

Consumer Price Impacts of Mexican Restrictions on GM Corn: An Economic Analysis

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19 September 2022

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List of Abbreviations

CGF – corn gluten feed
CGM – corn gluten meal
Crys. Fruc. – crystalline fructose
DDGS – dried distillers' grains with solubles
FAO – Food and Agriculture Organization of the United Nations
FCR - feed conversion ratio
GDP – Gross Domestic Product
Ha - hectare
HFCS – high fructose corn syrup
IP – Identity preservation/identity preserved
MT – metric ton(s)
MMT – million metric tons
ROW – rest of the world
TMT – Thousand metric tons
UN – United Nations
USDA – U.S. Department of Agriculture
WPI – World Perspectives, Inc.

I. Executive Summary

This updated study on Mexico's announced ban on genetically modified (GM) corn considers the complicated impacts of recent changes in the global corn markets, including the war in Ukraine. It also focuses more intently on specific impacts, such as the implications for Mexican consumers. Lacking explicit legal clarification, the 31 December 2020 Presidential Decree is interpreted in this study to result in a ban on all GM corn imports.

Because North America produces more than a third of the world's corn and most of it is GM varieties, the impacts of Mexico's planned ban on GM corn would be felt deeply and broadly. The following summarized impacts are not all inclusive but provide a general sense of the more complex implications found inside this report.

Impacts on U.S.

Economy: Over the 10-year forecast period, the Mexican ban on GM corn would cause the U.S. economy to lose \$73.89 billion in economic output, and Gross Domestic Product (GDP) would contract by \$30.55 billion over 10 years. Additionally, the U.S. would lose 32,217 jobs annually with labor income falling \$18.38 billion.

Corn Farming: The net economic loss in the first year of the ban to the U.S. corn industry is \$3.56 billion, followed by an additional \$5.56 billion loss in the second year. Cumulatively over the 10-year forecast period, the industry would experience a \$13.61 billion economic loss.

Corn Wet Milling: The U.S. corn wet milling industry would suffer \$7.65 billion in losses over the 10-year forecast period.

Ethanol: The U.S. ethanol industry (including DDGS) would incur a net loss of \$521.5 million after accounting for gains from lower GM corn prices.

Transportation: Transportation linkages (rail, trucking, shipping) on both sides of the border would contract. The U.S. rail industry alone would lose \$3.33 billion in economic output over 10-years.

Impacts on Canada

Corn Sector: The North American corn industry is closely linked, and Canada's corn sector would lose \$33.94 million in farm revenue over 10 years.

Economy: The broader impacts of changes in the corn sector would cause the Canadian economy to lose \$92.85 million in economic output over the 10-year forecast period.

Impacts on Mexico

Economy: Mexico's GDP would fall by \$11.72 billion over 10 years, and economic output would be reduced by \$19.39 billion. There would be an annual loss of 56,958 jobs, which would reduce labor income by \$2.99 billion.

Cost-Benefit: In the first year of the ban, non-GM corn prices would rise 48 percent to \$8.14/bushel and, assuming supplies can be found, Mexico would pay an additional \$571 million for imported corn. Overall, the cost of non-GM corn will rise 19 percent over the 10-year forecast period. The GM corn ban may be intended to assist corn farms, but its impact on food prices would adversely impact most of the Mexican population, especially the nearly half the population (55.7 million people) considered to be living in poverty.

Inflation: The GM corn ban would increase the cost of corn by an average of 19 percent over the 10-year forecast period. This would inflate the cost of most foods and other goods utilized by Mexicans. Additionally, \$1.056 billion in costs related to grain segregation, identity preservation, and genetic testing of imports would be passed along to Mexican consumers.

Livestock Sector: Due to a 13.7 percent increase in feed costs, the cost of producing animal protein would rise. In particular, poultry meat prices would rise by 66.7 percent. For Mexico's poorest populations, prices may rise to the point that eggs become a luxury item. The result is a contraction of the livestock sector as Mexican consumers choose imported animal protein products produced more cheaply using GM corn.

Impact on Health: Mexican intake of protein has improved but is still below that of other North Americans and remains below the daily recommended levels for good health. The GM corn ban would raise the cost of protein, lowering its intake and presenting a special risk to pregnant and lactating women. Corn is also used in the manufacture of pharmaceuticals, which could introduce uncertainties affecting their availability and cost.

Impacts on Food Security: More than 10 percent of the Mexican population lacks access to adequate food. This number doubles or triples in the nine poorest Mexican states, mostly in the south. The lowest income decile spends 52 percent of their funds on food with corn and corn-derived products representing a significant share of calories. The price of corn is the single largest indicator of access to food for this segment of the population and the price of basic foods would rise significantly.

Impacts on Food Safety: Three-quarters of processed foods utilize the starch, protein, fiber, or oil from corn to make them safer, more nutritious, tasteful, more durable, and more affordable. Processing foods also provides consumers with greater variety and increased food security. Corn is heavily used in processed foods because it has a long shelf life and is relatively inexpensive. Its use in food processing fundamentally enables the feeding of the masses affordably, deliciously, abundantly, and conveniently. The GM corn ban could disrupt the supply of these ingredients essential to food processing, and thus reduce the availability or increase prices of processed foods.

Conveniences: Corn is used in hundreds of industrial products, from construction to medicines to textiles, to make them more affordable, sustainable, biodegradable, etc. Higher corn prices will be felt across a broad swath of non-food products.

Liability: The legal risks to the Mexican corn value chain must be calculated by professional insurance risk managers using sophisticated actuarial statistical methods.

International Impacts

Opportunity Costs: Just as biotechnology is seeing a broader global uptake and new breeding techniques are in the offing, Mexico's GM ban would have long-term adverse impacts on future innovation as the development of new genetic traits becomes stifled. This includes the ability to sustainably increase production and make crops more resilient to the environmental stressors caused by climate change.

Environmental Impacts: Non-GM crop production forgoes the benefits of higher yields and reduced land use in addition to lower chemical applications and no-till practices that protect soils and lower carbon emissions.

II. Introduction

In March 2022 and on behalf of Crop Life International (CLI), World Perspectives, Inc. (WPI) completed an economic analysis of the likely impacts from the Mexican government's proposed policy of banning genetically modified (GM) corn. The study, *The Economic Impacts of a Mexican Ban on GM Corn Imports (World Perspectives, Inc., 2022)*, found significant economic damages could occur due to Mexico's proposed policy and the resulting trade disruptions. Notably, the Mexican economy was projected to lose 138,000 jobs across the nation and suffer a GDP contraction of \$4.3 billion over a 10-year period.

While the study for Crop Life International was conducted with the best data and projections available, world grain markets changed dramatically after the study's release. Specifically, the Russian invasion of Ukraine and the resulting suspension of Ukrainian grain and agricultural product exports created significant increases in world commodity prices. Moreover, drought in parts of South America, North Africa, and North America further reduced commodity supplies and exacerbated price gains. The effect of this shift in the world commodity outlook was that the numbers and outlook presented in the March 2022 Crop Life International study no longer reflected the new, smaller supply, higher price economic environment. It is crucial to note, however, that the conclusions in the Crop Life International study are neither "wrong" nor invalid. Rather, their creation under the assumptions of a larger supply, lower price environment means they represent the lower bound of the impacts that could occur if Mexico bans GM corn.

Considering the changes to world commodity markets, WPI was asked to update the analysis originally presented in the Crop Life International study to align key assumptions and findings with grain market realities. For example, the original Crop Life International study assumed Ukraine would be a significant non-GM corn supplier to Mexico, an assumption that needed reexamination given the Russian invasion. Beyond updating the Crop Life International study, WPI was asked to more thoroughly examine the impacts of Mexico's proposed policy on Mexican consumers. Corn-derived products, particularly those from the corn wet milling process, are widely used in the industrial and consumer industries, with the latter including both foods and pharmaceuticals. Consequently, this study not only updates the analysis of the supply, demand, and price changes, but expands examination of how consumer prices, product availability, and food security could shift under a Mexican ban on GM corn.

