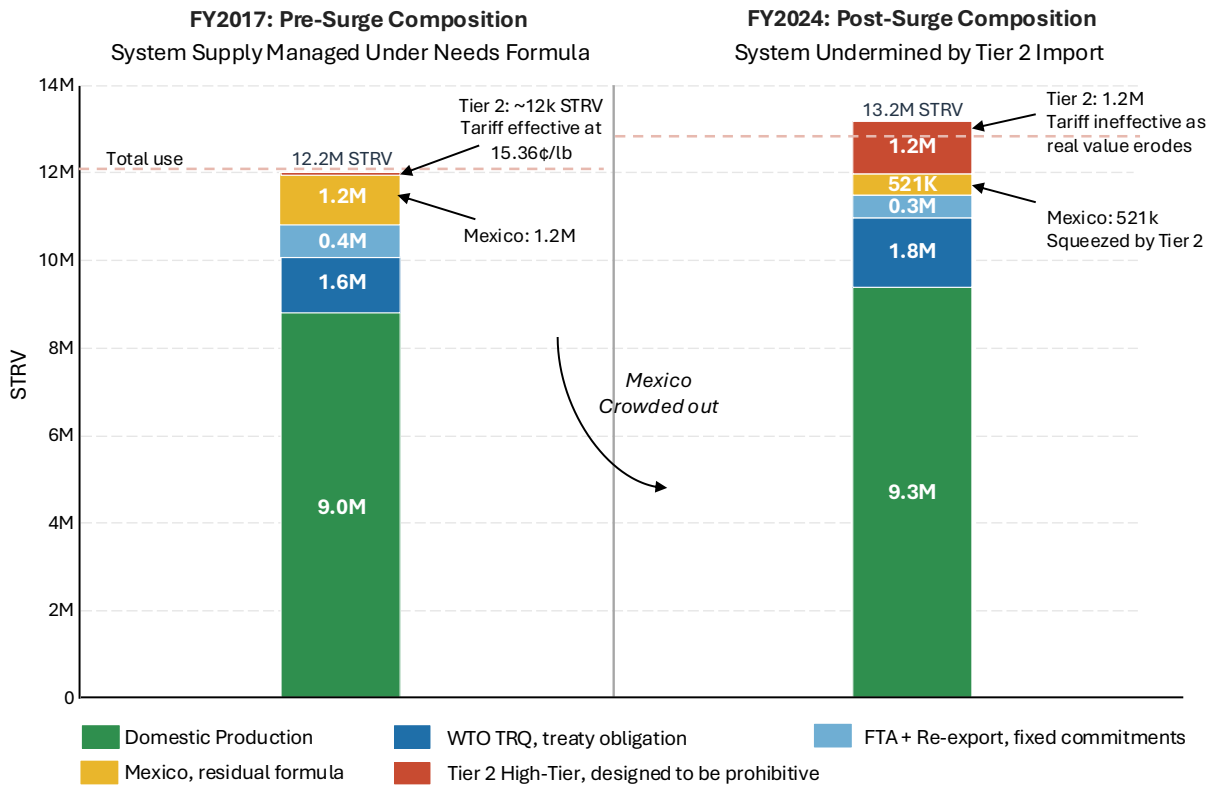
1. Introduction

The U.S. sugar market operates under the U.S. sugar program, which includes loan rates, domestic marketing allotments, and a trade policy framework built over nine decades of policy development (Section 2). The trade policy framework comprises three principal instruments: a tariff-rate quota (TRQ), bilateral Suspension Agreements governing Mexican sugar exports through the Needs Formula, and a Tier 2 (over-quota) specific tariff of 15.36 cents per pound (cents/lb), historically high enough to prevent over-quota imports.

Over-quota imports remained negligible through FY2017, and the Needs Formula maintained ending stocks-to-use (S/U) ratios near the 13.5% policy target. Beginning in FY2018, over-quota volumes increased. Figure 1 shows how the composition of the U.S. sugar supply changed over this period, and Section 2 documents the volume path and the institutional conditions that shaped it. For notation, this paper uses the WASDE convention of reporting the combined total of Tier 2 and "other program" imports as "Tier 2," because the "other program" component is small relative to Tier 2 volumes and does not materially affect the analysis. All terminology is defined in Appendix A.

The economic analysis proceeds in five linked steps. First, inflation has eroded the real value of the 15.36-cent specific tariff. Second, the U.S.-world price spread has narrowed to the point where over-quota entry becomes profitable. Third, Tier 2 imports surge. Fourth, the Needs Formula subtracts projected Tier 2 volume from Mexico's allocation, so Mexican-administered supply is displaced by Brazilian arbitrage supply. Fifth, because the two channels price differently, the compositional shift accumulates excess stocks and caps domestic prices. Section 4 quantifies the resulting price depression.

Figure 1: ***U.S. Sugar Supply Architecture: Five Sources, Two Eras.***



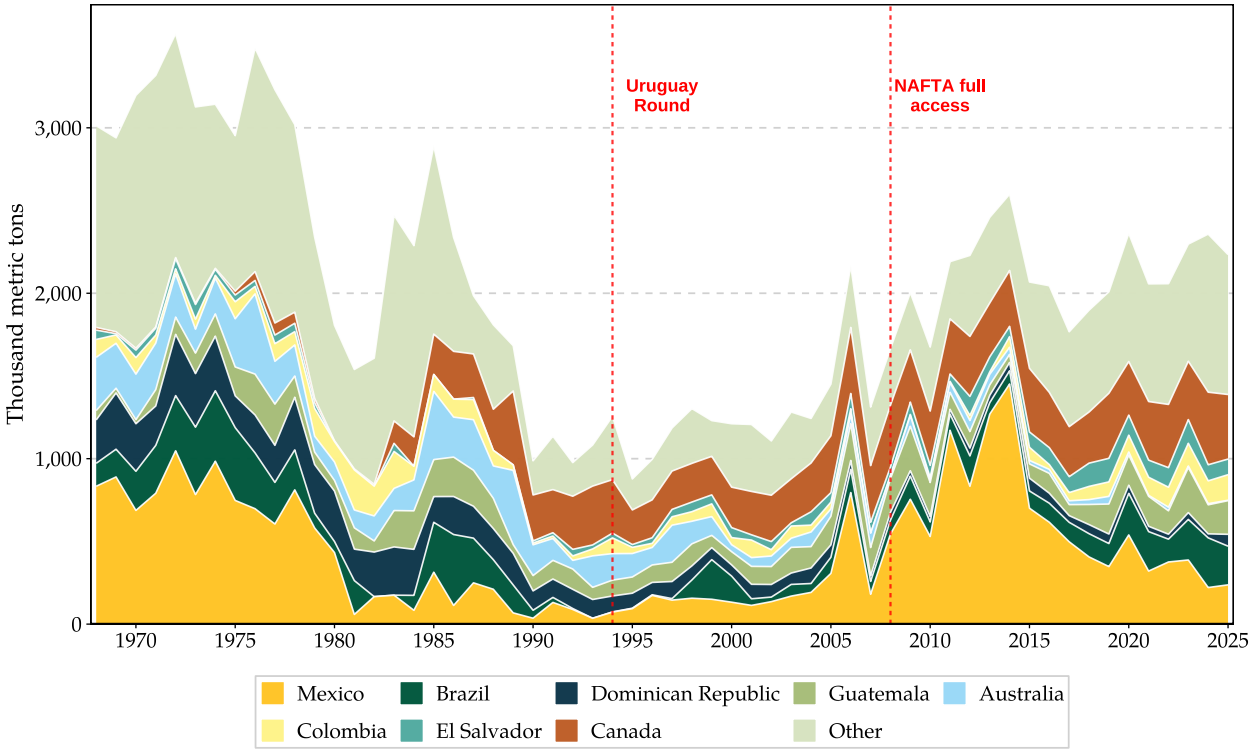
Note: FY2017 is the last pre-surge year with negligible over-quota imports and ending S/U near the 13.5% policy target. FY2024 is the peak post-surge year. Following WASDE convention, "Tier 2" includes Tier 2 and "other program" imports combined.

Source: NDSU-ARPC illustration.

2. Background and Institutional Context

U.S. sugar import policy has passed through several distinct regulatory periods since the 1930s, though, again, components of sugar policy date back to the founding of the country and have developed over time. In each period, since the 1930s, an import barrier was weakened or removed, low-cost foreign sugar entered the domestic market in volumes it could not absorb, and domestic producers sustained significant losses, including permanent closures of some processing facilities. The barrier eroded through inflation acting on a fixed specific duty rather than through a discrete policy change, and the price effect operates through a compositional shift in imports rather than a simple volume increase. Figure 2 provides a history of U.S. imports and their composition over the past several decades.

Figure 2: ***Composition of U.S. Sugar Imports by Country of Origin, 1968–2025.***



Note: Sugar in this figure includes all HS codes under the Bulk, Intermediate, and Consumer-Oriented (BICO) commodity category "Sugars and Sweeteners."

Source: NDSU-ARPC using data from USDA FAS GATS.

2.1 U.S. Sugar Policy between 1934-1994

Depression-era sugar prices fell to roughly 1.5 cents/lb, below the cost of production plus freight. The Jones-Costigan Act of 1934 responded with the first comprehensive federal sugar program, combining country-specific import quotas, domestic marketing allotments, and excise-tax-funded grower payments. That framework kept the market stable for four decades, with some modifications along the way. Congress let the Sugar Act expire on December 31, 1974, during a world price spike to approximately 65 cents/lb.

Within two years, world prices fell below 9 cents/lb as high prices had stimulated global production expansion. Under those conditions, 3.9 to 4.7 million STRV entered the U.S. market annually, and several beet processing plants closed by the end of the decade. In 1977, the U.S. International Trade Commission (USITC) found increased sugar imports threatened serious injury under Section 201 of the Trade Act of 1974, but President Carter declined to impose quotas. The Food and Agriculture Act of 1977 instead

introduced mandatory price support at 13.5 cents/lb through nonrecourse loans, although the program soon required import fees and related border measures to prevent loan forfeitures. The Agriculture and Food Act of 1981 established the system that largely continues today, with mandatory nonrecourse supports at graduated loan rates that have been adjusted periodically through subsequent farm legislation. The 2025 One Big Beautiful Bill raised the raw cane sugar loan rate from 19.75 to 24.00 cents/lb and the refined beet rate from 25.38 to 32.77 cents/lb.

When world prices again fell below 9 cents/lb in 1982–1983, Section 22 import fees, capped at 50 percent ad valorem, no longer provided enough protection. In 1982, the U.S. imposed emergency absolute quotas allocated by country based on import shares from 1975 to 1981 (Suarez, 1997). This allocation method still governs the WTO tariff-rate quota distribution. The Food Security Act of 1985 then codified the program's no-cost mandate by requiring the Secretary of Agriculture to operate the sugar program without cost to the Federal Government by avoiding Commodity Credit Corporation (CCC) forfeitures (7 U.S.C. § 7272(f)(1)). Following a panel ruling by the Council of the General Agreement on Tariffs and Trade (GATT), Presidential Proclamation 6179 converted the program to a tariff-rate quota effective October 1, 1990. This change created the two-tier structure that continues to this day, with near-zero duties on in-quota imports and over-quota rates that were designed at the time to be prohibitive.

2.2 WTO and NAFTA (1995-2017)

From 1995 through 2017, over-quota imports averaged roughly 10,000 STRV per year to a market consuming over 12 million STRV annually. The program evolved through four farm bills (1996, 2002, 2008, 2014), each making certain changes, except for the 2014 Farm Bill, which was a straight extension. The Tier 2 tariff did not disrupt the market, and the over-quota channel remained largely outside policy debate.

Between FY2003–FY2007 and FY2008–FY2014, Mexican sugar exports to the United States surged from about 60,000 to 1,419,000 STRV per year. Following the end of NAFTA's sugar transition on January 1, 2008, Mexico gained unlimited duty-free access to the U.S. sugar market. By FY2013, oversupply had pushed domestic prices below loan forfeiture levels, triggering approximately 382,000 tons of CCC forfeitures valued at $172 million and net government outlays of $259 million in FY2013 and FY2014, the largest deviation from the no-cost mandate to that point in the program's history.

The antidumping and countervailing duty investigations led to a negotiated settlement. Commerce found preliminary dumping margins of about 40 to 47 percent on Mexican sugar. The Suspension Agreements in

December 2014 set reference prices of $0.2225 per pound for other sugar and $0.2600 per pound for refined sugar, limited refined shipments to 53 percent of Mexico's exports, and tied Mexico's export volume to the Needs Formula, which targets a 13.5 percent ending S/U ratio. The 2017 amendments tightened terms further by raising the reference prices to 23 and 28 cents, lowering the polarity threshold from 99.5 to 99.2 degrees, and cutting the refined cap to 30 percent.

2.3 The Supply Architecture and the Needs Formula

The U.S. sugar market draws on five supply sources arranged in a policy hierarchy, including domestic production (~9.3 million STRV), WTO TRQ imports (~1.1–1.5 million), FTA and program imports, Mexico under the 2014 Suspension Agreements, and Tier 2 over-quota imports.

