Reversing Deep Integration: The Case of US-Mexico Corn Trade

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Introduction

Mexico is one of the oldest and strongest trading partners of the US. Through trade partnerships such as the North American Free Trade Agreement (NAFTA) and the more recent United States-Mexico-Canada Agreement (USMCA), intraregional trade flows have been bolstered (Conner 2023). As the Mexican beef sector grows, US export-oriented agriculture, especially corn, has found increasing shares destined for Mexico. However, the integration of US and Mexico agricultural markets that have lowered costs and fostered specialization represents a risk from changing policy agendas.

In 2018, Andrés Manuel López Obrador won the Mexican presidential election ushering in a new agenda for trade and agriculture. In late 2020, President Lopez-Obrador of Mexico signed a decree banning genetically modified (GM) corn and the use of herbicide glyphosate in the production of food for consumption. Concordant with that decree, Mexico's agricultural ministry has identified a domestic agenda that calls for a 30-40% reduction in corn imports and an increase in domestic production (Beaumont-Smith 2023).

In a sobering realization of Mexico's dependency on imported US corn, the executive decree has been modified multiple times, pushing back its effective date and narrowing the definition of GM corn in the human food system. Though the ban is not currently expected to be applied to corn intended for animal feed and industrial use (Reuters, 2023), the most recent Mexican decree, February 13, 2023, calls for banning the use of biotechnology corn in tortillas or dough and for the gradual substitution of biotechnology corn in all products for human consumption and for animal feed (USTR, 2023).

The US is one of the world's largest exporters of corn commanding roughly 30% of the global corn market, virtually all of which is some variety of biologically modified. Mexico has become the top destination for US corn exports in the past two decades. In 2022, the USDA recorded that 15.4 million metric tons went to Mexico, accounting for 26.6% of total exported volume (USDA FAS GATS, 2023). Imported corn is mainly utilized in the growing beef industries to be used as feed. Current beef production levels have left Mexico dependent on imported US GM corn. The sizeable volume of GM corn trade makes shifting Mexican trade policy a worry for US corn producers. US farm organizations believe that the decree threatens to reverse intraregional integration in the agricultural sectors while undermining global efforts to encourage innovation, sustainability and national security. The ban runs contrary to the newly implemented USMCA. In efforts to salvage the USMCA and general integrated trade between Mexico and US agriculture, the United States trade representatives requested a trade dispute panel under the USMCA in August 2023 (Beaumont-Smith 2023).

Background

Recent work published in the AJAE has already quantitatively examined the potential effects of Mexico's GM ban, showing the costs are ultimately borne on Mexican households (Beckman *et al.*, 2024). Beckman's work utilizes a computable general equilibrium (CGE) model with land movement restrictions that better reflect reality, noting that land competition would emerge as the largest obstacle. Beckman *et al.* (2024) finds that Mexico would decrease corn imports by 40% and increase domestic production by 65%, a change that would employ an additional 3.3 million hectares of land to corn production. This drastic shock to the grain market would cause the estimated Mexican price of corn to increase by 24% and related agricultural products to increase by 6%. These price increases ultimately cause average Mexican household expenses on food to increase anywhere from 6.7-13.9%. Other studies have further shown how the US and Mexican corn sectors have changed since the transition to free trade under the North American Free Trade Agreement (NAFTA), particularly how US sourced imports allow for an expansion in consumption in Mexico (Zahniser, 2019).

While Beckman *et al.* (2024) focus on Mexican welfare and capacity to replace imported corn, others have considered the broader impact on the US and global corn markets. Sheldon (2023) finds that the ban could disproportionately affect US producers in different states. Heterogeneity in Mexico's corn imports show that some states, such as Illinois, send 70% of exported corn to Mexico while other corn producing states such as Ohio send virtually none (Sheldon, 2023). In the long run, if the dispute is not settled, this could drive down prices across the US and introduce considerable regulatory uncertainty, undermining the stable operation of commodity markets.