Crucially, this study and its predecessor are independent works that are not directly comparable. Both use equally valid data, methods, and approaches to factually answer specific questions. Differences in results exist due to the highly dynamic nature of commodity markets and the associated long-term outlooks, as well as shifts in macroeconomic trends, such as inflation and energy prices. Again, it must be noted that one study is not "better" or "worse" than the other. Rather, they are equally valid analyses of the probable impacts during contrasting "lower price" or "higher price" commodity environments.

This study makes four key assumptions that form the foundation for much of the analysis presented herein.

- 1. Mexico's ban applies to feed and food imports:** As noted in the introduction, since issuing its decree in late 2020, Mexico has not offered clarifying guidance on which classes of corn or corn-derived products would be subject to the proposed ban. Considering this, the ban is assumed to apply to all corn imports from all countries, whether it be for feed or human food use. Additionally, the proposed policy is assumed to apply to GM corn-derived products, including dried distillers' grains with solubles (DDGS, a common livestock feed ingredient), corn starch and sweeteners, and other derivative products.
- 2. The grain industry does not adjust to accommodate the ban before its effective date:** The consequences of Mexico's proposed policy change would exert sufficiently large costs on both the U.S. and Mexican grain systems that neither would adjust operations and incur the associated costs before the ban becomes clearly effective. This assumption is supported from conversations with industry members who indicate that the costs of preparing in advance for a GM corn ban are too great should it be postponed or altered. This has the effect

of magnifying the “suddenness” of the shock as lack of advanced preparation means the marketplace would have to scramble to make the adjustments *ex post*.

3. **Farmers in the U.S. and abroad cannot alter planting decisions in the first year:** Due to the timing of the policy’s expected implementation, farmers in the U.S. and other major corn-producing countries would be largely unable to adjust acreage in response to price changes for non-GM and GM corn. Certainly, in the Southern Hemisphere, where corn would already be seeded¹ by the policy’s proposed 1 January 2024 implementation date, there is no opportunity to alter production of what’s already growing. In the U.S., farmers may have some limited ability to switch, but non-GM crop planting intentions are generally solidified in November or December when seed contracts are signed. Additionally, the U.S. seed industry would have limited non-GM corn seed supplies and would be unable to accommodate any significant demand shift. Consequently, this study assumes that farmers have no ability to alter production and supplies in the first year of a ban on GM corn imports.
4. **There are no significant adverse weather impacts of sudden demand shocks:** Long-term weather predictions and their impact on crop yields and farmer decision making remain suspect at best. There exists, to WPI’s knowledge, no reliable method of predicting when or where droughts, floods, or abnormal temperatures would occur more than a few months in advance. Consequently, most crop forecasting models, including those used in this study, rely on the assumption of “normal” weather patterns and trendline² yield forecasts. Similarly, this study assumes there is no sudden change in corn demand other than that created by Mexico’s proposed policy. While these assumptions simplify the modeling process, they underestimate the disruptive impact of adverse weather or sudden demand changes on global commodity trade and pricing. As detailed later in this report, Mexico’s proposed policy change makes the country more reliant on a “niche” product (non-GM corn) that is highly susceptible to supply chain shocks. While not explicitly modeled in this study, a drought in the early years of Mexico’s pending policy shift would severely disrupt the fledgling non-GM corn market and force non-GM prices higher than currently predicted. That would exacerbate the impacts on Mexico’s economy, its consumers, and prices for major commodities and consumer products. As such, this study can be viewed as a best-case analysis of the impacts that would occur.

To examine impacts of Mexico’s policy in light of recent changes to the U.S., Mexican, and world corn balance sheets, WPI relied upon multiple analytical and econometric methods. First, WPI’s proprietary, dynamic supply and demand models were used in conjunction with U.S. Department of Agriculture’s (USDA) long-term international outlook data to create both baseline (i.e., without Mexico’s decree) and post-GM-ban market outlooks. Specifically, 10-year projections were made for corn supply, demand, and prices for the U.S., Mexico, Canada, and select countries around the world (e.g., Ukraine and Brazil) both with and without the impacts of Mexico’s GM corn ban. Following that, IMPLAN economic input-output models were used to examine the economic “ripple effects” of how the policy change would affect industries across North America. Finally, WPI used proprietary models, desk research, and various regression techniques to estimate³ the impact of Mexico’s policy on consumer prices and Mexico’s food security outlook.

Briefly, this study finds that the sudden shift to non-GM corn imports by Mexico would cause non-GM corn prices to increase sharply, peaking at 42 percent above baseline values. Conversely, GM corn prices would fall 10 percent over three years following the ban and these price changes would fundamentally alter crop acreage and the U.S. grain handling system. As the shock ripples through the U.S. economy, this study finds that GDP would contract by \$30.55 billion, and \$73.89 billion in economic output would be lost.

¹ Except for the Brazilian *safrinha* corn crop, which is typically planted in February. Even so, farmers would have little time to sell back GM corn seed and secure non-GM varieties, if sufficient non-GM supplies even exist.

² Trendline yield forecast are those created by using simple regressions that help account for gradual yield improvements over time, including yield benefits from using hybrid or GM seeds.

³ For details on the models and analytical approaches used in this study, please see [Appendix A – Data and Methods](#) on page 47 of this report.

The impacts are not limited to the U.S., however, and Mexico would feel the effects of a policy change to non-GM corn. Over the 10-year forecast period, higher non-GM corn prices mean Mexico would pay \$9.73 billion more to import corn than it would otherwise, an increase of 19 percent over baseline forecasts. Additionally, tortilla prices would increase sharply, peaking at 30 percent above baseline forecasts and averaging 16 percent higher over 10 years. Additionally, the Mexican livestock sector would see feed costs increase by 13.7 percent, on average, which would cause the industry to contract by 1.2 percent annually. The total impacts of added costs for consumers, costs to import grain, and the contraction in the livestock sector mean that a policy banning GM corn would cost Mexico's economy 56,958 jobs annually, create a contraction in GDP of \$11.72 billion and reduce economic output by \$19.39 billion over 10 years. This study also finds that a shift towards exclusive non-GM corn use in Mexico would have secondary and tertiary impacts on the environment, human health, and the food security of Mexican consumers. Further details are provided in the following chapters.

Noting that Mexico could yet clarify or amend the details of its announced policy, analyses of two alternative scenarios was also conducted. Specifically, examining the impacts of a policy where GM corn is permitted for livestock feed but not human or industrial uses, non-GM corn prices rise by 9.5 percent with Mexico paying \$291.99 million to import 3.7 MMT more of non-GM corn compared to the baseline level. Secondly, a scenario whereby Mexico's policy permits GM corn for use in livestock feed and industrial uses finds that non-GM corn prices rise by 11-14 cents over 10 years and Mexico would pay \$36.6 million in added costs, or 0.38 percent of the additional \$9.73 billion costs predicted in a full-GM corn ban scenario.

There are some limitations of this study that must be addressed. First, this study makes no attempt to identify or quantify the likely retaliatory response(s) against Mexican exports should Mexico pursue its stated policy. Mexico's policy goal would violate its USMCA obligations and may elicit a retaliatory response by the U.S. and Canada. Such actions would create additional negative impacts on the Mexican economy, though these are not quantified in this research. Second, this study assumes farmers and participants in the grain value chain make decisions in purely economically rational terms. There are, however, factors outside pure economics that drive producer and firm decision making that may alter the responses expected in this study. For example, farmers may be reluctant to adopt non-GM or organic production practices due to concerns about having "weedy" fields. Additionally, there may be incentives and efficiencies gained by maintaining GM production practices that are not modeled in this study (for example, maintaining seed supplier relationships if a seed supplier does not choose to supply non-GM seed). These potential actions certainly influence the real-world reactions should Mexico pursue a non-GM corn policy, but they are omitted for the purposes of this study and our analysis focuses on examining purely financially motivated decisions.