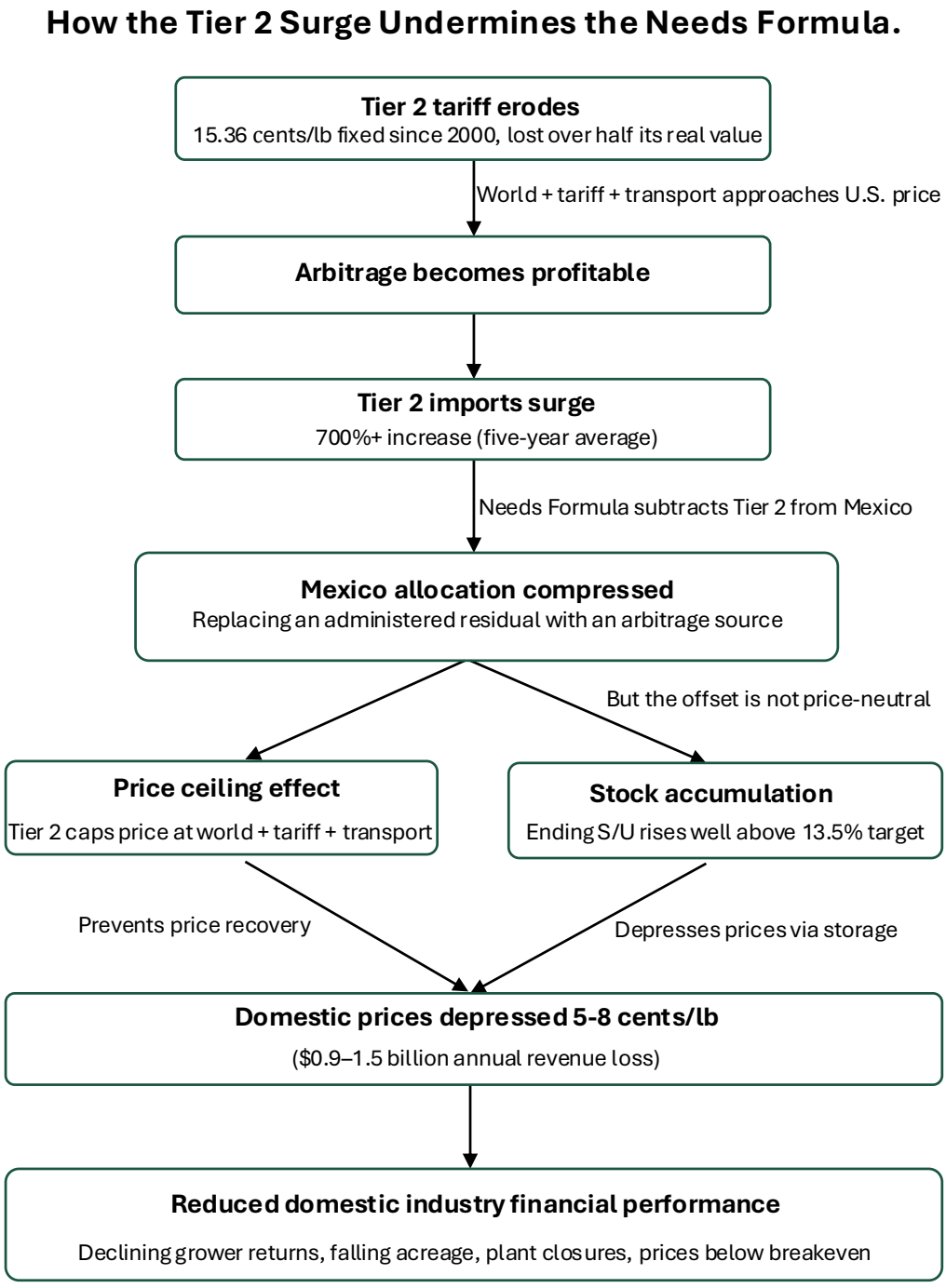
Mexico serves as the residual supplier under the Needs Formula, which targets a 13.5% ending S/U ratio. Tier 2 imports are then intended to be subtracted from Mexico's allocation on a one-for-one basis. When over-quota volumes were 10,000 STRV, this offset was negligible. Once those volumes reach hundreds of thousands of tons, they replace Mexican supply, which entered at negotiated reference prices, with unmanaged supply entering at world price plus the eroded tariff. Total import volumes stayed within 3.2-3.8 million STRV, but their composition changed substantially, as price-responsive arbitrage imports displaced residual imports administered through the formula. This substitution across import channels is central to the price effects estimated in this paper. Figure 3 shows this Needs Formula feedback loop.

The substitution between Mexican and Tier 2 supply is not price-neutral even when total import volume is unchanged. Mexican supply arrives on an administered schedule at negotiated reference prices that do not respond to domestic market conditions. Tier 2 supply arrives on arbitrage whenever the U.S. price exceeds the world price plus tariff and transport. Replacing the first with the second caps the domestic price from above. When arbitrage-driven volume exceeds what the Needs Formula can offset through Mexico's allocation, stocks accumulate beyond the 13.5% target. Section 2.5 develops this mechanism formally.

2.4 Tariff Erosion and the Tier 2 Surge

Under the Uruguay Round Agreement on Agriculture (1994), the United States replaced sugar import quotas with tariff-rate quotas. The over-quota tariff on raw sugar was set at 17.62 cents/lb in January 1995, and phased down to 15.36 cents by 2000. The agreement also set a minimum access commitment

Figure 3: *The Needs Formula Feedback Loop.*

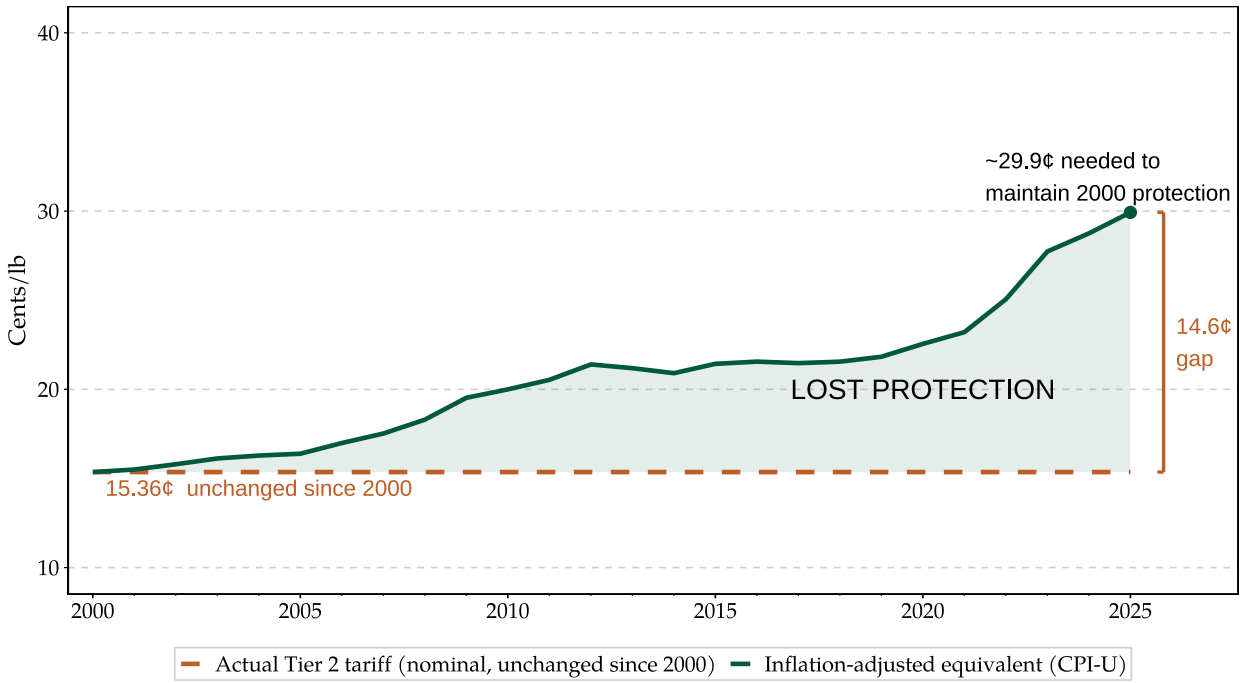


Source: NDSU-ARPC illustration based on USDA suspension agreement procedures.

of 1,117,195 metric tons raw value for raw cane sugar and 22,000 metric tons raw value for refined sugar, and set the corresponding over-quota tariff on refined sugar at 16.21 cents/lb. Because the tariff was set as a fixed specific duty, its real protective value eroded over time. By 2025, rising sugar CPI-U had re-

duced its real value by approximately 49% relative to 2000 (Figure 4). As a result, the U.S.-world price spread narrowed below the level at which over-quota entry becomes commercially viable. Tier 2 volumes responded with an acceleration that defines the core injury period, increasing from roughly 10,000 STRV per year in the pre-2018 baseline to 64,000 in FY2018, 91,000 in FY2019, 206,000 in FY2020, 212,000 in FY2021, 390,000 in FY2022, 455,000 in FY2023, and a record 1,231,000 STRV in FY2024.

Figure 4: ***The Frozen Tariff: 25 Years of Inflation Erosion.***

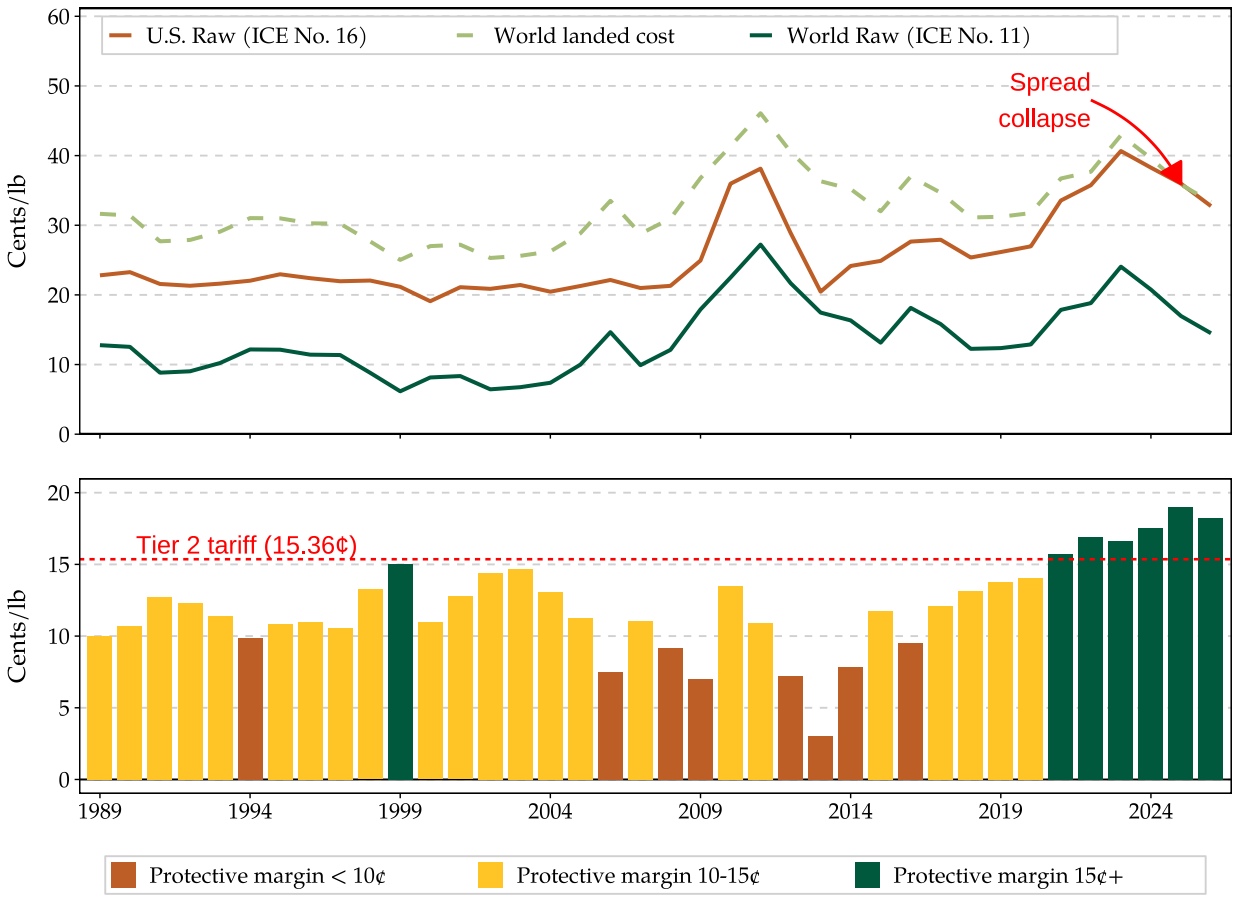


Note: The gap between the nominal tariff and its inflation-adjusted equivalent shows the erosion of protection over time.

Source: NDSU-ARPC using data from U.S. tariff schedule (19 U.S.C. § 1202, HTS 1701.14), and U.S. Bureau of Labor Statistics Sugar CPI-U.

When established in 1994, the over-quota tariff was equivalent to nearly 242 percent ad valorem (U.S. International Trade Commission, 2001). An ad valorem rate would have maintained protection automatically, whereas the specific duty lost approximately half its real value over time. Figure 5 shows the long-run U.S.-world price spread. During the quota and TRQ eras, the spread averaged 10–16 cents/lb, which was generally sufficient to deter over-quota entry. The dashed line indicates the Tier 2 landed cost, equal to the world price plus duty and transport costs. As the domestic price approaches this line, the tariff loses its ability to deter over-quota entry. Figure 6 plots the U.S.-world raw sugar price spread alongside Tier 2 imports and shows that the recent surge in over-quota entry coincided with a marked narrowing of the spread.

Figure 5: ***U.S. vs. World Raw Sugar Prices and the Protective Margin, 1989–2026.***



Note: The estimated landed cost of Tier 2 imports is calculated as the world price plus duty and transport costs. The protective margin is the U.S.-world price spread.