Economic analysis by the World Perspectives group (WPI) found significant economic damages that echo that of other studies, additionally, they project a loss in 138,000 Mexican jobs and a GDP contraction of $4.3B over 10 years. Specific to US welfare, WPI finds a loss of $4.99B to the US GM corn producers offset by $1,43B gains in the non-GM corn sectors resulting in a $3.56B net loss in the US farm sector in the first year of the ban.

Though current, the US-Mexico GM corn trade dispute is not unique. Ever since the adoption of biological engineering in agriculture, many have been skeptical of application and imported products due to concerns over domestic producer incomes, culinary heritage, and human health (Food policy paper cite). This hesitancy over GM imports has been the subject of many studies over the last three decades.

Research has shown that even under modest restrictions, the increased costs of labeling, traceability, and certification of GM imports create supply-side distortions (Vigani and Olper, 2012). As GM adoption has increased and policies have diverged, methods for indexing relative openness to GM trade have been developed to summarize policy differences by country showing that increases in GM restrictiveness result in lost export revenue (Addey, 2021).

Computable general equilibrium models have already proven to be valuable in assessing questions regarding GM commodity trade. Mahaffey, Taheripour, and Tyner use a CGE model to highlight the contributions of GM trade to both economic efficiency and sustainability. Modeling two scenarios of banned GM trade and increased GM trade, Mahaffey et al. show that GM integration in trade increases trade volumes and decreases prices among trade partners resulting in increased welfare measures across the economy of up to $9.75B. The US is disproportionately affected by bans of GM trade as the US is the largest producer of GM commodities such as corn, soybenas, and cotton. Notably, Mahaffey et al. found that banning GM trade increases land use in crop production causing deforestation and increased greenhouse gas emissions of nearly a billion tons. As the global agenda moves towards sustainability goals, divergence in individual countries trade policy regarding GM imports can pose a threat to sustainability cooperation.

Our approach employs a computable general equilibrium (CGE) model with scenarios that ban GM corn imports to Mexico as was done in Beckman et al. Our work is differentiated by the focus on a) examining the potential US policy response to reduce corn exports to Mexico and b) examining the contribution to global corn market inefficiency caused by both the Mexican import protection and the likely US subsidy response. We outline our model and data approach in the next section.

Model Description

The starting point for our analysis is the standard GTAP model (Corong *et al.* 2017) and database (Aguiar *et al.* 2023). The GTAP database consists of more than sixty production sectors (with associated commodity outputs) and one hundred countries. The full database is typically aggregated to create sector and region composites that allow the modeler to focus on commodities and regions of policy interest. The aggregation we use for the current analysis is presented in table Aggreg1, showing that we have reduced the database size to 11 regions and 18 commodities (in addition to the five primary factors).

Table Aggreg1. Model primary factors, regions, and commodities

GTAP Set	List of components
Endowments (5)	Land, Unskilled labor, Skilled labor, Capital, Natural resources
Regions (11)	USA. Mexico, Canada, China, India, Japan, UK, EU, Argentina, Brazil, Rest of world (ROW)
Commodities (18)	Rice, Wheat, Grains, Fruit & Vegetables, Oilseeds, Sugarcane, Plant fibers (cotton), Crops nec, Livestock, Extraction industries, Meat & dairy, Vegetable oils, Processed rice, Sugar, Other foods, Beverage and tobacco, Manufacturing, Services

The regional aggregation is motivated by the need to isolate the US and Mexico for the primary policy incidence. Additional regions are maintained for major corn export and import regions. In terms of commodities, we maintain primary agricultural (i.e. farm) sectors as they exist in the database as well as the food processing sectors that use these farm products as intermediates. The need for this level of sector detail is to be able to capture the price effects of sluggish land demand moving in and out of corn production in US and Mexico as well as the cost of production changes that will occur moving toward the retail end of the supply chain.