III. Background

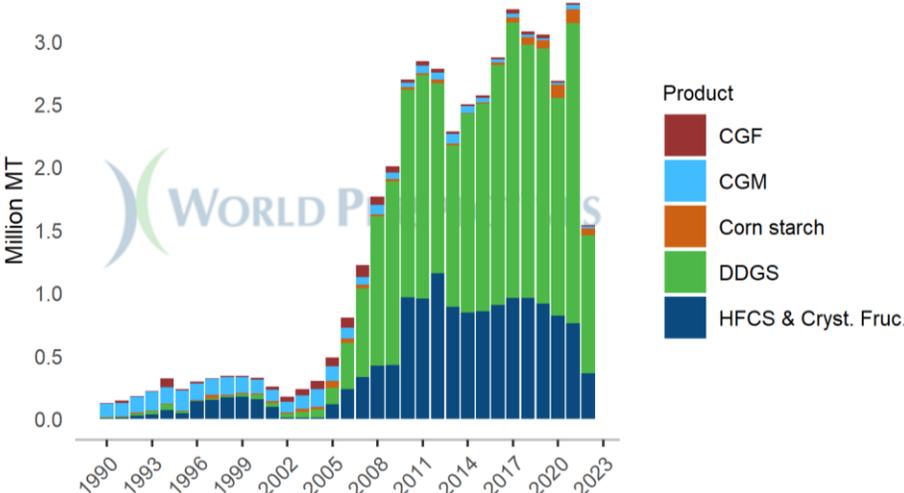
The day of 31 December 2020 marked a significant shift in Mexico’s agriculture and trade policy. On that date, Mexico’s government issued a decree expressing a policy goal to gradually phase out glyphosate and GM corn use in the country. Since then, however, there has been little consistency from Mexican officials and courts as to how or when the policy would be implemented. Some senior Mexican officials have at various times indicated the ban would not apply to animal feed. Moreover, the Mexican government still lacks a process and has yet specified how GM and non-GM corn imports would be segregated, tested, or otherwise differentiated. Finally, and perhaps most importantly for consumers, clarification on how GM corn-derived products (including meat, corn-based food ingredients, pharmaceutical and industrial products) will be handled is still pending.

As noted in the Crop Life International study, Mexico’s decree is a significant shift in the country’s trade policy and food security strategy. The policy would impact not only the Mexican economy, but also the U.S. and Canadian economies and grain handling systems. Its impacts will create significant shifts in world corn trade flows. Mexico’s policy would effectively act as a trade protectionist measure and contribute no value-creation along the corn value chain. The latter point is important as without value creation to offset the policy’s costs, grain handling and processing firms will have to absorb the costs themselves or pass them along to consumers. As U.S. and Canadian retaliation against imports from Mexico would be highly speculative, this analysis makes no attempt to quantify the effects of potential retaliation.

Mexico and the U.S. will both see significant changes in their respective corn and feed markets due to the size and historic importance of corn trade between the two countries. From 2018 through 2020, Mexico was the largest export market for U.S. corn and accounted for nearly 30 percent of U.S. corn exports. Due to changes in its internal corn market, China overtook Mexico as the largest buyer of U.S. corn in 2021, but Mexico’s corn imports from the U.S. still increased 16 percent to 16.9 MMT. For additional context, Mexico’s 2021 corn imports represented 4.4 percent of the U.S. 2021/22 crop and exceeded the production of the U.S.’ eighth largest corn producing state, Ohio.

In addition to corn, the U.S. exports significant volumes of corn products to Mexico, including DDGS, corn starches, and sweeteners. Trade in these products expanded significantly following the 1994 North American Free Trade Agreement (NAFTA). Moreover, the expansion of the U.S. ethanol industry in the mid-2000’s created robust supplies of DDGS that could be shipped to Mexican livestock feeders. In 2021, the U.S. shipped 3.3 MMT of corn-derived products (excluding consumer-oriented products) to Mexico (Figure 1).

Figure 1: U.S. Annual Corn Product Exports to Mexico



Source: USDA FAS, World Perspectives.
 Note that 2022 volumes are year-to-date.

IV. Results

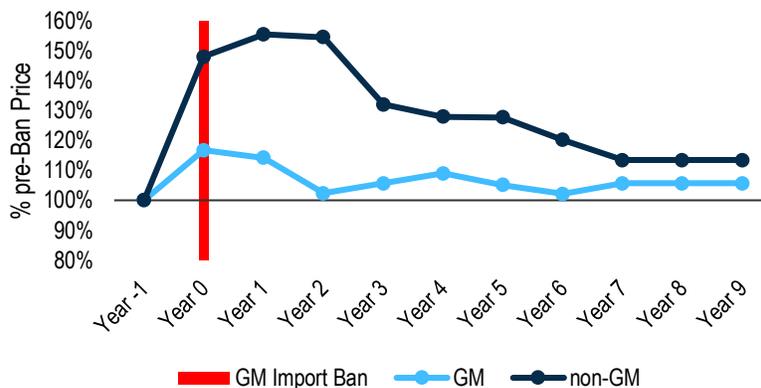
U.S. Acreage and Supply/Demand Responses

Market Responses in the Ban's First Year

This study, consistent with the findings presented in the March 2022 report for Crop Life International, finds that a Mexican ban on GM corn imports would create significant changes in the U.S., Canadian, and Mexican corn markets. Most notably, the U.S. non-GM corn price would rise 48 percent from the prior year (20 percent above the baseline forecast) to \$8.14/bushel in the first year of the ban (Year 0) due to the added demand from Mexico (Figure 2). WPI estimates that the U.S. non-GM corn ending stocks-to-use ratio⁴ would likely fall by 3.6 percentage points to 7.0 percent in Year 0, a historically tight ratio that the U.S. corn market has not seen since the drought year of 2012/13.

In the first year of the ban, this study finds that the U.S. would be able to export 2.7 MMT of non-GM corn to Mexico, 17 percent of Mexico's import demand. Note that in Year 0, the U.S. would still fill 2.5 MMT of non-GM export demand by Japan and South Korea, as well as 22 MMT of domestic non-GM corn use. Demand from these sectors is highly inelastic and much of the corn is forward contracted before the growing season, making it practically unavailable for export to Mexico.

Figure 2: Predicted U.S. GM and non-GM Corn Prices as Percent Pre-Ban Price



Source: World Perspectives, Inc.

The U.S. GM corn farming sector would also see significant changes in Year 0, specifically an increase in the ending stocks-to-use ratio that could push prices \$0.32/bushel (5 percent) lower than would have otherwise occurred. The reason U.S. ending stocks do not increase by a greater amount is due to shifts in world corn trade. Specifically, Brazil, Argentina, Ukraine, and Canada increase their own non-GM exports to Mexico (exporting, collectively, 12.9 MMT of non-GM corn), creating a shortfall in shipments to other global importers. The U.S. GM market fills some of this trade shortage which prevents GM supplies from growing more significantly.

In Year 0, the price changes identified above would create a net economic loss of \$4.99 billion for the U.S. GM corn farming industry, versus what the sector would have otherwise received. That loss could be partly offset by a gain of \$1.43 billion in the non-GM corn farming sector, creating a **net economic loss for the U.S. total corn farming sector of \$3.56 billion⁵ in the first year of the ban.**

⁴ A metric commonly used by the grain industry to evaluate “leftover” supply at the end of a marketing year compared to total consumption. The ending stocks-to-use ratio is also typically an important predictor of grain prices.

⁵ These findings are consistent with those of the March 2022 Crop Life International study, which estimated a loss of \$4.4 billion for the U.S. GM corn sector, gains of \$1.86 billion for non-GM corn farming, and a net corn farming sector loss of \$2.54 billion.