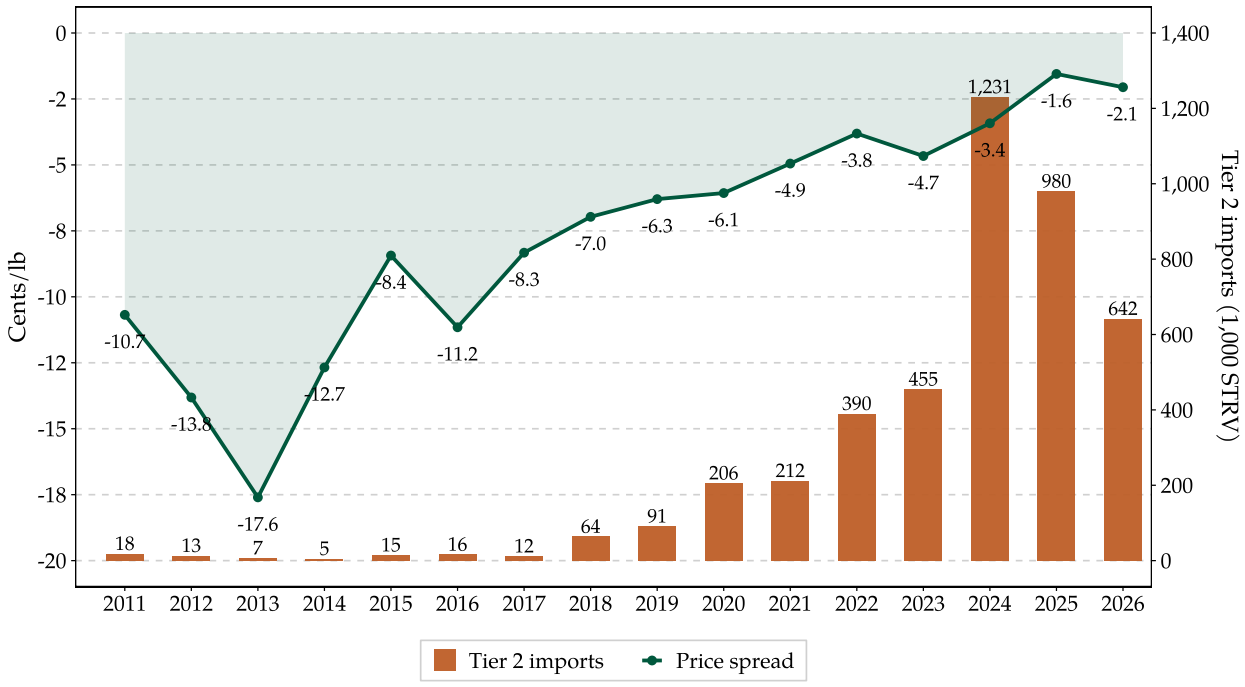
Source: NDSU-ARPC using data from USDA ERS Sugar and Sweeteners Yearbook.

2.5 Why a Compositional Shift Affects Prices

Mexico absorbs demand shocks without transmitting them to prices. Tier 2 enters on arbitrage whenever the domestic price exceeds the world price plus tariff and transport costs, effectively placing a price ceiling. Replacing an administered residual supplier with an arbitrage-driven source tends to cap prices from above and to accumulate stocks beyond the formula's target. The shift also includes a product dimension, as Tier 2 includes a substantial share of refined sugar (see Figure 13) that competes directly with domestic beet sugar production. Figure 7 compares Mexico and Tier 2 import volumes and the ending S/U before and after the Tier 2 surge, illustrating that once Tier 2 volumes increased, the Needs Formula no longer kept ending S/U close to its 13.5% target.

By FY2026, beginning S/U had exceeded the 13.5% target embedded in the Needs Formula, reflected in the 1.135 multiplier in Section II.R of the Suspension Agreement. USDA separately maintains a broader "traditional range" of 13.5% to 15.5% for guiding discretionary TRQ and allotment actions, but the formula itself targets 13.5% at each quarterly WASDE recalculation. This overhang accumulated because, once over-quota volumes exceeded what Mexico would have supplied, excess supply accumulated in domestic inventories year after year. The WASDE projects ending S/U for FY2026 at 15.24%, still above the policy target and still exerting downward pressure on prices.

Figure 6: ***As Price Protection Erodes, Tier 2 Imports Surge.***



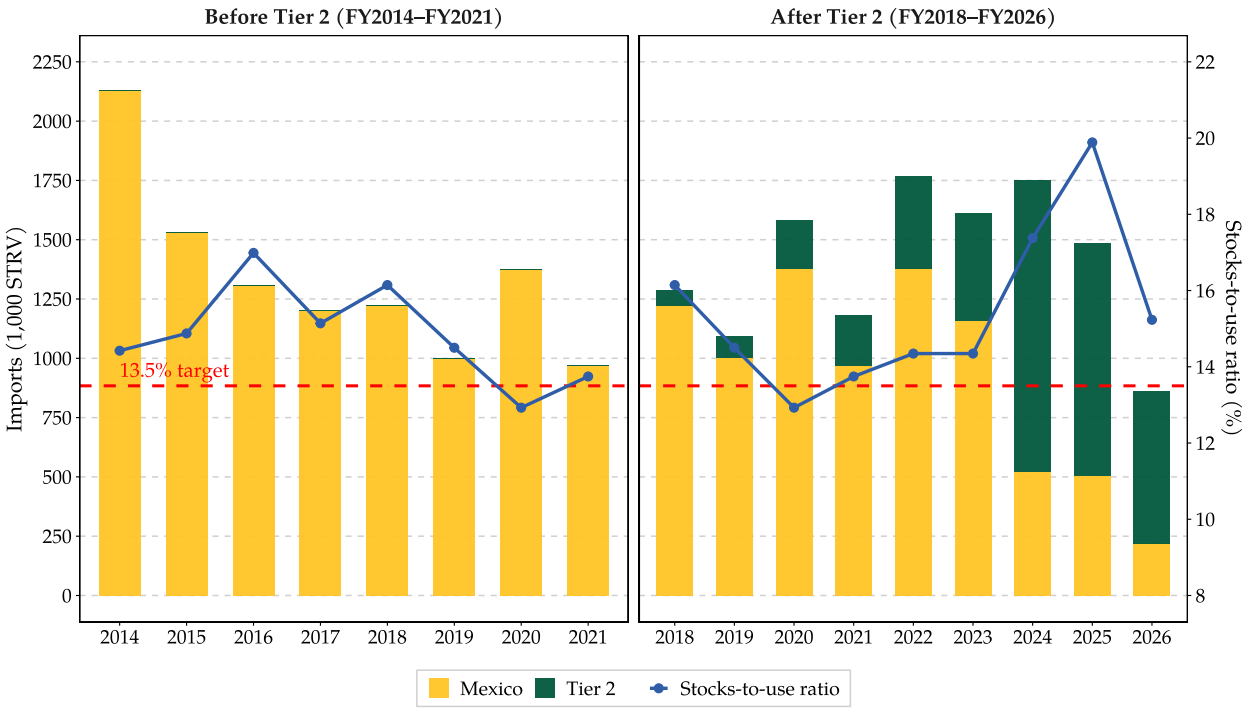
Note: The shaded area shows the U.S.-world raw sugar price spread, which is the price protection margin.
Source: NDSU-ARPC using data from USDA ERS Sugar and Sweeteners Yearbook.

2.6 The Tariff Framework After the IEEPA Decision

On February 20, 2026, the Supreme Court held in *Learning Resources* that IEEPA does not authorize the President to impose tariffs. The ruling removed the reciprocal and country-specific tariffs that had been layered on top of the existing tariff-rate quota system since April 2025. During the period they were in effect, IEEPA tariffs raised the barrier to Tier 2 imports. For Brazil and other major exporters, the addi-

tional levies pushed the total landed cost of over-quota sugar well above the domestic price, leaving Tier 2 trade unprofitable for most origins.

Figure 7: ***Ending S/U and the Needs Formula Before and After the Tier 2 Surge.***



Note: After the Tier 2 surge, the ending stocks-to-use ratio rose noticeably above the 13.5% target.
Source: NDSU-ARPC using data from USDA ERS Sugar and Sweeteners Yearbook.

Following the IEEPA invalidation, a 10% ad valorem global surcharge was imposed under Section 122 of the Trade Act of 1974. For sugar, the uniform 10% rate replaced the substantially higher IEEPA rates that had been applied to major exporters. The Section 122 surcharge is time-limited to 150 days from February 24, 2026, roughly through July 24, 2026, unless extended by Act of Congress. After expiration, the U.S. sugar market's import protection reverts to the 15.36-cent Tier 2 duty alone, the same rate in place during the FY2024 peak of over 1.2 million STRV of Tier 2 imports.

2.7 Economic Implications of the Post-IEEPA Environment

The IEEPA overlay may explain part of the decline in Tier 2 volumes during FY2025. Tier 2 imports fell from an estimated 1,231,000 STRV in FY2024 to an estimated 980,000 in FY2025, likely reflecting a combination of the IEEPA tariff overlay, elevated refined stocks that reduced contracted Tier 2 entries,

and softer domestic demand. But within three weeks of the Supreme Court ruling, USDA's March WASDE revised Tier 2 projections upward by 134,000 STRV to 642,000 for FY2026, suggesting the arbitrage incentive underlying the Tier 2 channel remains intact.

At current world prices, the 10% Section 122 surcharge is not large enough to close the arbitrage window, and the over-quota import channel remains commercially viable. Global sugar markets are projected to stay in surplus through 2027. Brazil, which supplies about 80% of over-quota volume, remains cost-competitive, with production cost at roughly 15 to 16 cents/lb, and benefits from real depreciation, with an exchange rate of around 5.80–6.20 reais per dollar. For FY2026, WASDE reduced domestic production to 9,280,000 STRV, reflecting in part losses from the Florida freeze, lowered the ending S/U ratio to 15.24%, and revised food deliveries upward. Because Tier 2 imports are recorded only as U.S. Customs and Border Protection actuals and are not fully projected in WASDE, while refined and specialty Tier 2 components are WASDE forecasts, the realized ending S/U ratio by September is likely to be higher than currently projected, as was the case in FY2025.

Domestic raw sugar prices fell to 33.65 cents/lb in November 2025, while refined beet sugar spot prices were at or below breakeven levels. Domestic supply response is highly inelastic. Sugar beet growers are bound by cooperative contracts that lock acreage before planting, and processors require minimum acreage to cover fixed costs. Sugarcane ratoon cycles of three to five years preclude annual acreage adjustment. Processing must be co-located with feedstock production because sugar content degrades in transport, eliminating the option of shifting output to alternative facilities. These constraints prevent producers from adjusting output in response to the Tier 2 import price ceiling.

The Section 122 replacement expires around July 24, 2026, with no clear successor. The result is a domestic sugar market with higher price floors and less effective over-quota protection than at any point since 1983. The price effects estimated in this paper were generated under these conditions, which will persist absent a tariff adjustment.

3. Analytical Framework

3.1 NDSU-ARPC Sugar Partial Equilibrium Model

We develop a static, linear PE framework with demand and supply curves calibrated to observed fiscal-year data using short-run elasticities from Elobeid and Beghin (2006). The counterfactual removes Tier

2 and recalculates Mexico's allocation through the Needs Formula. All inputs are from the March 2026 WASDE. The full derivation is provided in Appendix B.

The counterfactual Needs Formula allocation assumes a 96% fill rate, the average share of calculated allocation shipped by Mexico during FY2015–FY2023 (88–100% range). A full-fill assumption would yield slightly larger price effects, but 96% remains the baseline because Mexico does not always ship the full calculated allocation due to logistics, stock management, and the stepped ratchet schedule.

The counterfactual proceeds in three sequential steps. First, Tier 2 is set to zero and all other WASDE quantities are held constant. Second, the Needs Formula recalculates Mexico's allocation as NF Mexico $=$ $(1.135 \times Q_D - BS - Q_S - \text{TRQ}) \times 0.96$ (see Appendix C). Third, the PE model clears the reduced-supply market with domestic supply, TRQ, and the NF-derived Mexico allocation.

3.2 Stocks-to-Use Regression

Following Good and Irwin (2015), we estimate a reciprocal specification of price on beginning S/U using FY2012–FY2022 data from the pre-surge period. Beginning S/U is predetermined at the start of the fiscal year and therefore plausibly exogenous to within-year price formation.

3.3 Stock-Adjusted Dynamic Extension

The static PE model does not account for dynamics. We construct a dynamic extension combining PE flow mechanics with the regression's price-stocks relationship. The total effect decomposes into a flow component, which captures the within-year supply shift, and a stock component, which captures the accumulated inventory overhang. The stock component applies the S/U regression coefficient ($b = 3.28$) to the difference between actual and counterfactual beginning stocks. The flow component is the within-year PE effect evaluated at counterfactual beginning stocks. At the observed baseline, both components equal zero, and the model reproduces observed prices. All estimated effects are deviations from actual market conditions. Appendix D provides the full derivation.