We actually modify the parameters of the production structure of GTAP (v7) relative to the standard version published in Corong *et al.* (2017). Figure ProdStr1 demonstrates the nested CES production structure where the percentage change of output in a sector **qo**, is a CES aggregate of two composite inputs representing purchased intermediates and the primary factors comprising value-added. The two sub-production functions that make the composite inputs are defined in quantity terms by percentage change variables **qva** and **qfa**. The substitution possibilities in value-added, purchased intermediates, and for sector output are respectively determined by the CES substitution elasticities *ESUBVA*, *ESUBC*, and *ESUBT*.

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                              qo(a,r)
                               /\
                              /  \  <----- CES[ESUBT]
                             /    \
                            /      \
                           /        \
                     qva(a,r)     qint(a,r)
                       /|\            |
CES[ESUBVA]-----> /  |  \           |  <------ CES[ESUBC]
                   /   |   \          |
                  /    |    \         |
                 /     |     \        |
             Land   Labor  Capital  qfa(c,a,r)
                qfe(e,a,r)
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Figure ProdStr1. Production tree structure in GTAP v7

Keeney and Hertel (2005)'s specialized version of the GTAP adopted the setup in ProdStr1 for agricultural sectors for analysis of WTO disciplines on domestic support, and we follow the parameterization they used whereby six regional parameter sets are mapped onto the countries of an aggregation for factor supply and substitution elasticities. The values in table Param1 give the Allen partial elasticities of substitution (APES) that correspond to each level of the production function and are used to calibrate the CES substitution parameters identified in the previous paragraph. We use the Keller formulae (equation 1, see Corong *et al.* 2017) to calibrate CES parameters from APES values where $\sigma^C_{a,r}$ is the CES elasticity at level C (purchased inputs) of the CES nest, $\delta^C_{a,r}$ is the cost share of the composite inputs at level C, $\alpha_r$is the appropriate APES for region (and level) from table Param1, and finally $\sigma^T_{a,r}$ is the CES elasticity at level T (top of the CES tree).

$$\sigma_{a,r}^{C} = \delta_{a,r}^{C}\left[\alpha_r + \left(\frac{\sigma_{a,r}^{T}}{\delta_{a,r}^{C}} - 1\right)\right] \quad (1)$$

The rows of table Param1 give the six groups of parameters from Keeney and Hertel (2005) as well as how they map to regions given in table Aggreg1. Note that the parameters in table Param1 are set to ½ of the size of those reported for the GTAP-AGR documentation. This is because we are trying to capture short to medium run adjustment – corresponding to our focus on removing ½ of estimated GMO corn imports from Mexico (see subsequent section). Restricting the supply response across regions forces most of the short-run adjustment into shifting land among crops and changing trade flows. A common critique of CGE models (and GTAP) historically had been the inattention to agricultural supply response at the time Keeney and Hertel (2005) was written. Subsequent work on the "biofuel boom" following Keeney and Hertel (2009) highlighted the importance of these parameters for understanding the incidence of biofuel policies in terms of prices and land use change (Beckman *et al.* 2011).

Table Param1. Key agricultural production parameters by region "group"

Region (group)	APES Top	APES Primary	APES Purchased
Group 1 (USA)	0.40	0.08	0.15
Group 2 (Mexico)	0.45	0.05	0.05
Group 3 (Canada)	0.25	0.08	0.25
Group 4 (S. America)	0.25	0.25	0.20
Group 5 (Asia)	0.25	0.15	0.15
Group 6 (ROW)	0.25	0.08	0.25

Our approach differs from that of Beckman *et al.* (2024) because our focus is not specific to the costs for Mexican consumers but the global corn market impacts of Mexico's GMO ban and anticipated domestic support increases in the US. Those authors use the GTAP-AEZ model as their mechanism for controlling Mexican corn expansion following the ban and find strong price impacts with significant negative welfare impacts for Mexican households. Our approach to parameterization is informed by the Beckman *et al.* (2024) modeling as well as other recent investigations into US and Mexico trade issues as were evident during the renegotiation of NAFTA to create the USMCA trade agreement for North America.