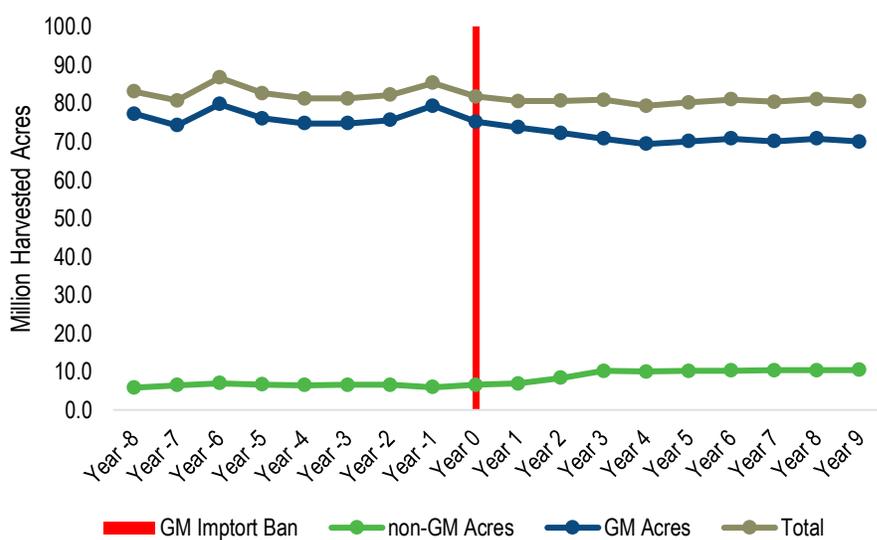
Results from the dynamic model simulations indicate that **Mexico would pay 26 percent more for non-GM imports** in Year 0 than it would in the baseline scenario for GM corn. As a result, Mexican importers and end-users are predicted to reduce their corn purchases, and Mexico's total corn imports in Year 0 fall from 17.7 MMT in the baseline case to 15.6 MMT, a decrease of 12 percent. Because the U.S. would be expected to provide just 2.7 MMT of Mexico's import needs, the balance (12.9 MMT) would likely be imported from Brazil, Argentina, Ukraine, and Canada. Notably, while roughly 8 percent of Brazil and Argentina's respective corn crops are non-GM, interviews with professionals in the South American grain industry suggest that there are multiple hurdles to exporting non-GM corn from these countries. Those hurdles include logistics, segregating and identity preserving, and certifying non-GM corn. Additionally, there are uncertainties as to whether Ukraine could adequately supply and certify non-GM grain to meet any possible GM-present threshold that would be required by Mexico. Finally, the freight costs of transporting grain from Ukraine to Mexico would be significant and force additional demand-rationing on the part of Mexican buyers. In short, while Brazil, Argentina, Ukraine, and Canada may on paper appear to be able to fill nearly 13 MMT of non-GM corn demand from Mexico, the reality of these countries' ability to fully supply Mexico in the event of a GM corn ban maybe less than predicted here. Consequently, the results from this study are likely to represent the lower bound of likely impacts on reduced imports and higher prices that Mexico would face, should the proposed GM ban be fully implemented.

As discussed later in this report, the smaller import volume would have important consequences for Mexico's food security and livestock sector. Notably, even after imports fall 2.1 MMT from the baseline scenario, the higher prices and freight costs Mexico faces in the global market mean the country would pay \$571 million more for its corn imports in Year 0 than it would otherwise. This \$571 million represents an economic cost to Mexico and, as discussed further in this paper, it is unclear how these costs would be transmitted through the Mexican economy.

Market Responses in the Ban's Second Year

In the first year of the ban, U.S. farmers have limited (i.e., zero) ability to switch acres from GM corn (or other crops) to non-GM corn. This is one reason why the U.S. non-GM ending stocks level falls so greatly – there is no potential to add supplies. In subsequent years, however, U.S. (and other producing countries) farmers can and do shift acreage significantly. This study finds that Year 1 (the first full marketing year after the ban) U.S. non-GM corn acres expand 5 percent in response to the 33 percent premium that non-GM prices hold to GM prices (Figure 3). Crucially, expansion of non-GM corn acres is constrained in Year 1 due to limited non-GM seed supplies. Seed companies – like other producers – are unable to increase non-GM plantings in Year 0 that would create non-GM seed supplies for Year 1.

Figure 3: Forecasted U.S. Corn Acreage Response to Mexico's GM Corn Ban

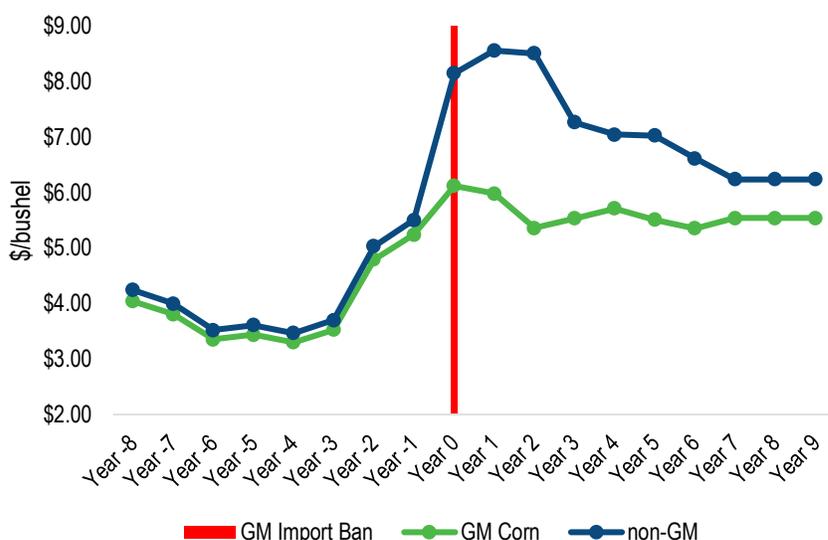


Source: World Perspectives, Inc.

In response to lower GM corn prices that would have otherwise occurred (Year 1 GM corn prices would be 9 percent below baseline predictions) U.S. farmers cut GM corn acres by 2 percent (approximately 1.5 million acres) in Year 1. Due to the seed supply constraints for non-GM corn, most of these acres are planted to other crops, including soybeans and sorghum.

With the marginal gains in non-GM corn production for Year 1, the U.S. supplies more of Mexico's non-GM import needs. U.S. non-GM exports to Mexico rise to 5.5 MMT in Year 1 (filling 36 percent of Mexico's import needs) while the U.S. continues to supply Japan and South Korea as well as its own domestic non-GM corn consumption. Notably, U.S. domestic consumption and exports to Japan and South Korea both fall in Year 1 due to the price increases as well as competition for forward contracts. In Year 0, U.S. exporters and grain handling firms would start to forward contract non-GM corn supplies to fill the Mexican market⁶, thereby lowering the volume available for U.S. domestic use. U.S. non-GM corn ending stocks remain tight in Year 1 and prices increase another 5 percent from their Year 0 value. **U.S. non-GM corn prices in Year 1 are forecast at \$8.56/bushel, or 30 percent above their baseline value** (Figure 4).

Figure 4: Forecasted U.S. Corn Price Response to Mexico's GM Corn Ban



Source: World Perspectives, Inc.

The U.S. GM corn farming sector sees another set of shocks in Year 1, most notably an increase in ending stocks and lower prices due to declining domestic use and exports. As world corn markets adjust to the impacts of Mexico's policy, production outside the U.S. increases and competes for U.S. market share. Consequently, U.S. exports fall 4.1 percent in Year 1. Similarly, the loss of the Mexican market for milled corn products (including DDGS, corn starches, and sweeteners) creates a small contraction in the U.S. dry and corn wet milling industries. These impacts are further detailed in section "[Impacts on the U.S. Corn Wet Milling Industry](#)" but contribute to a decline in U.S. domestic consumption. Feed use of corn in the U.S. helps offset some of these effects, but the net impact to the U.S. GM corn farming sector is a 3 percent increase in the ending stocks-to-use ratio and a 2 percent fall in farm prices.

The U.S. corn farming sector would suffer a net economic loss in the second year of Mexico's ban on GM corn as occurred in the first year. Smaller production and lower prices would create an \$8.0 billion loss for the GM corn farming sector that may only be partly offset by a \$2.47 billion gain in the non-GM corn sector. The net loss for the U.S. corn farming industry, relative to the baseline scenario, would be \$5.56 billion.

⁶ Note that U.S. firms would be extremely reluctant to commit to forward contracting without purchase contracts for specific volumes signed with Mexican firms.