3.4 Raw-Refined Price Transmission

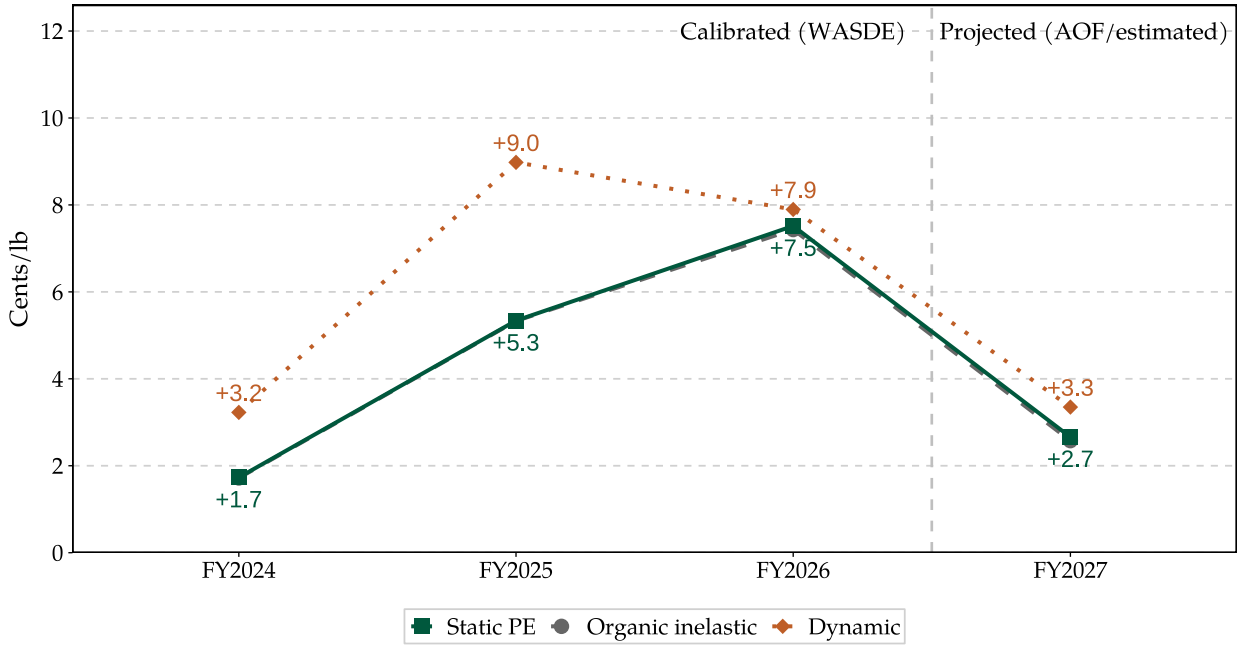
The PE framework is calibrated to ICE No. 16, the benchmark U.S. raw cane sugar price. Approximately 55% of domestic sugar production is sold as refined beet sugar, which faces more direct competition from

refined Tier 2 imports. Thus, we estimate the transmission from ICE No. 16 prices to Midwest refined beet spot prices using monthly USDA ERS data from January 2009 through February 2026. We test both series for unit roots, estimate their long-run relationship using an Engle-Granger cointegration approach, and use an error-correction model to characterize short-run adjustment. The estimated pass-through coefficient is then applied to the PE model's raw-price effects to infer refined-market impacts and segment-specific revenue effects.

4. Partial Equilibrium Model Results

Our static PE model estimates that removing Tier 2 imports and allowing the Needs Formula to expand Mexico's allocation would have raised domestic raw sugar prices by approximately 1.7 to 7.5 cents/lb across FY2024–FY2026 (Figure 8). The effect is smallest in FY2024 (+1.7 cents/lb) because the Needs Formula nearly fully replaces the removed Tier 2 within the year. The effect is largest in FY2026 (+7.5 cents/lb), when cumulative Tier 2 inflows from prior years had pushed beginning stocks well above the 13.5% target, leaving less room for Mexico under the Needs Formula.

Figure 8: ***Estimated Price Effect of Tier 2 Imports: Three Specifications.***



Note: The price effects shown in the figure are deviations from P_0.

Source: NDSU-ARPC.

An organic-inelastic sensitivity, which excludes organic Tier 2 imports that would likely continue being imported under a higher tariff because of their large price premiums, confirms that the central results are robust. The adjustment reduces the effect by around 0.1 cents/lb, while the Needs Formula absorbs the change through a corresponding reduction in Mexico's allocation.

Figure 9: ***Actual and Counterfactual Import Composition and Ending S/U Ratios.***

Note: The top panel compares actual and counterfactual import composition, and the bottom panel shows the corresponding ending S/U ratios. Static CF and Organic-Inelastic CF use actual beginning stocks and do not incorporate stock carryover. For visual clarity, Organic-Inelastic CF ending S/U values are not labeled.

Source: NDSU-ARPC and WASDE.

The stock-adjusted dynamic extension produces total effects of +3.2 to +9.0 cents/lb for FY2024 to FY2027. By FY2025–FY2026, the stock component explains most of the total price depression, indicating that current excess stocks largely result from cumulative Tier 2 inflows from FY2021–FY2024. In FY2026–FY2027, the within-year flow effect turns negative because lower counterfactual beginning stocks allow the Needs Formula to expand Mexico's allocation that exceeds the Tier 2 quantity removed. Even so, the total effect remains positive because stock relief more than offsets the flow reversal.

Figure 9 compares actual import composition and S/U ratios with three counterfactual scenarios, showing that removing Tier 2 imports largely replaces them with Mexico's allocation and brings ending S/U back close to the 13.5% target. In the no-Tier 2 counterfactual, where Tier 2 is forced to zero and the Needs Formula recalculates Mexico's allocation at counterfactual beginning stocks for each year, the Needs Formula restores ending S/U toward the 13.5% policy target in every year, landing at approximately 13.0–13.1% in some years due to the 96% fill-rate assumption, and Mexico ships 1,183–1,436k STRV, consistent with how the managed supply system was designed to operate.

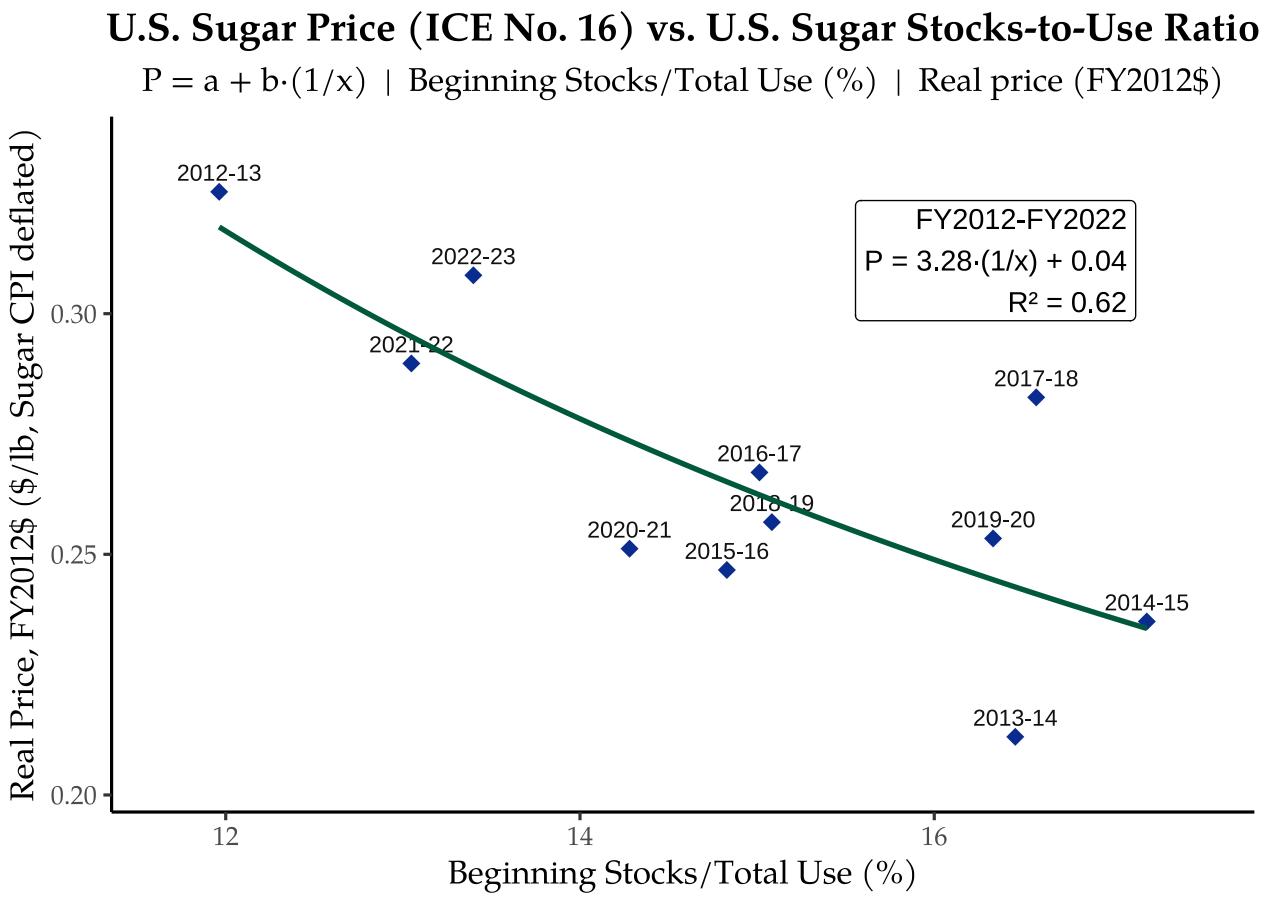
The results remain robust to alternative elasticity assumptions drawn from the sugar economics literature. Under the most inelastic specification ($e_D = -0.05$, $e_S = 0.10$), the P_0-anchored price effects are roughly 2.5 times as large as in the Elobeid and Beghin (2006) baseline, reaching +13.1 cents/lb in FY2025 and +18.5 cents/lb in FY2026. These values push the linear approximation beyond a reasonable range, implying insulated prices of 50–52 cents/lb, or 35–55% above observed prices, and should therefore be treated as upper bounds. A long-run elasticity specification from earlier literature yields smaller but still positive effects. Appendix E reports the full sensitivity results and parameter sources.

5. Econometric Validation

The S/U regression corroborates the partial equilibrium results. The reciprocal coefficient on beginning S/U is statistically significant at the 1% level and explains approximately 62% of real price variation across the FY2012–FY2022 pre-surge period. Figure 10 plots the relationship between the real ICE No. 16 price and the beginning S/U over the sample. Appendix F provides an additional robustness check.

Figure 11 plots actual and regression-implied counterfactual prices, with labeled gaps showing the estimated price effects. Applied to the FY2024–FY2027 period, the regression indicates that the import-driven stock overhang depressed domestic prices by approximately 2 to 11 cents/lb (nominal), with the largest effects in FY2025–FY2026 when beginning S/U was furthest above the 13.5% target.

Figure 10: *ICE No. 16 and Beginning S/U, FY2012–FY2022.*



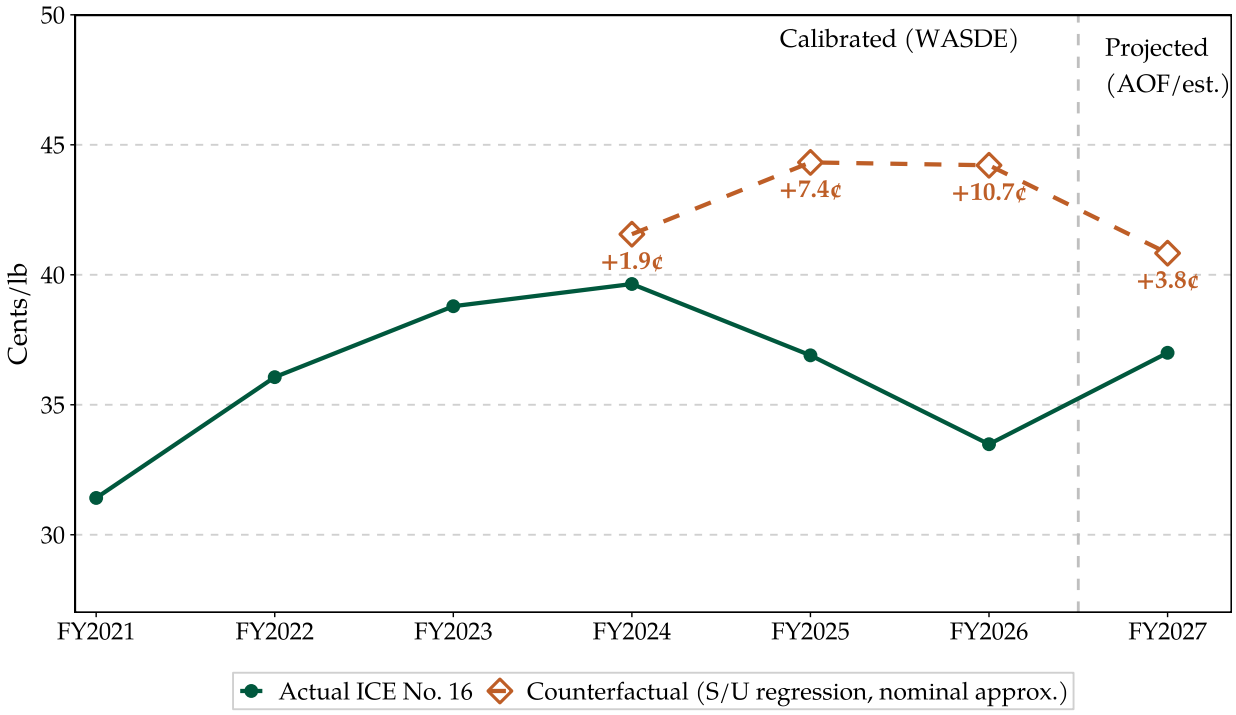
Note: Each point represents a fiscal year from FY2012 to FY2022. The curve shows the fitted reciprocal relationship between the real ICE No. 16 price and the beginning S/U ratio.