Scenario Discussion

We follow previous CGE examinations of trade volume restrictions (bans or quotas) by shocking the quantity of trade along a bilateral trade route. This variable is normally endogenous, so we must change the model closure so that the *ad valorem* tax variable (the associated bilateral tariff) in the model is free to adjust to solve for market prices that will produce the desired quantity result. This approach has been used in North American agricultural trade by Chepeliev *et al.* (2018) and Beckman *et al.* (2024) using versions of the GTAP model.

Chepeliev *et al*. (2018) calculated their shocks using estimated changes to quotas anticipated from negotiated modalities of the USMCA trade agreement created to replace NAFTA. Beckman *et al*. (2024) implement a complete ban on GMO corn into Mexico, using reference data on corn production from major importers and estimates of those national supplies that are comprised of GMO product. Their calculated reductions of corn imports into Mexico are proportional to the amount of GMO corn produced.

We take this same direct approach to modeling a ban on Mexican imports of GMO corn from its trading partners starting from the Beckman *et al*. (2024) calculated shares of GMO corn in total production for the US (93%), Argentina (90%), Brazil (90%), and Canda (98%). Their scenario is elaborated for 2014 (the database year they use). We are using the GTAP database version 11 with 2017 as a base year (Aguiar *et* al. 2022) and we have elected not to separate corn from the remainder of grains in defining production activities in our model[1]. This means that we modify the shocks from Beckman *et al*. (2024) using the calculated share from US and other exporter production data to identify the share of corn in total grain production.

Table ScenCalc1. Calculation of shocks from source information for Mexican GMO ban

Region	Value share of GMO in total corn (Col 1)	Value share of corn in grain (Col 2)	Share of GMO corn in grain (Col 3 = Col 1 x Col 2)	Shock to implement Mexican GMO ban (Col 4 = 0.5 x Col 3)
US	93%	95%	89%	44%
Canada	98%	61%	60%	30%
Argentina	90%	85%	76%	38%
Brazil	90%	95%	86%	43%

Table ScenCalc1 reports our calculation of shocks to implement the GMO ban in Mexico. The first column is Beckman *et al*.'s (2024) reported shock level. In column two we report the 2019 value share of all corn in total grain production. The third column represents the product of the first two columns, giving us the estimated share of GMO corn within all grain production of the selected grain export regions. Finally, we calculate one-half of the shares in column 3,

[1] We did use the Horridge's SplitComm utility (2008) to estimate a split corn and other grains version of the database for 2017 using estimated export shares and domestic production totals from USDA sources as was done in Beckman et al. (2024). Our findings indicate that the utility can replicate the relative trade shares quite accurately but that the resulting domestic production sectors are a poor fit to published data. Given our interest in examining an alternative scenario where the US "responds" to the Mexican GMO ban with a subsidy to producers having a suspect domestic sector split would complicate our scenario design and subsequently the findings of the follow-on effects of US efforts to compensate grain producers.

as our scenario is targeted to a reduction of one-half of the GMO imports of corn into Mexico, representing a partial or first phase ban[2].

We report results from two separate scenarios, each of which incorporates the shocks to Mexican corn imports reported in table ScenCalc1. The first or "base" scenario only includes the quantity shocks included in the table, with an endogenous bilateral tariff (**tms** in the GTAP model) being allowed to adjust to capture the price effect and quota rents from the restricted trade. In our second "alternative" scenario, we add to the "base" scenario by imposing a constant farm sector returns condition in the United States. Specifically, we endogenize an output subsidy variable (**to** in the GTAP model) and exogenize the returns to farm factors in the corn sector (**pva** in the GTAP model). Our selectin of the value-added returns is consistent with past trade policy events. Specifically, our approach mirrors the trade aid delivered to farmers to replace lost income when China imposed retaliatory tariffs on US soybeans as part of the "trade war" of 2018-2020 (CRS 2019). In the results section that follows

<u>Results</u>

Our primary shock in both the base and alternative scenarios is to reduce imports of grans into Mexico. The basic trade results for the US and Mexico as well as an aggregated rest of the world (ROW) are reported in the top section of Table Result1. The values in the table are volumes of trade measured in millions of US dollars (2017). The column for Mexico reports the exogenous shock that reduces US exports to Mexico of grain by $1.3 billion. Additional minor reductions from other GMO corn exporters are subsumed in the ROW value which on net indicates a net export of grains into Mexico (i.e. either non-GMO corn imports or non-corn grains to replace lost domestic production).