As occurs in the first year of the ban, the 30 percent price increase above baseline values further restricts Mexico's corn import demand. Imports for Year 1 are forecast to be 26 percent smaller than would have otherwise occurred. This occurs as end-users, including the livestock industry, and consumers ration demand and increase use of substitute goods. Again, despite importing smaller volumes, the higher prices and freight costs Mexico faces in the global market mean the country would pay \$107 million more for its corn imports in Year 1 than it would otherwise.

Market Responses After the Ban's Third Year

The third year (Year 2) of Mexico's GM corn ban would likely see some of the greatest changes to the U.S. balance sheet and world corn trade. With non-GM seed supplies becoming less restrictive, U.S. non-GM corn acreage rises 22 percent, and the U.S. would likely export 10.6 MMT of non-GM corn to Mexico (70 percent of Mexico's imports). The U.S. non-GM ending stocks-to-use ratio is predicted to remain historically low, but non-GM prices would fall \$0.06/bushel in Year 2.

U.S. GM corn acres could fall another 2 percent in Year 2 and, despite smaller production and gains in domestic consumption, the GM ending stocks-to-use ratio would rise another 1.5 percent while prices fall 6 percent. Notably, the U.S. corn farming sector would still experience a net economic loss as the GM sector loses \$9.54 billion versus the baseline case, and the non-GM sector would offset \$5.28 billion of that loss. The net economic loss in Year 2 is predicted to be \$4.27 billion across the entire U.S. corn farming sector.

The high-priced environment of Year 2 continues to ration Mexican corn demand. Mexico's corn imports are forecast to be 5.9 MMT lower than in the baseline forecast for that period and the country would likely pay \$8.50/bushel for its corn imports – a figure 42 percent above the baseline forecast. Moreover, that estimated price is \$3.14/bushel (59 percent) greater than the \$5.36/bushel GM corn price forecast in the baseline scenario. Mexico would face corn import costs for that year that would be \$362 million above baseline projections.

In the third year of the ban, Mexico would likely pay \$8.50/bushel for non-GM corn imports, a price 50 percent greater than the baseline forecast.

In the fourth year after Mexico implements its proposed ban on GM corn (Year 3), U.S. non-GM corn production is forecast to increase another 21 percent and America fills 100 percent of Mexico's non-GM import needs. The U.S. non-GM ending stocks-to-use ratio would increase 2.3 percentage points and non-GM corn prices could fall 15 percent. GM corn acres fall another 2 percent in Year 3 and three consecutive years of declining acreage and slowly expanding domestic use pull ending stocks lower. Prices rise 3 percent but remain 1 percent below their baseline values. Notably, the U.S. corn farming sector would suffer a net economic loss of \$572 million, but gains in the non-GM sector nearly offset losses in the GM sector. In Year 3, Mexico's imports would expand in response to lower non-GM corn prices and total 15.7 MMT, which is still 6.2 MMT below the baseline forecast.

In Years 4-9, the U.S., Mexican, and world corn markets gradually stabilize around this new equilibrium. WPI's models find that U.S. GM and non-GM corn acreage would undergo minor shifts each year based on changes to prices in their respective markets, but total corn harvested acres remain relatively steady and near 80 million. U.S. supplies and ending stocks gradually increase and find stability that allows prices to hold steady near \$6.24/bushel for non-GM corn and \$5.54/bushel for GM corn. Note that non-GM corn retains an approximate 11 percent price premium over GM corn to compensate producers for the agronomic realities of greater yield variability and lower overall yield potential.

Impacts of Ten Years of Market Adjustments

In the long run, three major impacts of Mexico's proposed policy become clear. The first is that the **U.S. corn farming sector would suffer net economic losses of \$13.61 billion during the 10-year forecast horizon**. WPI estimates that in five of the 10 forecast years, gains from the non-GM sector would more than offset losses in the GM sector and

the U.S. corn farming economy would experience net gains during these years. Those gains, however, are insufficient to offset the losses of other years, particularly the first three in the forecast period.

The second impact is that price premium for non-GM corn means **Mexico would pay a cumulative \$9.73 billion more for its corn imports over 10 years under a GM corn ban** than is predicted in the baseline scenario. This equates to a purchase cost increase of 19 percent. Notably, **these cost estimates represent the lower bound of possible impacts** if non-GM corn prices do not fall and converge to GM prices as predicted in this study. There is risk that non-GM corn prices could rise sharply and remain at those elevated levels, as happened when Japan's demand for non-GM food ingredients expanded through policy changes. For additional information on the Japanese non-GM corn market as a possible guiding example for the impacts of Mexico's proposed policy, please see the section "[Case Study: Japan's Move to non-GM Corn and Its Impact on U.S. Corn Prices](#)".

The third major impact would be a permanent reduction in Mexico's total corn imports, which are predicted to remain some 30 percent below USDA's baseline projections. This occurs because growth in the Mexican livestock sector would stall, and the industry would contract in light of higher feed prices. Gains in Mexico's domestic corn production (which is primarily white corn) would offset a small portion of the lost import volume but the country would suffer a net reduction in corn supply over the 10-year forecast period. This, as detailed later in this study, would create higher food prices for Mexican consumers. One notable example is the fact that tortilla prices would rise 16 percent, on average, from what would have otherwise occurred without the proposed GM corn ban.

Case Study: Japan's Move to non-GM Corn and Its Impact on U.S. Corn Prices

Japan is one of the world's largest per-capita importers of food and feed produced using modern biotechnologies. Japan uses a science-based, transparent process for evaluating and granting approval for import and production of genetically engineered products. It approves new events within anticipated time periods that mostly align with industry expectations for market release.

This study assumes the literal interpretation of Mexico's Decree and that all GM corn imports would be banned. It has been noted that non-GM corn has not become commoditized in Japan after many years of use. Reports indicate that the premium for non-GM corn imports remain in the range of 50-60 cents or more per bushel. However, Japan has a uniquely blended GM/non-GM corn market that requires substantial additional costs for segregation, traceability, and labeling.

According to USDA, in CY2020, Japan imported 15.8 million tons of corn, of which approximately a third was for food use. The agency further estimates that nearly half to two-thirds of the imported corn for food use is non-segregated or GE, but it emphasizes there are no official statistics available.

The complexity of the Japanese GM versus non-GM market is due to regulations that only require GM labeling when the products and/or ingredients that are GM are among the top three ingredients in the product and account for at least five percent of the product. This results in a much more specialized market for the use of non-GM corn, and thus, the sustained premiums being demanded. Note that the Japanese Consumer Affairs Agency has a new labeling protocol for GM foods starting in 2023, though its market impact is unclear.

Impacts on Industries Linked to Corn Farming

While the preceding section explained the changes to the U.S. farm economy and grain balance sheets, Mexico's ban on GM corn imports would impact industries and economic sectors beyond corn farming. Some specific industries that would be directly or indirectly impacted are the grain handling industry, the rail transportation industry, the ethanol (dry

corn milling), and corn wet milling industries. This section details the impacts and economic responses by each of these industries.

Costs of Grain Segregation and Identity Preservation

As noted in the March 2022 Crop Life International study, a ban on GM corn by Mexico would create massive changes in the U.S. grain handling industry. Non-GM grain would have to be segregated and identity preservation (IP) strictly maintained to meet the requirements of Mexico's proposed policy. The U.S. grain handling industry, which currently handles non-GM grain via a "segregation within bulk" strategy, would likely eventually shift to a bifurcated system in which GM and non-GM grain is handled by specific, separate facilities.

Elbehri (2007) noted that there are two primary cost categories associated with identity-preserved (IP) grain markets:

- The costs of physical separation and tracking of grain; and
- Costs of mitigating specific risks inherent to IP grain markets, especially the risk of shipments being rejected for exceeding GM tolerance levels⁷.

This section estimates the financial costs of each of these categories and their likely impact on the U.S. and Mexican corn value chain in the presence of a Mexican ban on GM imports.