Source: NDSU-ARPC using data from USDA ERS Sugar and Sweeteners Yearbook.

6. Cross-Validation

The PE model, the S/U regression, and the dynamic extension apply different approaches. The PE model and S/U regression are independently estimated, while the dynamic extension reflects elements of both channels. Figure 12 compares estimated price effects across the three methods. For the core injury period of FY2025–FY2026, all three methods indicate price effects in the range of 5 to 11 cents/lb, providing cross-validation for the main finding. Key limitations and assumptions are discussed in Appendix G.

Figure 11: ***Actual vs. Counterfactual U.S. Raw Sugar Prices from the Stocks-To-Use Regression.***



Note: The labeled gaps are the estimated price effects, converted from real to nominal cents/lb. Prices in the regression are deflated using the Sugar CPI.

Source: NDSU-ARPC and WASDE.

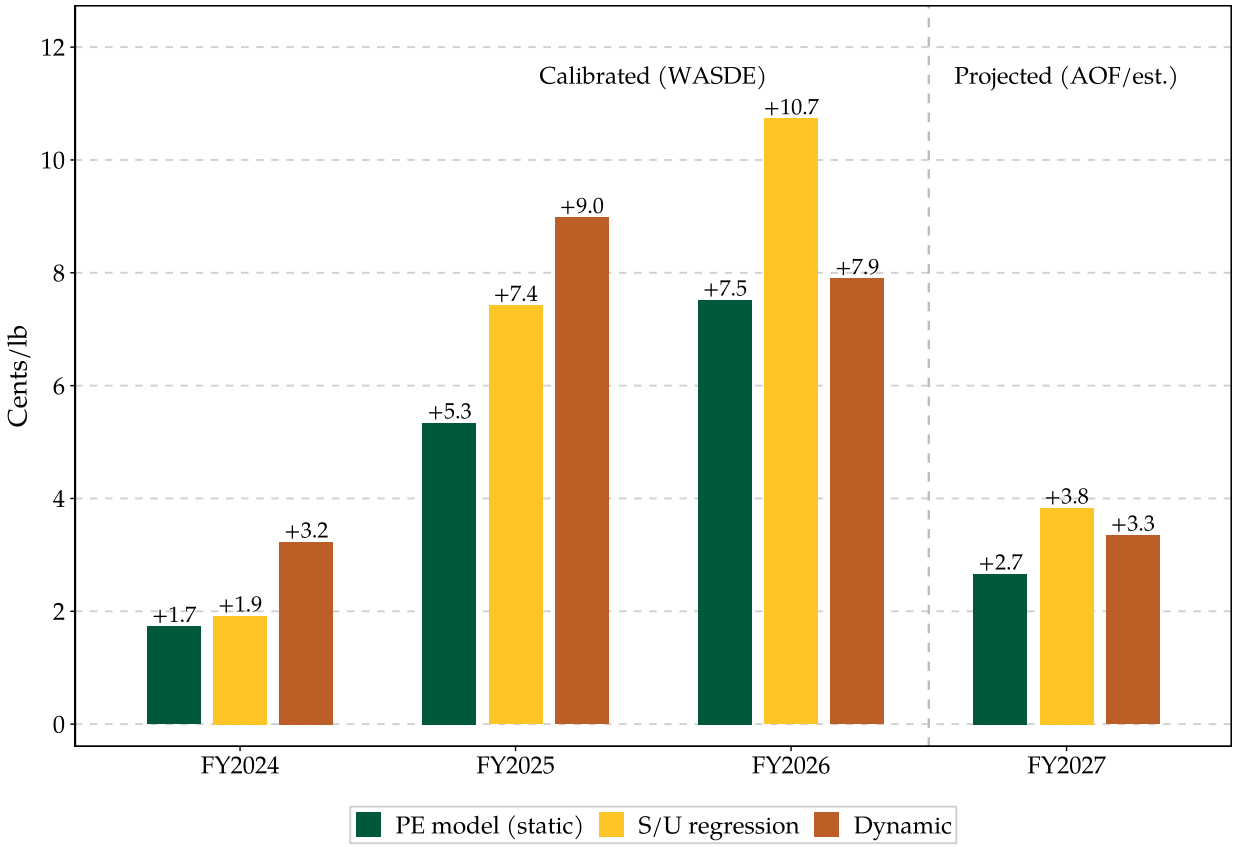
7. Raw-Refined Price Transmission

The PE model is calibrated to ICE No. 16, the benchmark U.S. raw cane sugar price. The primary injury channel for domestic sugar beet producers, however, operates through the refined sugar market, where beet sugar competes directly. To assess whether the raw price effects estimated above transmit to refined beet prices, we conduct a cointegration analysis using monthly ICE No. 16 and Midwest refined beet spot prices from the USDA ERS Sugar Yearbook, over the post-2008 period from January 2009 to February 2026, with a sample of 202 months.

The two price series exhibit strong co-movement over the full sample period (Pearson $r = 0.859$). Augmented Dickey-Fuller tests confirm both series are I(1) in levels and I(0) in first differences. An Engle-Granger cointegration test rejects the null of no cointegration ($\tau = -4.06$, 5% critical value = -3.34), indicating a statistically significant long-run equilibrium relationship. The estimated long-run price transmission coefficient is $\beta = 1.32$ (se = 0.072), meaning that a 1 cent increase in the ICE No. 16 raw price is associated with a 1.32 cent increase in the Midwest refined beet price over the long run. An error cor-

rection model indicates that approximately 11% of any deviation from this equilibrium is corrected each month, with a half-life of adjustment of roughly 6 months (see Appendix H for full estimation results).

Figure 12: ***Comparison of Estimated Price Effects Across Three Methods, FY2024–FY2027.***



Note: The figure reports price effects relative to P_0 under three specifications: static PE, nominal S/U regression, and dynamic flow-plus-stock.

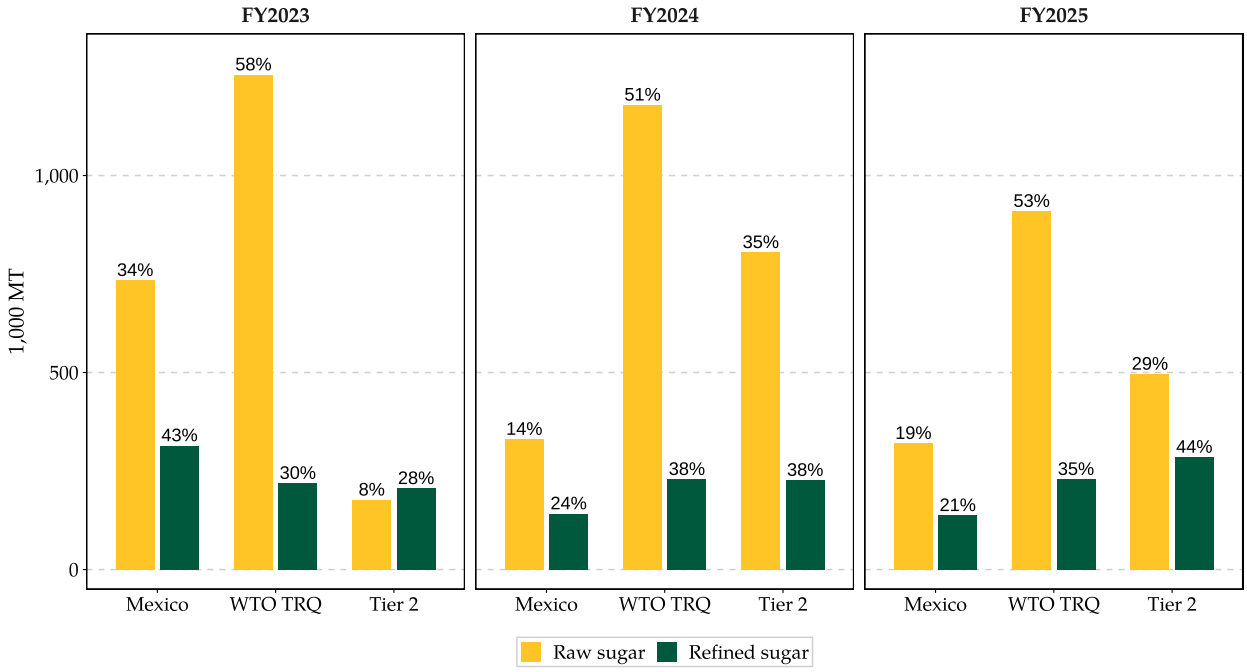
Source: NDSU-ARPC.

The greater-than-unity price transmission implies that the PE model's central estimates are conservative for the refined beet segment. Applying the 1.32 coefficient to the static PE price effects yields implied refined beet price effects of +2.2 cents/lb in FY2024, +7.0 cents/lb in FY2025, and +9.9 cents/lb in FY2026. For the core injury period of FY2025–FY2026, the implied refined beet price depression is approximately 7 to 10 cents/lb, compared with the central estimates of 5–8 cents/lb estimated at the ICE No. 16 level.

The compositional structure of Tier 2 imports further amplifies this result (Figure 13). Under the Suspension Agreements, Mexico's exports are limited to no more than 30% refined sugar (polarity at or above

99.2°), with at least 70% classified as "Other Sugar" (bulk, freely flowing). Tier 2 imports face no such constraint. In FY2025, about 34% of Tier 2 imports entered as refined sugar and an additional 7% as specialty or organic products, meaning that roughly 41% of Tier 2 volume competed directly with domestic beet sugar without passing through the cane refining step. The compositional shift from Mexico (30% refined) to Tier 2 (41% refined) therefore places a disproportionate share of the import pressure on the refined beet segment, which accounts for about 55% of domestic sugar production.

Figure 13: ***U.S. Sugar Imports by Source: Raw and Refined Shares, FY2023–FY2025.***



Note: Bars show import volumes by source and product type. Percentage labels are calculated within each source-year category as the share of total imports accounted for by each product type.

Source: NDSU-ARPC using data from USDA ERS Sugar and Sweeteners Yearbook.

Applied to the sugar beet segment specifically, the implied revenue impact is substantial. At about 5.1 million STRV of beet sugar production, equivalent to 10.3 billion pounds annually and roughly 55% of the domestic total, the refined-market-adjusted price depression of 7 to 10 cents/lb implies annual revenue losses of about $0.7 billion to $1.0 billion for sugar beet producers during the core injury period of FY2025–FY2026. This beet-specific estimate represents the majority of the aggregate $0.9 to $1.5 billion revenue impact reported in Section 8.1, and is consistent with the broader finding that the compositional shift from Mexico to Tier 2 concentrates injury on the refined beet segment.

The price transmission analysis above focuses on the refined beet segment, which faces the most di-

rect competition from Tier 2 refined imports. However, the domestic sugarcane sector is also exposed to refined price effects. A substantial share of U.S. cane production is processed through integrated mill-refinery operations and sold at the wholesale refined price rather than the raw benchmark. To the extent that cane-segment revenue is realized at the refined level, the cointegration-adjusted price effect of 7 to 10 cents/lb would apply to that portion of cane output as well, implying cane-segment losses of approximately $0.6 billion to $0.8 billion rather than the $0.4 billion to $0.7 billion estimated at the ICE No. 16 level alone. Section 8.1 reports the revenue implications under both pricing assumptions.

8. Implications for Domestic Industry Financial Performance

8.1 Revenue Impact

At current U.S. production of approximately 9.3 million STRV, or 18.7 billion pounds annually, the estimated price depression of 5–8 cents/lb implies annual revenue losses to domestic producers of approximately $0.9 billion to $1.5 billion during the FY2025–FY2026 core injury period.

Disaggregating by segment and applying the corresponding price effects yields a more precise estimate of revenue losses. For sugar beet producers (approximately 5.1 million STRV, or 10.3 billion pounds annually), the cointegration-adjusted refined beet price effect of 7 to 10 cents/lb (Section 7) implies annual revenue losses of approximately $0.7 billion to $1.0 billion. For sugarcane producers (approximately 4.2 million STRV, or 8.4 billion pounds), the ICE No. 16 price effect of 5–8 cents/lb applies directly, implying annual revenue losses of approximately $0.4 billion to $0.7 billion. The disaggregated total of $1.1 billion to $1.7 billion exceeds the aggregate estimate of $0.9 to $1.5 billion because the aggregate calculation applied the ICE No. 16 effect uniformly to all production, understating the amplified injury to the refined beet segment. The aggregate central estimate therefore remains a conservative lower bound on total domestic industry losses. If the cointegration-adjusted refined price effect is also applied to the sugarcane segment, on the basis that raw cane sugar is ultimately refined and sold at the wholesale refined price through integrated mill-refinery operations, cane-segment losses rise to approximately $0.6 billion to $0.8 billion, and the disaggregated total increases to approximately $1.3 billion to $1.8 billion.

The appropriate revenue estimate depends on the level at which the injury is assessed. As shown in Table 1, **Row 1 ($0.9–1.5B) is the central estimate** cited in the Executive Summary and Conclusion, which applies the PE model's raw price effect uniformly and serves as a conservative lower bound. **Row 2 ($1.1–1.7B)** is the preferred aggregate estimate for industry-level discussion, which adjusts for the fact that sugar beet

producers sell refined product directly and therefore experience the amplified refined price effect documented in Section 7. **Row 3 ($1.3–1.8B)** is a refined-adjusted sensitivity that applies amplified raw-to-refined pass-through to both the beet and cane segments. Under this assumption, the implied industry-wide loss is $1.3 to $1.8 billion. All three estimates are reported because the domestic sugar industry spans multiple processing stages with different pricing structures.