Following the lost exports to Mexico from the GMO restriction we see the US with a small net expansion of grain exports to other countries. Mexico has two main channels to replace lost imports from the US – expansion and concurrently exporting less grain outside the country. The middle column representing imports in Mexico remains the same in the middle section of the table when we shift focus to our alternative scenario in which the US counters the GMO ban with new subsidies to grain producers (see previous section). The subsidy is expansionary for grain production, with increased production of US grains for export to other countries of 961 million US$. This expansion of US exports displaces trade among the third country set (not US or Mexico), with a loss of 421 million US$ in grain trade between those countries. The bottom section of table Result1 summarizes the differences in grain trade effects of the Mexican GMO ban and the GMO ban followed by US grain subsidies.

[2] We tested several scenarios for a complete ban and found that a one-shot comparative static analysis did not produce sufficient data accuracy. With our primary interest being the 2-3 year run our focus on a partial shock is consistent with the immediate adjustment of barring GMO imports and the agricultural production changes in Mexico are consistent with what Beckman *et al.* (2024) indicate is possible in terms of expanded Mexican production.

Table Result1. Bilateral grain trade select results, volume of trade ($mn)

Exporter (row)/ Importer (col)	Base experiment, Mexico bans GMO grain imports		
	USA	Mexico	Other countries
USA	0	-1287	84
Mexico	-6	0	-182
Other countries	-2	41	88
	Alternative scenario, US subsidizes grain production losses		
	USA	Mexico	Other countries
USA	0	-1287	961
Mexico	-7	0	-185
Other countries	-73	41	-421
	Difference (Alternative scenario – Base scenario)		
	USA	Mexico	Other countries
USA	0	0	877
Mexico	-1	0	-3
Other countries	-71	0	-509

In table Result2, we see that the alternative scenario where the US responds with production subsidies to grain producers is expansionary only relative to the base scenario of a GMO ban in Mexico. Specifically, we see the base scenario indicates a two percent reduction in grain output for the US becomes effectively zero when the US responds with a subsidy designed to insulate US producers from the GMO ban. The table gives grain output changes (percent change and volume) for all of the regions of the model including the large increase in domestic Mexican production required when the shocks representing the GMO corn ban are imposed. In both the base and alternative scenarios, Mexican grain output increase by nearly twenty-four percent.

Focusing on the base scenario, we see a series of minor output changes in grains across third countries with only Brazil's total production declining. It is here we most clearly see the deep integration of the US and Mexico and particularly how it has evolved in trade of corn. Breakdown in that integration primarily burdens the US and Mexico, with Mexico having to disrupt its domestic production and the US having to contract corn production. When the US responds to Mexico's action by maintaining its domestic corn sector, we begin to see the knock-on effects into other countries more dramatically. Production in all countries falls as the US becomes a relatively cheap exporter outside of Mexico with large corn exporters like Brazil, Argentina, and Canada having one to two percent reductions in output. Among the ROW collection of countries, the small expansion (less than +0.5 percent) in grain production in the base scenario turns to a small reduction (more than -0.5 percent).

The changes in grain production in table Result2 represent shifts in agricultural production in both the US and Mexico. The effects in the US are relatively minor as we see the lost grain exports lead to small expansions in other sectors, mostly to use resources released from reduced grain production. The story in the US is primarily demand driven so we see only a modest difference in US production of other agricultural commodities under either scenario. Promoting grain production with a subsidy replaces lost exports to Mexico by displacing other trade in global grain markets effectively holding production at pre-GMO ban levels.