Costs of Physical Grain Segregation and IP

The costs of physical grain separation were estimated to range from 1 to 27 cents per bushel by Elbehri (2007), depending on the specifics of grain type and volumes handled by a facility. Similar work (Doshi and Eudes, 2007) found that segregation costs ranged from 1 to 50 cents per bushel. In the Crop Life International study, World Perspectives, Inc. (2022) estimated that the cost of corn segregation and IP was 18.5 cents per bushel in 2002 dollars, which equates to 27 cents per bushel in 2020 dollars. After two years of significant inflation in the U.S., this study estimates that costs for segregating and IP GM and non-GM corn are near 29.5 cents per bushel in 2022 dollars.

The 29.5 cent per bushel segregation and IP costs would create an \$11.8 billion added burden for the U.S. grain industry in the first four years of a Mexican ban on GM corn. Like the findings in World Perspectives, Inc. (2022), this study finds that the costs of segregation and IP would gradually decrease and approach zero (e.g., no additional marginal cost) in the final six years of the ban. The initial costs are significant, however, and firms must either absorb them (accept smaller profits) or pass them along to consumers (raise prices) or farmers (lower bids for grain).

For the volume of non-GM corn exported to Mexico, this study estimates that U.S. grain handling firms and exporters would simply pass along the costs associated with segregation and IP. That is, the 29.5-cent per bushel cost would be added – either in the form of higher offers for corn or surcharges – to what Mexican importers pay. **Over the 10-year forecast horizon, this would equate to a \$971.9 million additional cost that Mexico would pay.**

As noted in the Crop Life International study (World Perspectives, Inc., 2022), it is unclear how the remaining \$10.83 billion cost would be transferred through the U.S. or world grain markets. In 2009, Desquilbet and Bullock noted that "the economics of technological innovation leading to market bifurcation are complicated" (pp. 671) and that bifurcated GM/non-GM grain markets may have multiple market equilibria. They conclude that the presence of multiple market solutions makes determination of net winners and losers difficult, and that the situation is further complicated by the presence of different producer and consumer attitudes towards GM grain and products.

⁷ As of this writing, Mexico has not issued guidance on tolerance levels for GE materials in grain exports after its ban is scheduled to take effect. This creates significant uncertainty for the market as the costs and practices necessary for meeting a 5 percent tolerance threshold are vastly different than those to meet a 1 percent threshold.

The physical costs of segregating and IP non-GM corn would also likely create an impact beyond the scope of this study. The first is that the added cost to grain handling firms would cause changes (likely reductions) in firm profits, employee wages and salaries, or staffing levels. WPI has been unable to find reliable estimates of how grain handling firms would respond, in terms of business operations and finances, to a bifurcated system. Consequently, we are unable to estimate the full economic “ripple effects” of full segregation and IP in the U.S. corn value chain⁸.

Cost of Specific Risk Mitigation in IP Grain Markets

Identity-preserved grain markets have certain risks inherent to their structure, namely the risk of cross-contamination that exceeds a given threshold. The Mexican government has yet to issue specific rules on contamination thresholds or testing requirements, but one must assume such rules would be applied. Otherwise, a GM corn ban cannot practically be enforced. Consequently, both exporters and importers would face the risk that shipments could be rejected at Mexican ports if they do not meet yet-undefined tolerance thresholds.

Practically, there are three participants in the U.S.-Mexico corn value chain who would face the risks associated with GM contamination of non-GM corn shipments. The first is U.S. exporters who would face the risk of shipments being rejected, a risk shared by the second participant, Mexican importers. Mexican importers would also face the risks and costs of non-compliance penalties should they accept shipments that contain GM grain. Finally, the third participant, the Mexican government, would risk being viewed as ineffective in policy enforcement should the country import “contaminated” grain. Each of these three participants, then, has strong incentives to test shipments to ensure the presence of GM material does not exceed a yet-undefined threshold. Consequently, WPI estimates that *both* exporters and importers would conduct and pay for genetic testing on every shipment of corn or corn-derived products.

In the March 2022 study, World Perspectives, Inc. estimated that the costs of genetic testing of corn exported via rail or sea at \$0.47/MT in 2020 dollars for both U.S. exporters and Mexican importers. Adjusting that rate for inflation, this study estimates the costs for genetic testing hit \$0.51/MT in 2022. **For U.S. firms, this would result in a \$70.33 million cost for genetic testing** over the 10-year forecast horizon, in addition to the \$11.8 billion cost associated with physical segregation and IP efforts. Following the March 2022 Crop Life International study, WPI notes that U.S. firms would likely simply pass along this \$70.33 million cost associated with genetic testing to Mexican importers. Consequently, **Mexican importers (or the Mexican government if testing costs are subsidized) would pay an additional \$84.21 million over 10 years solely for the genetic testing** on imported shipments. Note that Mexican firms would pay a greater cost than U.S. firms because Mexico would test non-U.S. imports in the first three years of the GM corn ban.

In total over the 10-year forecast period, Mexico would see added, non-price costs of \$1.056 billion for its non-GM corn imports. This cost is the combined impact of grain segregation and IP costs passed from U.S. exporter to Mexican importers and end-users as well as the \$84.12 million Mexico will pay in genetic testing of corn imports. This is a cost that would divert scarce resources away from other applications that would not exist if the proposed GM ban were abandoned.

Contraction in the U.S. Rail Transportation Industry

A policy whereby GM corn is banned for production and import into Mexico would cause considerable impacts on the U.S. rail transportation industry. The ban would reduce U.S. corn, DDGS, and corn wet milling product exports, the majority of which is transported to Mexico via rail. This, in turn, would constrict overall demand for U.S. rail freight and create a negative net impact on the rail transportation sector.

As noted earlier in this report, U.S. corn exports to Mexico would fall 13.4 and 13.1 MMT, respectively, from their baseline forecasts in the first two years of a GM corn ban. Not only would corn exports be impacted, but DDGS exports

⁸ IMPLAN economic input-output models deal only with firm- or industry-level changes in terms of employment, wages, or economic output (revenues) and do not estimate the impact(s) of price changes.

would also fall from their baseline forecast (2.4 MMT annually, on average) along with corn wet milling products (CGF, CGM, sweeteners, corn starches, etc., averaging 880 TMT annually). The degree to which this would impact the U.S. rail transportation sector depends on the role railways play in each product's typical export mode. Based on U.S. Customs District export data⁹WPI estimates that, on average, 86 percent of U.S. DDGS (including CGM and CGFP) exports to Mexico are executed by rail. Additionally, WPI estimates that 61 percent of U.S. corn exports to Mexico are conducted by rail, with the balance being moved by ocean ports in the U.S. Gulf. Indisputably, rail transportation is a critical mode for shipping corn and corn products to the Mexican market.

As noted in the March 2022 study, soymeal (and other feedstuff) product exports would fill some of the gap created by the lost corn and co-product export volumes. Determination of the exact products and volumes that would replace lost corn and corn product exports depends greatly on the specifics of Mexican livestock operations' feed rations and product availability in addition to pricing on the world market. Such analysis is beyond the scope of this analysis, however, and to remain consistent with our prior approach, WPI assumes that half the lost DDGS, CGF, and CGM exports would be replaced by soymeal (or other feedstuffs) in the first year. We further assume that substitute feedstuff exports would grow 5 percent annually thereafter.

Based on WPI's forecasts of changes in GM and non-GM corn, DDGS, and corn wet milling products exports to Mexico and historic rail shipping volumes, this study finds that total corn and corn-product rail freight to Mexico would fall 10.17 MMT in the first year of a Mexican ban on GM corn. On average over the 10-year forecast period, we estimate that rail volume would be 5.9 MMT less than in the baseline scenario. Despite the projected increase in non-GM corn exports and other, substitute feedstuffs, this analysis finds that U.S. rail export volumes would likely not return to baseline values within the 10-year forecast period. **That is, the loss of the Mexican corn and corn-products market creates an economic shock so large that the industry does not recover within 10 years.**

Using USDA data for rail freight rates from western Corn Belt locations to Mexico¹⁰, this net decrease in rail volume would create a **\$3.33 billion cumulative revenue loss for U.S. railroads over 10 years**. The revenue loss would likely create a pronounced contraction in the U.S. rail industry, and railroads that are traditionally large suppliers to Mexico would see the greatest impacts.