Table 1: ***Annual Revenue Impact Sensitivity by Segment and Pricing Assumption, FY2025–FY2026.***

Pricing Assumption	Beet (10.3B lbs)	Cane (8.4B lbs)	Total
ICE No. 16 raw sugar uniform (5–8 cents/lb)	$0.5–0.8B	$0.4–0.7B	$0.9–1.5B
Beet refined-adjusted, cane at raw	$0.7–1.0B	$0.4–0.7B	$1.1–1.7B
Full refined pass-through (7–10 cents/lb)	$0.7–1.0B	$0.6–0.8B	$1.3–1.8B

Note: Beet price effects use the cointegration-adjusted refined pass-through, applying the 1.32 coefficient to the ICE No. 16 price effect. Full refined pass-through applies the same adjustment to cane, on the basis that raw cane sugar is refined before retail sale.

Source: NDSU-ARPC.

8.2 Observable Financial Indicators

Grower-level data are consistent with the modeled effects. Refined beet sugar spot prices have fallen to or below estimated breakeven costs, and cooperative grower payments have declined significantly. The number of operating U.S. sugar mills, refineries, and processing facilities has fallen substantially since 1996. Sugarbeet acreage has declined for three consecutive years to one of the lowest levels in more than four decades.

8.3 The Import Effect Relative to Other Factors

The estimated price effect operates independently of other factors contributing to industry distress. Input cost inflation affects producers globally, and the import price ceiling prevents domestic cost recovery. Hurricane damage is geographically limited to Florida and Louisiana. Freeze events, including the February 2026 Florida freeze that reduced cane production by 243,000 STRV in March WASDE, 2026, affect regional production but do not explain the nationwide pattern, because beet-producing states also face freeze risk. The modest decline in food deliveries over recent years is substantially smaller in magnitude than the Tier 2 import surge. Domestic production increases over the same period were modest and were

themselves a response to pre-existing price signals rather than an independent shock. The Tier 2 import channel is the largest identifiable source of the supply-demand imbalance that the PE model and S/U regression jointly identify as the primary driver of price depression.

8.4 Forward-Looking Conditions

The tariff environment that partially suppressed Tier 2 flows during FY2025 has changed substantially. The IEEPA tariffs have been invalidated, and the temporary Section 122 surcharge of 10% expires by late July 2026. After that date, the only remaining barrier to over-quota imports is the 15.36-cent specific tariff, which has lost approximately half of its real value to inflation. This is the same rate at which Tier 2 volumes surged from negligible levels to over 1.2 million STRV at their FY2024 peak. The underlying conditions documented in Section 2.6 have not changed. The FY2025 decline in Tier 2 volumes is more consistent with temporary tariff interventions than with a structural market correction. WASDE's most recent upward revision of projected Tier 2 imports, made within weeks of the ruling, is consistent with an import incentive that remains in place. The cumulative stock overhang from the FY2021–FY2024 surge continues to depress prices independently of current flows, and a renewed increase in over-quota volumes would compound the estimated effect on the domestic industry.

9. Conclusion

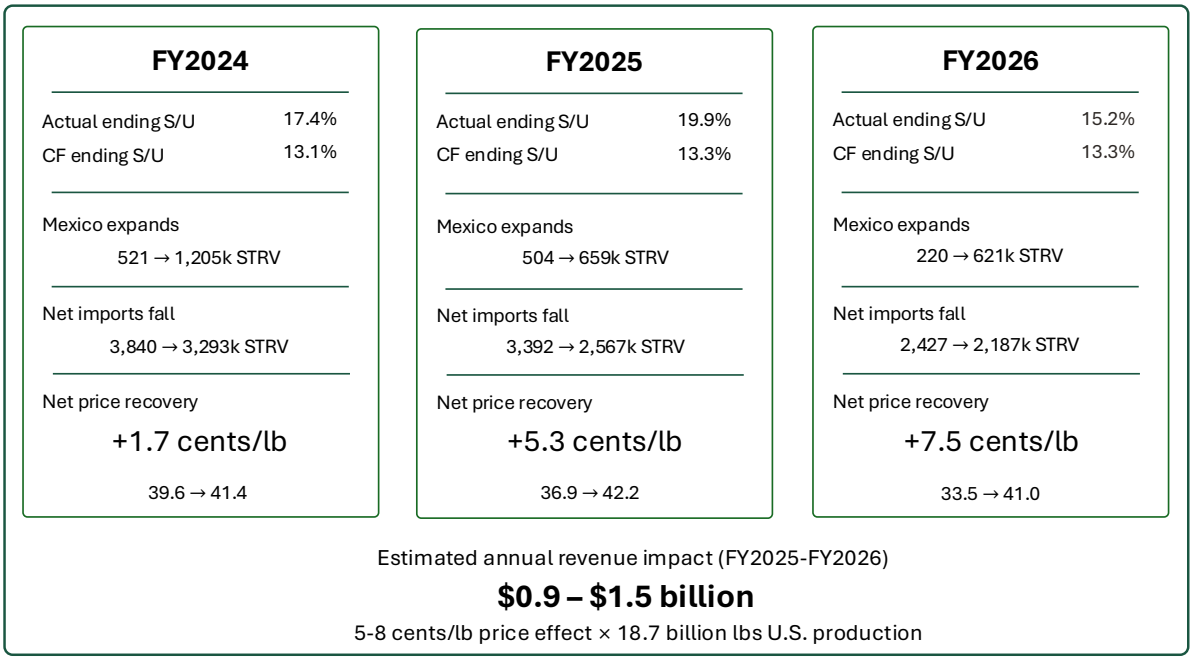
Two separate analytical methods indicate that over-quota sugar imports are associated with a depression in U.S. domestic raw sugar prices of approximately 5–8 cents/lb during FY2025–FY2026, the core injury window in which cumulative Tier 2 inflows generated the largest import displacement and stock overhang. The mechanism is a compositional shift in which administered residual supply from Mexico was displaced by arbitrage-driven Tier 2 supply that imposes a price ceiling on the domestic market. In that setting, the Needs Formula no longer stabilizes stocks around its 13.5% target in the way it was designed to do, and excess supply accumulates in inventories that weigh on prices. A dynamic extension further indicates that the elevated inventories currently suppressing prices are largely attributable to cumulative Tier 2 inflows during FY2021–FY2024. Across the static PE model, the stocks-to-use regression, and the stock-adjusted dynamic extension, the evidence points to the same qualitative conclusion and a similar order of magnitude for the price effect.

The economic implications for the domestic industry are substantial. Our central estimate implies annual revenue losses of $0.9–1.5 billion for domestic producers during FY2025–FY2026 (Figure 14). When the raw-to-refined pass-through is fully applied to both the beet and cane segments, the aggregate estimate rises to $1.3–1.8 billion, with the sugar beet segment absorbing the majority of the injury at an estimated $0.7–1.0 billion and the sugarcane segment at $0.6–0.8 billion.

Although the exact magnitude is subject to modeling uncertainty, that uncertainty does not alter the central result. The paper documents sensitivity to alternative elasticities and related assumptions in Appendices E and G. Across specifications, the sign of the effect remains stable, and the mechanism remains consistent with the institutional design of the Needs Formula and the observed stock buildup. The implied economic harm is robust to modeling assumptions.

Under the current tariff regime, and absent a substantial shift in world market conditions, the estimated revenue effects would continue to weigh on the financial performance of U.S. sugar mills, refineries, and processing facilities.

Figure 14: ***Estimated Effects of Removing Tier 2 Imports, FY2024–FY2026.***



Note: The figure reports the headline results from the static PE model for FY2024–FY2026.
Source: NDSU-ARPC.

Technical Appendix

A. Terminology and data conventions.

Throughout this paper, *Tier 2*, *over-quota*, and *high-tier* imports refer to the same channel, sugar entering at the HTS 1701.14 rate of 15.36 cents/lb above the WTO tariff-rate quota ceiling. We use *Tier 2* as the default term, inclusive of the small "other program" residual described above. *S/U* refers to the ending stocks-to-use ratio except where *beginning S/U* is specified. The *core injury window* refers to FY2025 and FY2026, when cumulative Tier 2 inflows had generated the largest stock overhang. The *counterfactual (CF)* is the no-Tier 2 scenario in which the Needs Formula recalculates Mexico's allocation; *static CF* is the single-period partial equilibrium result, *dynamic CF* adds stock propagation across years, and *organic-inelastic CF* excludes organic Tier 2 volume from the removal. All reported price effects are nominal cents/lb anchored to observed fiscal-year P_0 unless explicitly labeled *real*. Fiscal-year volumes are observed (USDA FAS and WASDE actuals) through FY2024, estimated for FY2025 based on the March 2026 WASDE with partial CBP actuals, and projected for FY2026–FY2027 using the USDA Agricultural Outlook Forum. Figures flag the observed/calibrated/projected boundary explicitly.

B. PE Model Structure and Calibration

The baseline model is a single-period, static partial equilibrium framework with three supply sources (domestic, TRQ, Mexico) and one demand function. Linear supply and demand curves are calibrated to pass through observed quantities at the observed price for each fiscal year.

Demand is given by

$$Q_D(P) = a_D + b_D \times P$$

with calibration based on a short-run demand elasticity of $e_D = -0.12$ (Elobeid and Beghin, 2006), reflecting the highly inelastic nature of U.S. sugar demand.

Domestic supply is given by

$$Q_S(P) = a_S + b_S \times P$$

calibrated using $e_S = +0.25$ (Elobeid and Beghin, 2006), representing the weighted aggregate response of beet and cane production.

Tier 2 import supply is given by

$$Q_{T2}(P) = a_{T2} + b_{T2} \times P$$

with $e_{T2} = +5.0$, reflecting the highly elastic nature of arbitrage-driven imports that respond strongly to the U.S.-world price spread. Tier 2 imports are present in the observed equilibrium but set to zero in the counterfactual. TRQ and program imports are fixed at observed levels because they are treaty-bound or administratively determined and therefore do not respond to price. Mexico is determined endogenously in the counterfactual through the Needs Formula (see Appendix C).

Calibration follows the standard elasticity relationship

$$e = \frac{dQ}{dP} \cdot \frac{P}{Q}$$

Under the linear specification, $dQ/dP = b$, so the slope is

$$b = e \cdot \frac{Q}{P}$$

and the intercept is

$$a = Q - bP$$

Thus, the elasticities enter the model through the calibrated slopes b_D, b_S, and b_{T2}.

The current equilibrium price with Tier 2 imports is

$$P_{\text{current}} = \frac{a_S + \text{TRQ} + \text{Mex} + a_{T2} - a_D}{b_D - b_S - b_{T2}}$$

The insulated counterfactual price without Tier 2 imports is

$$P_{\text{insulated}} = \frac{a_S + \text{TRQ} + \text{NF}_{\text{Mexico}} - a_D}{b_D - b_S}$$

The price effect equals $P_{\text{insulated}} - P_0$, where P_0 is the observed fiscal-year price. This P_0-anchored measure captures both the within-year flow displacement and the implicit stock overhang embedded in the observed price.

C. The Counterfactual: Needs Formula with Tier 2 = 0

The model mimics USDA's actual sequential administrative process rather than embedding the Needs Formula as a simultaneous equilibrium condition. The NF was designed as an administrative accounting rule applied to WASDE projections, not as a market-clearing mechanism.

The sequential approach proceeds in three steps:

First, USDA observes existing WASDE projections for production and demand. In the counterfactual, Tier 2 is set to zero and all other projections are initially unchanged.

Second, the Needs Formula recalculates Mexico's allocation by

$$\text{NF Mexico} = (1.135 \times Q_D - BS - Q_S - \text{TRQ}) \times 0.96$$

The 1.135 multiplier derives from the Suspension Agreement target of 13.5% ending S/U. The 96% fill rate reflects the historical average utilization rate, as Mexico filled between 88% and 100% of its NF allocation during FY2015–FY2023. Mexico does not always ship the full allocation due to logistics, stock management, and the stepped ratchet schedule.

Third, solve the PE model with domestic supply, TRQ, and the NF-derived Mexico allocation. The Tier 2 supply curve is absent. The insulated price clears the reduced-supply market:

$$P_{\text{insulated}} = \frac{a_S + \text{TRQ} + \text{NF}_{\text{Mexico}} - a_D}{b_D - b_S}$$

D. Stock-Adjusted Dynamic Extension

The static PE model is inherently one-period and therefore does not capture intertemporal stock dynamics. The dynamic extension decomposes the total price effect into two components:

$$\text{Total\_effect} = \text{Flow\_effect} + \text{Stock\_effect}$$

Flow effect is the within-year PE price impact, evaluated at counterfactual beginning stocks. It is defined as the difference between the insulated price, with the Needs Formula Mexico allocation recalculated

using counterfactual beginning stocks, and the model baseline price. The flow effect therefore captures the current-year supply displacement caused by Tier 2 imports.

Stock effect is the price impact of the accumulated inventory overhang, computed using the S/U regression coefficient applied to the difference between actual and counterfactual beginning S/U:

$$\text{Stock effect} = \left[P_{\text{reg}}(\text{CF beginning S/U}) - P_{\text{reg}}(\text{Actual beginning S/U})\right] \times \text{CPI} \times 100$$

where $P_{\text{reg}}(S/U) = a + b \times (1/SU)$ is the fitted regression relationship.