Table Result2. Grain output changes by region for both scenarios

Region	Base scenario (Mexico partial ban of GMO corn)		Alternative scenario (GMO ban plus US subsidy response)	
	%change	Volume (US $mn)	%change	Volume (US $mn)
USA	-1.93	-1183	0.00	1
Mexico	24.19	1437	23.91	1421
Canada	0.15	6	-1.86	-78
China	0.02	11	-0.12	-85
India	0.03	3	-0.05	-5
Japan	-0.08	0	-2.52	-9
UK	0.05	1	-0.14	-2
EU	0.11	26	-0.32	-76
Argentina	0.28	16	-0.94	-55
Brazil	-0.07	-14	-0.85	-174
ROW	0.21	176	-0.36	-294

The results in Mexico are more dramatic, with resources required from across all agriculture required to expand production of grains to meet domestic demands with no GMO imports of corn. As with the US, the scenarios present little difference as both the base and alternative scenarios "break" the deep integration of US and Mexico agriculture via corn trade. The largest reductions in Mexican agricultural commodity output are in oilseeds, wheat, cereals, and wheat. Reductions in the livestock sector are at one percent as the demand drivers from exports and domestic meat production are a primary cause of the expansion of Mexican domestic grain production.

Table Result3. Agricultural production changes, US & Mexico (%changes)

Agricultural sector	United States		Mexico	
	Base scenario (GMO ban)	Alt scenario (+US subsidy)	Base scenario (GMO ban)	Alt scenario (+US subsidy)
Rice	0.06	0.01	-2.31	-2.27
Wheat	-0.14	-0.22	-2.81	-2.80
Grains	-1.93	0.00	24.19	23.91
Veg & Fruit	0.20	0.18	-1.47	-1.39
Oilseeds	0.03	0.00	-3.60	-3.54
Sugarcane	0.02	0.08	-0.51	-0.51
Cotton	0.07	0.02	-1.18	-1.15
Cereals (nec)	0.15	0.10	-2.41	-2.38
Livestock	0.05	0.12	-1.09	-1.10

Table Result4. Basic prices for agricultural commodities, US & Mexico (%changes)

Agricultural sector	United States		Mexico	
	Base scenario (GMO ban)	Alt scenario (+US subsidy)	Base scenario (GMO ban)	Alt scenario (+US subsidy)
Rice	-0.01	0.03	0.17	0.18
Wheat	-0.04	-0.01	-0.15	-0.16
Grains	-0.25	-6.59	18.44	18.19
Veg & Fruit	0.02	0.09	0.62	0.66
Oilseeds	-0.03	0.03	-0.57	-0.55
Sugarcane	-0.06	0.08	1.58	1.56
Cotton	-0.01	0.02	1.03	1.03
Cereals (nec)	0.00	0.10	0.61	0.60
Livestock	0.02	-0.05	0.32	0.29

Moving from the domestic supply of grains in US and Mexico to market prices we see relatively small results outside of the grains markets. For the US the Mexican GMO ban causes a slight drop (-0.25 percent) in the market price for corn. In Mexico, the domestic price for grains soars by more than eighteen percent – as the cost of production spikes following the dramatic reorganization of Mexican agriculture. As we saw with grain output in table Result3, the results for prices are little affected by the add-on response of a US subsidy to grain producers. The one difference is the lower market price for grains that leads to the US being a more competitive exporter consistent with the results we saw in table Result2. The negative 6.5 percent affect on market price for grains is effectively the subsidy level applied to producers since the subsidy level is set to maintain producer returns in grain production. There are small increases in market prices in the US across other commodities owing to the production factor price increases when grain producers bid up those prices.

Our final look to US and Mexico agricultural impacts following the two implemented scenarios are the changes in land use (percentage change) by sector in table Result5. Mexico requires an increase of more than ten percent of land in grain production in either scenario. For the US, the small reduction of land demand by grain producers (-0.66 percent) under the GMO ban scenario is effectively eliminated when the subsidy replacing farm returns for gran producers is put in place. The small increase in land demands for other sectors under the GMO ban are reversed in sign to small reductions for field crops when the US subsidy implementation occurs in our alternative scenario.