Impacts on the U.S. Ethanol Industry

As noted earlier in this report, Mexico has issued no official or consistent guidance on whether its ban would apply to milled products derived from GM corn. Similar to the March 2022 study, this study assumes that that ban *will* apply to GM corn-derived products and feed ingredients, including dried distillers' grains with solubles (DDGS), corn gluten meal (CGM), and corn gluten feed (CGF). Mexico is the largest export destination for U.S. DDGS, a co-product of dry-mill ethanol production, and accounted for 21 percent of U.S. DDGS exports in 2021.

The ethanol industry (defined, for the purposes of this study, as only including dry corn milling facilities) would face several possible impacts from Mexico's intended ban on GM corn. The first is that - if the ban applies to products including DDGS - the industry would face a sudden decrease in demand and consumption of a key co-product. This would create a product surplus in the U.S. market that would depress prices and ethanol production margins. The second is that the decreases in GM corn prices would lower variable costs for the ethanol industry and improve production margins. The extent to which these two impacts offset each other would determine the overall net gains or losses for the industry due to Mexico's proposed ban. This section examines the likely impacts of these two dynamics and the net margin difference faced by the industry.

Following the estimation approach of prior study (see World Perspectives, Inc., 2022, p. 17), WPI estimates that the loss of the Mexican market for U.S. DDGS exports would result in a 2.4-MMT increase in domestic supplies in the first

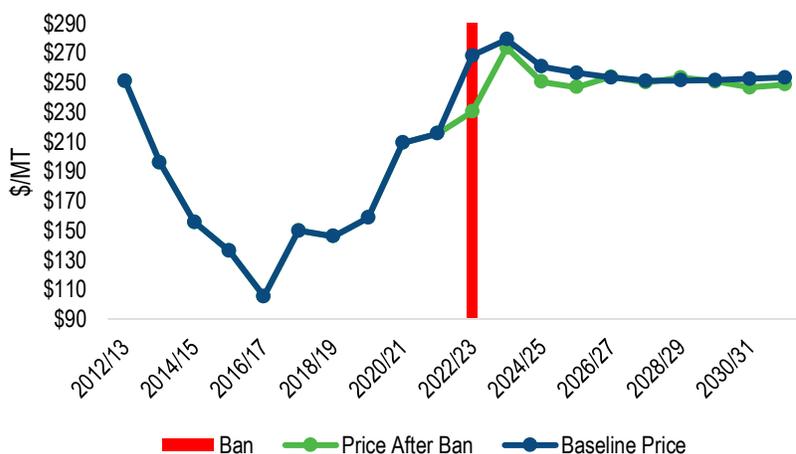
⁹ Obtained from the USDA Foreign Agricultural Service's (FAS) Global Agricultural Trade Statistics (GATS) database.

¹⁰ Available here: <https://www.ams.usda.gov/services/transportation-analysis/qtr-datasets>

year of the ban (Year 0). U.S. domestic consumption would expand 1 percent¹¹ in response to lower prices and rest-of-world (ROW) exports increase 9 percent. Still, the loss of a major export market would leave 1.6 MMT of additional DDGS supply in the U.S. market, and DDGS prices would fall 14 percent from their baseline projection. Subsequent adjustments by both the ethanol industry, DDGS end-users (i.e., livestock feeders), and international DDGS buyers, result in DDGS prices that would be near their baseline value by the end of the 10-year forecast period. Despite increases in both U.S. domestic and ROW exports, total DDGS consumption would never fully recover from the initial loss of the Mexican export market. Over the 10-year period, U.S. DDGS consumption cumulatively falls 3.5 MMT, with most of those losses occurring in the first year of the ban.

The impact of the lost export market would be U.S. DDGS prices that are 3 percent lower, on average, than forecast in the baseline scenario (Figure 5). This, in turn, would cause U.S. ethanol margins fall by \$0.02/gallon (4.6 percent) over the forecast period, on average. The ethanol industry’s response would be to cut production of ethanol and DDGS by 0.8 percent¹², on average, each year following the ban. This, combined with lower prices for would create a net \$3.5 billion loss for the industry over 10 years.

Figure 5: Forecast U.S. DDGS Prices, FOB Central Illinois Ethanol Plant



Source: World Perspectives, Inc.

The impact of Mexico’s GM corn ban on the U.S. ethanol sector would be a cumulative net loss of \$521 million in industry output compared to the baseline scenario. A large portion of the net \$3.5 billion loss created by the shock to the DDGS market would be offset by the impacts of lower GM corn prices. Lower corn values, on average, across the 10-year forecast period would result in a 0.7 percent increase in ethanol output, as industry margins benefit from lower input costs. Cumulatively, the impacts of lower corn prices would create a net economic benefit of \$2.98 billion over 10 years, reducing the \$3.5 billion loss from the shock to the DDGS market into a **cumulative net loss of \$521.5 million for the ethanol industry.**

Finally, should Mexico’s ban on GM corn apply to corn for feed use but not to GM corn-derived feed products, then the policy’s impact would be to increase demand for products like DDGS at the expense of corn consumption. In this case, the U.S. ethanol industry would see higher demand for DDGS from Mexican livestock feeders who would substitute, to the extent possible, DDGS for corn in rations. This would create a net increase in U.S. DDGS prices and bolster ethanol production margins. This is an unlikely outcome, however, as the Mexican government has, to date, limited any

¹¹ The reason U.S. domestic consumption does not expand more is that DDGS consumption in the cattle, swine, and poultry industries has reached its saturation point. Additionally, the biological time lags associated with expanding cattle production – the primary consumer of DDGS – dictate limited response by the industry to lower feed costs in Years 0 and 1.

¹² Ethanol output is highly inelastic in response to prices due to 1) the Renewable Fuels Mandate and 2) the high fixed costs of entering or exiting the industry. Consequently, a 1 percent change in ethanol margins elicits a far smaller change in ethanol output.

tentative mention of exemptions to its GM ban as applying to “feed” imports broadly, with no distinction as to corn versus corn-derived products.

Impacts on the U.S. Corn Wet Milling Industry

Expanding on the March 2022 study on behalf of Crop Life International (World Perspectives, Inc., 2022), this study examines in greater detail the impacts of Mexico’s intended GM corn import ban on the corn wet milling industry. Like the corn dry milling industry, wet mills use corn as the base input into an industrial process that separates the starch in the corn kernel from other components. In contrast, corn wet milling is more complicated and requires greater start-up and investment costs but produces higher-value products than the dry milling industry. [Appendix C – Uses of Corn Wet Milling Products](#), offers a partial list of the myriad products that can be created from the corn wet milling process.

For this study, we focus on five key products of the U.S. corn wet milling industry: corn gluten feed (CGF), corn gluten meal (CGM), high fructose corn syrup (HFCS) and crystalline fructose (CF), and corn starch. Corn starch is perhaps the key output from the corn wet milling process as it can be further transformed into consumer food products, industrial applications, pharmaceutical ingredients, and others. Based on USDA data as well as industry and academic research, WPI created baseline forecasts of U.S. production, exports (to Mexico and rest of world (ROW) destinations), domestic use, and prices for each of these products.