Counterfactual beginning stocks are propagated recursively over time. For FY2024, counterfactual beginning stocks are set equal to actual beginning stocks because the two series share a common starting point. For each subsequent year, counterfactual beginning stocks are given by the previous year's counterfactual ending stocks:

$$\text{CF ending stocks} = \text{CF beginning stocks} + \text{CF supply} - \text{total use}$$

$$\text{CF supply} = \text{production} + \text{TRQ} + \text{NF Mexico (at CF beginning stocks)}$$

At actual data, both the flow and stock components equal zero.

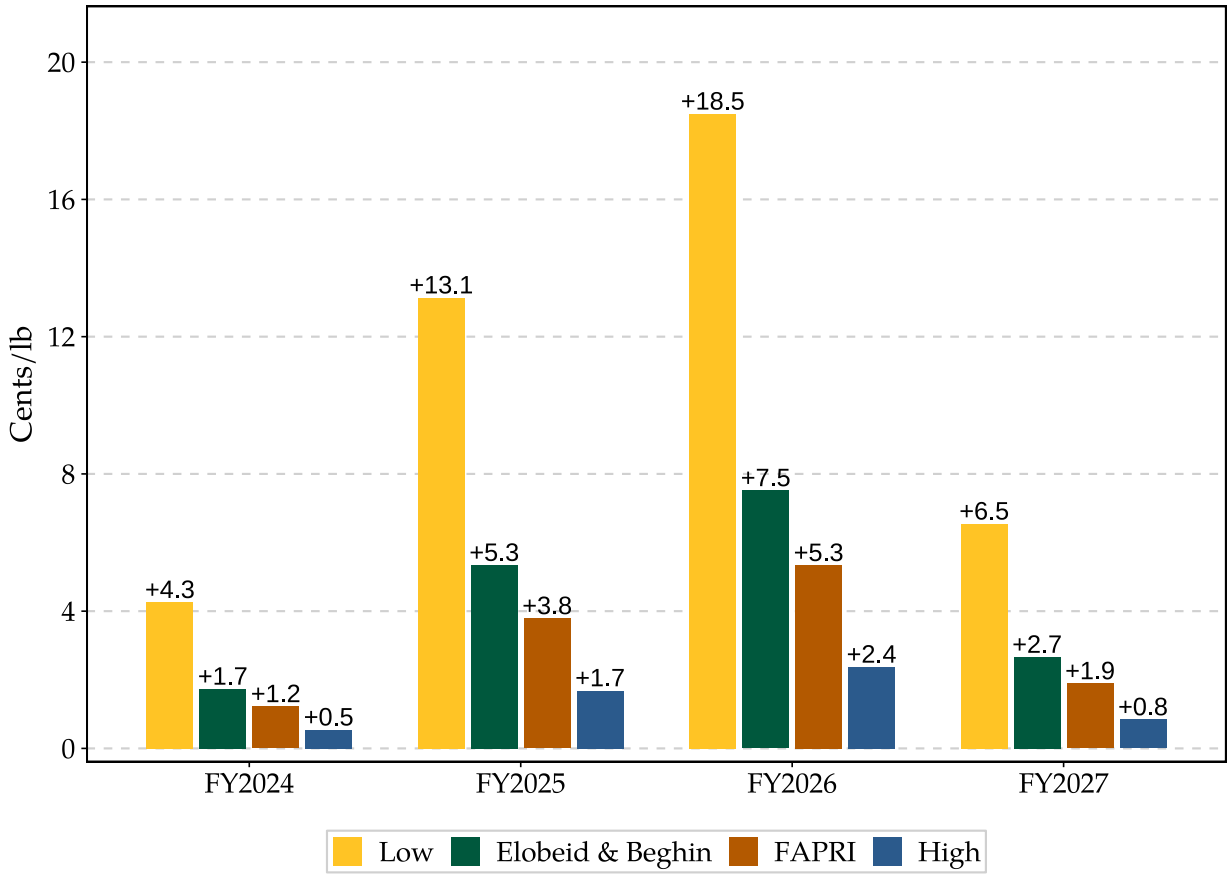
E. Elasticity Sensitivity Analysis

The demand and supply elasticities govern how much of the Tier 2 supply displacement is absorbed through quantity adjustment versus price adjustment. More inelastic markets require larger price movements to restore equilibrium, and more elastic markets adjust through quantities with smaller price changes. The sugar economics literature reflects broad consensus that U.S. sugar demand and supply are highly inelastic in the short run, and the range of empirically grounded estimates is narrow. This appendix documents the three specifications tested, their provenance, and the quantitative impact on results. In addition, Section G.4 reports a supplementary sensitivity check that replaces the baseline demand elasticity with the current FAPRI estimate. The price effects under alternative elasticities are shown in Figure 15.

Because the Needs Formula Mexico allocation is determined at P_0 using observed WASDE quantities (not model-derived equilibrium quantities), the elasticities do not affect the counterfactual supply composition. They affect only the slope of the domestic supply and demand curves and therefore only the equilibrium price computation. This is a deliberate design feature; the sensitivity analysis isolates the effect of

market responsiveness assumptions from the institutional mechanics of the Needs Formula.

Figure 15: ***Elasticity Sensitivity Analysis: Price Effects Under Alternative Elasticities.***



Note: All results are from the static PE model under alternative elasticity assumptions.

Source: NDSU-ARPC.

E.1 Baseline Elasticities: Elobeid and Beghin (2006) ($e_D = -0.12$, $e_S = 0.25$)

The central estimates in this paper use the Elobeid and Beghin (2006), econometrically estimated using annual data from 1980 to 2001, based on simple linear specifications estimated by ordinary least squares. The demand value of -0.12 is functionally equivalent to the FAO's independently reported U.S. sugar price elasticity of -0.11 (Food and Agriculture Organization of the United Nations, 2003). The supply value of 0.25 reflects aggregation across cane, beet, and refining margins and represents a short-to-intermediate-run adjustment horizon.

Several major welfare studies of U.S. sugar policy published since 2000 use the same or similar elasticity

values (Beghin et al. (2003), Beghin and Elobeid (2015), Sinclair and Countryman (2019), and Lewer and Parrish (2020)).

E.2 The Low Specification: Crop-Level Short-Run Estimates ($e_D = -0.05$, $e_S = 0.10$)

The most inelastic specification draws on Beghin et al. (2003), who established crop-level supply elasticities of 0.05 for sugarcane and 0.10 for sugar beet. The demand value of -0.05 is consistent with Lewer and Parrish (2020), who described it as "near the mean of the encountered range" in their literature review. Lewer and Parrish's supply elasticity is much higher, so our low specification combines their low-end demand assumption with crop-level short-run supply values from Beghin et al. (2003) rather than replicating their full parameter pair. The estimates in Beghin et al. (2003) were developed in work prepared for a 2000 government study of the sugar program.

This specification represents the most constrained short-run case. Sugarcane is a perennial crop with 3-5 year ratoon cycles, sugar beet operates on multi-year rotations with contracted acreage, and processing infrastructure requires massive fixed capital. Under these conditions, neither supply nor demand can adjust meaningfully within a single fiscal year, and the domestic price must absorb nearly the entire supply displacement. This amplifies price effects by approximately 2.5 times the Elobeid and Beghin (2006) baseline.

E.3 An Additional High-Elasticity Scenario from Earlier Literature

As an additional sensitivity check, we also report a high-elasticity specification based on earlier literature used in sugar policy simulations. This scenario is not recommended, but is included for comparison with a more responsive market environment. The parameter values are drawn from an earlier literature-based calibration. In particular, Schmitz and Lewis (2015) note that their "high" elasticity estimates were taken from Kennedy and Schmitz (2009), who in turn adapted a range of elasticities from previous studies, including Lopez (1989) and Lopez (1990), Tyers and Anderson (1992), Gardiner et al. (1989), and Uri and Boyd (1994).

The demand value of -0.60 implies a much more elastic demand response, so a larger share of the market adjustment occurs through quantities rather than prices. The supply value of 0.50 implies a multi-year horizon in which acreage and processing capacity can fully adjust, an assumption inconsistent with the single-fiscal-year static framework employed in this analysis.

For that reason, we place less weight on this specification, but report it for transparency and completeness. Its implied adjustment horizons are inconsistent with the model's static within-year structure, and the values substantially exceed the consensus range of empirically estimated short-run elasticities. The specification is nonetheless informative in one important respect. Even under these maximally elastic assumptions, the price effect of Tier 2 removal remains positive in every fiscal year examined (+0.5 to +2.4 cents/lb in FY2024–FY2026). The direction of the finding is robust to even an extreme departure from the empirical consensus.

E.4 Sensitivity Results

Table 2 reports P_0-anchored price effects and implied annual revenue impacts. The Elobeid and Beghin (2006) baseline and Low specification, which together span the empirically grounded short-run parameter space, are the primary results. An additional specification using the current FAPRI demand elasticity of -0.246 (FAPRI, 2026), estimated on the FY2016 to FY2025 period, produces price effects of +3.8 to +5.3 cents/lb for FY2025-FY2026. This more elastic demand specification reduces the price effects relative to the Elobeid and Beghin (2006) baseline, but the direction and order of magnitude of the finding remain unchanged.

For completeness, the long-run specification from earlier literature ($e_D = -0.60$, $e_S = 0.50$) produces price effects of +0.54 (FY2024), +1.68 (FY2025), +2.37 (FY2026), and +0.84 (FY2027) cents/lb. As discussed in Section G.3, these values reflect a constructed robustness test using long-run adjustment horizons that are methodologically inconsistent with the single-fiscal-year static PE framework. They are not included in the primary results but confirm sign robustness. The Elobeid and Beghin (2006) baseline remains the appropriate central case for short-run trade policy analysis, and the central results of this paper are anchored to that specification.

F. Stocks-to-Use Regression

Following Good and Irwin (2015), we estimate the following reciprocal specification

$$P_{\text{real}} = a + b \times \frac{1}{\text{beginning S/U}}$$

where P_{real} is the CPI-deflated ICE No. 16 price ($/lb, expressed in FY2011 dollars), and beginning S/U is the beginning stocks-to-use ratio expressed in percentage points. The estimation sample covers the

Table 2: ***Elasticity Sensitivity Analysis: PE Model Results.***

	FY2024	FY2025	FY2026	FY2027
P_0-Anchored Price Effect (cents/lb)				
Low ($e_D = -0.05$, $e_S = 0.10$)	+4.26	+13.13	+18.49	+6.54
Baseline ($e_D = -0.12$, $e_S = 0.25$)	+1.73	+5.34	+7.52	+2.66
High ($e_D = -0.60$, $e_S = 0.50$)	+0.54	+1.68	+2.37	+0.84
FAPRI ($e_D = -0.246$, $e_S = 0.25$)	+1.22	+3.79	+5.34	+1.89
Revenue Impact ($B/year)				
Low (most inelastic)	$0.79	$2.47	$3.43	$1.21
Baseline (Elobeid-Beghin)	$0.32	$1.00	$1.40	$0.49
High (from earlier literature)	$0.10	$0.32	$0.44	$0.16
FAPRI	$0.23	$0.71	$0.99	$0.35
Insulated Price (cents/lb)				
Low (most inelastic)	43.90	50.04	51.97	43.54
Baseline (Elobeid-Beghin)	41.38	42.24	41.00	39.66
High (from earlier literature)	40.19	38.59	35.86	37.84
FAPRI	40.87	40.69	38.82	38.89
Observed P_0 (ICE No. 16)	*39.65*	*36.90*	*33.48*	*37.00*
NF Mexico Allocation (k STRV)				
All scenarios	1,205	659	621	983
Mexico actual	*521*	*504*	*220*	*529*

Note: NF Mexico allocation is identical across elasticity scenarios because it is calculated from observed WASDE quantities.

Source: NDSU-ARPC.

period from FY2012 to FY2022, yielding 11 pre-surge observations. Beginning S/U is used because it is predetermined at the start of the fiscal year and is therefore more plausibly exogenous to within-year price formation. This does not fully eliminate endogeneity, since storage arbitrage can create intertemporal linkages across years, but it is a practical and defensible choice given the limited sample size and available data structure.

Table 3: ***Stocks-To-Use Regression Results.***

	No Controls	World Price	Time Trend
Intercept (a)	0.044 (0.058)	0.037 (0.057)	0.042 (0.060)
Reciprocal S/U (b)	3.277*** (0.849)	2.764** (0.953)	3.193*** (0.892)
ICE No. 11	—	0.259 (0.230)	—
Time trend	—	—	0.001 (0.002)
N	11	11	11
R^2	0.624	0.675	0.640

Note: *** $p < 0.01$, ** $p < 0.05$. Standard errors are in parentheses. The dependent variable is CPI-deflated ICE No. 16 ($/lb).