The final empirical results we present are the equivalent variation measures in US million dollars as reported in table Result6. We report decomposed results separated into allocative efficiency, terms of trade, and the total national welfare effect. It is here we wee that exacerbating effect of the US following the trade ban with its own distortionary subsidy to grain producers. The lowered market price for US grains as well as the output expansion of a subsidized sector effectively triples the welfare cost of the breakdown in US-Mexico integration. As we've seen with other instances of trade protections against US agricultural exports the US is willing to pay to maintain farm incomes so even at nearing $0.5 billion dollars in additional lost welfare the result doesn't stand as prohibitive for a country with extensive domestic support to its small agricultural sector like the US.

Table Result5. Land demands by agricultural sector, US & Mexico (%change)

Agricultural sector	United States		Mexico	
	Base scenario (GMO ban)	Alt scenario (+US subsidy)	Base scenario (GMO ban)	Alt scenario (+US subsidy)
Rice	0.12	-0.03	-2.63	-2.60
Wheat	0.04	-0.12	-2.89	-2.87
Grains	-0.66	-0.08	10.36	10.25
Veg & Fruit	0.18	0.05	-2.21	-2.16
Oilseeds	0.10	-0.03	-3.29	-3.24
Sugarcane	0.09	0.01	-1.69	-1.67
Cotton	0.12	-0.03	-2.04	-2.01
Cereals (nec)	0.15	0.03	-2.63	-2.60
Livestock	0.11	0.05	-2.20	-2.19

Table Result6. Welfare decomposition, US & Mexico ($US mn)

Region	Base Expt. (Mexico GMO Ban)			Altern. Expt. (US grain subsidies)		
	Allocat. Eff.	Terms of Trade	EV Total	Allocat. Eff.	Terms of Trade	EV Total
USA	53	-332	-278	-145	-720	-866
Mexico	-1085	230	-855	-1116	376	-740
Canada	27	100	127	22	74	96
China	-31	-49	-80	8	-7	1
India	-10	-29	-39	-3	-28	-30
Japan	-10	-23	-33	2	192	193
UK	-3	-13	-16	-4	-12	-15
EU	-22	-47	-70	-20	-63	-83
Argentina	4	21	25	-3	-32	-34
Brazil	12	26	39	2	-31	-29
ROW	-60	116	56	-43	251	208

In Mexico, the terms of trade of cheaper US exports (recall the countries still trade extensively) reverses some of the welfare losses in Mexico of the GMO ban. Those terms of trade effects of subsidized (lower) US grain prices show up across agricultural importers of US products like Japan, Canada and ROW in table Result6. Competing grain exporters like Argentina and Brazil see their terms of trade welfare costs reversed as the US price causes a dip in the world trade price of global grains trade. Even though the scenarios are primarily a terms of trade story, the allocative effects are significant in the US and Mexico. The US actually experiences a small allocative gain in the base scenario as production of a subsidized sector declines slightly. This is reversed when output expands alongside the subsidy rate in the alternative scenario. Mexico's allocative effect increases only slightly with the overall effect still being the expanded production to replace lost imports is inefficient relative to the status quo when the US and Mexico were highly integrated in grains via extensive specialized corn trade.

Conclusion

We have examined the impacts of a GMO corn ban in Mexico and the likely follow-on response by the United States of subsidizing corn production. The ban in Mexico is disruptive. The North American corn market is deeply integrated with Mexico dependent on US imports and Mexico becoming a critical destination for excess US corn supplies. Moving from this deep integration is costly in Mexico and the United States. For Mexico, outputs across all of agriculture need to be curtailed (as well as exports) to compensate for lost imports. This increases the price of corn in Mexico significantly and increases rental rates on land. The lost market for the US leads to reduced output, lower returns in US corn (and other agriculture), and lower world prices.

When we add the US farm policy response to subsidize corn producers for lost farm income the major add-on effect is to export the disruption of North American integration to the rest of the world. Subsidized US output is nearly identical to that before the Mexican GMO ban in our scenario and replaces exports around the world. The effects are relatively mild (owing to the small share of agriculture and isolating on corn) but the changes are clear – the GMO ban is welfare reducing and US responses exacerbates these losses.

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