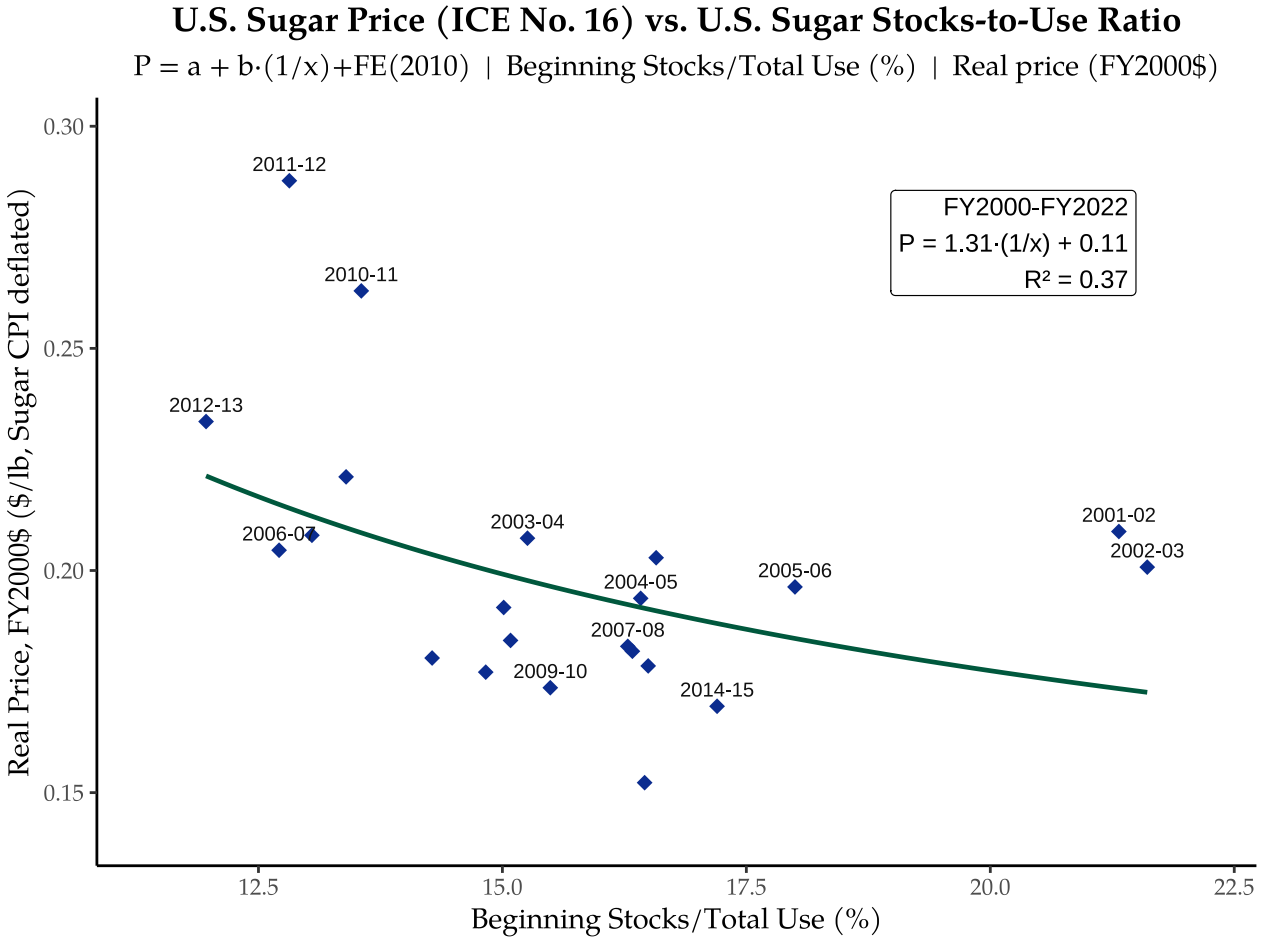
Source: NDSU-ARPC estimates using USDA ERS data, FY2012–FY2022.

The reciprocal coefficient of 3.28 implies that a one-percentage-point increase in $1/SU$ raises real prices by approximately 3.3 cents/lb. The world price control enters a positive but statistically insignificant coefficient ($p = 0.30$), which is consistent with the insulated-market, and the time trend is essentially zero.

Using $b = 3.2774$, we compute counterfactual prices as the difference between the predicted price at the actual beginning S/U and at the 13.5% target beginning S/U, which is the level that would have prevailed if the Needs Formula had maintained its target. Real effects are converted to nominal cents using a CPI ratio of approximately 1.25 (FY2025 dollars / FY2012 dollars). The counterfactual prices estimated by the regression represent the price levels that would obtain if the Tier 2 channel were closed. This would require a tariff adjustment sufficient to restore the prohibitive margin. Under the current 15.36-cent rate, the arbitrage ceiling (world price plus duty plus transport) would prevent full domestic price recovery even if stocks tightened to the 13.5% target, because the same spread that attracted Tier 2 entry would continue to cap prices from above.

As a robustness check, we re-estimated the S/U regression using the full sample from FY2000 to FY2022

Figure 16: ***ICE No. 16 Prices and Beginning Stocks-To-Use Ratios, FY2000–FY2022: Robustness Check.***



Note: Each point represents a fiscal year from FY2000 to FY2022. The curve shows the fitted reciprocal relationship between the real ICE No. 16 price and the beginning S/U ratio in the longer-sample robustness check with fixed effects.

Source: NDSU-ARPC using data from USDA ERS Sugar and Sweeteners Yearbook.

and included a fixed effect for FY2010 to absorb the unusually large Tier 2 import spike in that year. Under this specification, the estimated relationship between price and beginning S/U remains negative and statistically significant. However, the estimated price response becomes smaller, with the coefficient declining to 1.31, and overall model fit is weaker, with an R^2 of 0.37. The specification from FY2012 to FY2022 is preferred because it better captures the policy and market conditions relevant for current projections. The pre-2014 period reflects a structurally different regime, including the absence of Suspension Agreements, the NAFTA transition, and different TRQ administration. Pooling those earlier observations with the modern period introduces a structural break that weakens the fit without adding much policy-relevant information for current projections. In addition, several high-S/U observations from the early 2000s do not follow the price-S/U relationship observed in the more recent period. However, the full-

sample regression still yields a negative and statistically significant relationship, confirming that the sign is robust even though the latter sample remains the more appropriate specification for the main analysis. A supplemental scatter plot for the full-sample specification is provided in Figure 16.

G. Caveats

The model treats sugar as a homogeneous good. Cointegration analysis shows a long-run price transmission coefficient of 1.32 from raw sugar prices to refined beet sugar prices, suggesting that the central ICE No. 16 price effects may understate the impact on the refined beet segment by approximately 32%. A fully disaggregated raw-refined PE specification with separate market-clearing equations for each stage would likely produce larger estimated effects on the refined beet segment, which absorbs the majority of refined Tier 2 competition, and represents a natural extension of this work.

Beginning stocks are excluded from the static PE market-clearing equation, although this is addressed by the dynamic extension. The regression also involves some extrapolation at FY2025–FY2026 S/U levels above the estimation range. In addition, the CCC nonrecourse loan rate is not modeled as a price floor. At FY2026 observed prices, the refined beet rate is within the proximity of the loan forfeiture trigger, indicating that import-driven price depression has brought the market to the CCC loan forfeiture threshold.

H. Raw-Refined Price Transmission Analysis

This appendix presents the cointegration and error correction model results summarized in Section 7. Data are monthly ICE No. 16 and Midwest refined beet spot prices from the USDA ERS Sugar and Sweeteners Yearbook.

Unit root tests. Augmented Dickey-Fuller tests on the post-2008 subsample (January 2009 to February 2026, $n = 202$) confirm both series are I(1), with ICE No. 16 in levels ($\tau = -2.28$, non-stationary) and in first differences ($\tau = -10.22$, stationary). Midwest refined beet in levels ($\tau = -2.18$, non-stationary) and in first differences ($\tau = -9.47$, stationary). Lag selection by AIC.

Engle-Granger cointegration test. The long-run regression $P_{\text{beet}} = \alpha + \beta \times P_{\text{ICE No. 16}}$ yields $\alpha = 1.087$ (se $= 2.212$) and $\beta = 1.323$ (se $= 0.072$) with $R^2 = 0.631$. The ADF test on residuals rejects the null of no cointegration ($\tau = -4.058$, 5% Engle-Granger critical value ≈ -3.34 for $n \approx 200$).

Error correction model. The ECM specification

$$\begin{aligned}\Delta\text{Beet}_t &= \alpha + \gamma\,\text{ECT}_{t-1} + \delta_0\,\Delta\text{ICE16}_t \\ &\quad + \phi_1\,\Delta\text{Beet}_{t-1} + \phi_2\,\Delta\text{Beet}_{t-2} + \theta_1\,\Delta\text{ICE16}_{t-1} + \theta_2\,\Delta\text{ICE16}_{t-2} + u_t\end{aligned}$$

yields a speed-of-adjustment coefficient $\gamma = -0.11$ (se $= 0.051$, $t = -2.16$, $p < 0.05$). This implies that roughly 11 percent of the deviation from long-run equilibrium is corrected each month, corresponding to a half-life of adjustment of about 5.9 months. The first lag of changes in ICE No. 16 prices is positive and statistically significant ($\theta_1 = 0.279$, se $= 0.09$, $t = 3.026$, $p < 0.01$), suggesting that short-run pass-through occurs with a delay rather than immediately within the same month. The low R^2 (0.115) is consistent with gradual price adjustment in a market where contracts and pricing practices introduce transmission lags.

Tier 2 import composition. ERS Monthly Sugar Import Data reports the following high-tier import composition for FY2025 (metric tons, commercial weight), with raw 496,151 (59%), refined 285,385 (34%), and specialty/organic 59,900 (7%). Under the Suspension Agreements, Mexico's exports are constrained to at most 30% refined (polarity $\geq$ 99.2°) and at least 70% "Other Sugar". The higher refined share in Tier 2 (41% including specialty) relative to Mexico (30%) implies that the shift concentrates injury disproportionately on the refined beet segment.

References

Beghin, John C., Barry El Osta, Jay R. Cherlow, and Samarendu Mohanty (2003). *The Cost of the U.S. Sugar Program Revisited*. Contemporary Economic Policy 21(1): 106–116.

Beghin, John C. and Amani Elobeid (2015). *The Impact of the U.S. Sugar Program Redux*. Applied Economic Perspectives and Policy 37(1): 1–33.

Elobeid, Amani and John C. Beghin (2006). *Multilateral Trade and Agricultural Policy Reforms in Sugar Markets*. Journal of Agricultural Economics 57(1): 23–48.

Food and Agriculture Organization of the United Nations (2003). *Sugar*. *Agricultural Commodities: Profiles and Relevant WTO Negotiating Issues*. Rome: FAO.

Gardiner, Walter H., Vernon O. Roningen, and Karen Liu (1989). *Elasticities in the Trade Liberalization Database*. Tech. rep. Staff Report No. AGES 89-20. Economic Research Service, U.S. Department of Agriculture.

Good, Darrel and Scott Irwin (2015). *The Relationship Between Stocks-to-Use and Corn Prices Revisited*. farmdoc daily 5(65).

Kennedy, P. Lynn and Andrew Schmitz (2009). *Production Response to Increased Imports: The Case of U.S. Sugar*. Journal of Agricultural and Applied Economics 41(3): 777–789.

Lewer, Joshua J. and Kyle Parrish (2020). *The Welfare Effects of the U.S. Sugar Program*. Southwestern Economic Review 47(1): 23–36.

Lopez, Rigoberto A. (1989). *Political Economy of U.S. Sugar Policies*. American Journal of Agricultural Economics 71(1): 20–31.

Lopez, Rigoberto A. (1990). *Economic Surpluses in the U.S. Sugar Market*. Northeastern Journal of Agricultural and Resource Economics 19(1): 28–36.

Schmitz, Troy G. and Karen E. Lewis (2015). *Impact of NAFTA on U.S. and Mexican Sugar Markets*. Journal of Agricultural and Resource Economics 40(3): 387–404.

Sinclair, Alex J. and Amanda M. Countryman (2019). *Not So Sweet: Economic Implications of Restricting U.S. Sugar Imports from Mexico*. Journal of Agricultural and Applied Economics 51: 368–384.

Suarez, Nydia R. (1997). *Origin of the U.S. Sugar Import Tariff-Rate Quota Shares*. Sugar and Sweetener SSS-221. Economic Research Service, U.S. Department of Agriculture.

Tyers, Rodney and Kym Anderson (1992). *Disarray in World Food Markets: A Quantitative Assessment*. Cambridge University Press.

Uri, Noel D. and Roy Boyd (1994). *The Impact of the Tariff-Rate Quota on Sugar Imports on the U.S. Economy*. Journal of Economic Studies 21(1): 16–40.

U.S. International Trade Commission (2001). *Industry and Trade Summary: Sugar*. Tech. rep. USITC Publication 3405. U.S. International Trade Commission.

Recommended Citation Format

Shawn Arita, Ming Wang, and Sandro Steinbach (2026). *Quantifying the Price Effects of Over-Quota Sugar Imports on the U.S. Domestic Market*. ARPC White Paper 2026–07. Agricultural Risk Policy Center, North Dakota State University.

Disclaimer

This ARPC White Paper is intended to inform discussion of agricultural policy and risk management. The analysis and conclusions are those of the authors and do not necessarily represent the views of the Agricultural Risk Policy Center at North Dakota State University, or any funding or partner institutions. All errors and omissions are the responsibility of the authors. This report is provided for informational and educational purposes only and does not constitute legal, financial, or policy advice. Readers should rely on their own professional judgment and consult additional data sources and qualified experts before making policy, legal, or business decisions.

About the Agricultural Risk Policy Center

The Agricultural Risk Policy Center at North Dakota State University conducts independent, evidence-based economic research to inform agricultural policy and strengthen the farm safety net. Our work focuses on evaluating risk management tools such as crop insurance and disaster assistance, analyzing market disruptions, and providing timely insights that support agricultural producers, policymakers, and industry leaders.

Strengthening the U.S. Farm Safety Net with Evidence-based Policy Insights.

Contact Us

arpc@ndsu.edu

www.ndsu.edu/agriculture/arpc

Richard H. Barry Hall 400, Fargo, ND

https://www.linkedin.com/company/ndsu-agricultural-risk-policy-center

NDSU AGRICULTURAL RISK POLICY CENTER