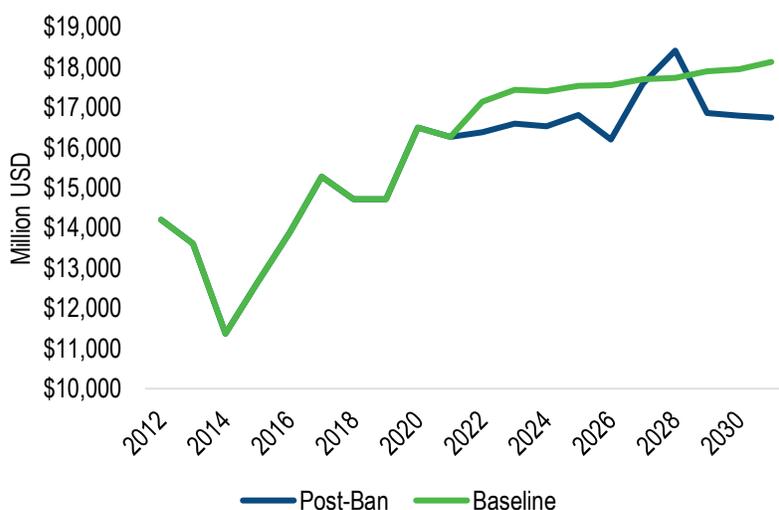
Mexico’s ban on GM corn is assumed to apply to these five major products from the corn wet milling process. For the feed ingredients (CGF and CGM), the logic is the same as follows for DDGS and feed corn – without additional details from the Mexican government about how its proposed ban would be applied, one must assume the policy applies equally to products for food and feed use. Mexico’s proposed GM corn policy, however, even if applied only to food uses, would still restrict U.S. exports of the sweetener products (HFCS and CF) and corn starch. The sweetener products are clearly intended for human consumption while corn starch has myriad applications and uses in consumer products. Unless the Mexican government issues clarifying guidance on how GM corn-derived products for human use are to be handled under its pending ban, U.S. exports of these products and the corn to produce them in Mexican facilities would cease.

To estimate the impact of Mexico’s GM corn ban on corn wet milling products, this study assumes that exports of major corn wet milling products to Mexico would end upon the ban’s effective date. In 2021, sweetener exports to Mexico accounted for 12 percent of U.S. production and corn starch exports to Mexico equaled 3 percent of U.S. production. As was the case with DDGS in the ethanol industry, the loss of the Mexican export market creates surplus product in the U.S., which is only partially offset by higher domestic use and ROW exports. The long-run impact of Mexico’s ban would be that U.S. corn-derived sweetener prices fall by 5.16 cents/lb. (13 percent), on average, following the ban while corn starch values fall 0.22 cents/lb. (1 percent) over the 10-year period. Notably, U.S. CGF and CGM exports to Mexico are sufficiently small as a share of overall production that the loss of the Mexican market would not significantly impact the prices of these two goods.

The net effect of lower product prices for the corn wet milling sector would be an average reduction of industry revenue by 7 percent over the 10-year forecast period. Due to the inelastic nature of corn wet milling production, the industry consumes 392 million fewer bushels of corn (3 percent of the baseline forecast) as the revenue losses would force the industry to contract. The combined effects of lower output prices and smaller total production would cut economic output from the corn wet milling sector by \$17.35 billion over 10 years.

In total, **the U.S. corn wet milling industry would suffer a net economic loss of \$7.65 billion over the 10-year forecast period** (Figure 6). Like the dry corn milling industry, the wet corn milling sector sees input costs reduced due to lower GM corn prices following Mexico’s ban. Lower corn costs offset some of the impacts of lower sweetener and corn starch product values and offer the industry incentives to expand production and, over 10 years, the industry sees a benefit of \$9.79 billion from lower GM-corn prices. In total, however, the gains from lower corn prices fail to offset the effects of lower product prices, and the corn wet milling industry suffers a \$7.56 billion net economic loss.

Figure 6: Predicted U.S. Corn Wet Milling Industry Economic Output



Source: World Perspectives, Inc.

Impacts of Lost Farm Revenue

The impacts of the \$13.61 billion of lost corn farming revenue would ripple through the U.S. economy via direct, indirect, and included impacts and **cause a contraction of \$17.98 billion in GDP**. Additionally, **U.S. economic output would fall by \$43.25 billion over 10-years and 21,663 jobs would be lost** due to the impact on corn farming revenue, reducing labor income by \$11.26 billion. Importantly for policy makers, U.S. federal tax revenue would fall \$2.231 billion from baseline projections (Figure 7).

Figure 7: Cumulative 10-Year Impacts on U.S. Economy from Lost Farm Revenue

Impact	Annual Avg. Employment	Labor Income	US GDP	Output
	<i>Full-time Equiv.</i>	<i>Billion USD, 2022 dollars</i>		
Direct	-5,029	-\$2.01	-\$2.50	-\$13.37
Indirect	-10,515	-\$5.65	-\$9.10	-\$18.51
Induced	-6,120	-\$3.60	-\$6.38	-\$11.37
Total	-21,663	-\$11.26	-\$17.98	-\$43.25

Source: World Perspectives, Inc.

Some industries in the U.S. would be more affected than others by a possible GM corn ban from Mexico. As expected, industries more closely tied to the corn farming sector see the greatest impact, and the fertilizer and agricultural chemical industries see significant negative impacts as their economic output is reduced (Figure 8).

Figure 8: 10-Year Impacts on U.S. Economic Sectors Most Closely Tied to Corn Farming

Economic Sector	Net Economic Growth	Impact on Output (Bill USD)
Grain farming	-20.6%	-\$13.98
Ag support activities	-6.4%	-\$2.26
Pesticide/Ag Chem. mfg.	-5.6%	-\$1.14
Nitrogen fertilizer mfg.	-4.7%	-\$0.51
Fertilizer mixing	-4.3%	-\$0.24
Phosphatic fertilizer mfg.	-4.2%	-\$0.25
Phosphate rock mining	-4.1%	-\$0.03
Potash mining	-3.8%	-\$0.06
Other chem & fertilizer	-0.6%	-\$0.01
Other wholesale	-0.4%	-\$1.54
Total		-\$20.02

Source: World Perspectives, Inc.

The impacts of a Mexican ban on GM corn can also be examined in light of the industries where employment is most greatly affected. The U.S. grain farming sector would see 5,029 jobs lost annually due to changes in the sector's revenue, and the ripple effects from that sector would cause the loss of an additional 231 jobs via indirect and induced impacts (Figure 9). Notably, employment in sectors that support agriculture (seed companies, crop scouts, etc.) would see a net reduction of 4,766 jobs annually over the 10-year forecast period due to the revenue impacts of a Mexican policy banning GM corn and corn products.

Figure 9: Annual Average Labor Impacts by Top-5 Sectors Most Affected by Changes in Corn Farming Revenue

Industry	Impact Type			Total
	Direct	Indirect	Induced	
Grain farming	-5,029	-223	-8	-5,261
Ag support activities	0	-4,746	-20	-4,766
Other real estate	0	-1,472	-208	-1,680
Nondurable goods wholesalers	0	-430	-37	-467
Full-service restaurants	0	-120	-265	-385

Source: World Perspectives, Inc.

Impacts of Contraction in the Rail Industry

The impacts of the \$3.33 billion revenue loss of the U.S. rail transportation sector would have significant and widespread impacts on the broader U.S. economy. Using IMPLAN economic input-output models, WPI estimates the impact of changes in rail industry revenues to the U.S. economy would create a \$7.78 billion loss in economic output over 10 years (Figure 10). Additionally, it would cause GDP to contract by \$4.18 billion and create a \$2.33 billion reduction in labor income (e.g., wages and salaries for U.S. workers). The shock would also cause an annual reduction of 2,795 jobs over the 10-year period.

Figure 10: Forecasted Cumulative 10-Year Impacts of Contraction in U.S. Rail Industry

Impact	Annual Avg. Employment	Labor Income	US GDP	Output
	<i>Full-time Equiv.</i>	<i>Million USD, 2022 dollars</i>		

Direct	-641	-\$857.53	-\$1,641.32	-\$3,113.17
Indirect	-906	-\$719.71	-\$1,238.65	-\$2,343.13
Induced	-1,248	-\$733.44	-\$1,302.17	-\$2,323.34
Total	-2,795	-\$2,310.68	-\$4,182.13	-\$7,779.64

Source: World Perspectives, Inc.

Impacts of Changes in the Ethanol Industry

The impacts of the \$521.5-million-dollar loss to the U.S. ethanol industry that would occur from a Mexican ban on GM corn would **create a contraction of \$596 million in U.S. GDP over the 10-year forecast period**. Additionally, approximately 406 jobs would be cut annually from the economy and labor income would fall \$303.27 million over 10 years and U.S. economic output would contract by \$1.771 billion (Figure 11).

Figure 11: Forecasted Cumulative 10-Year Impacts of Changes in the Ethanol Sector on the U.S. Economy

Impact	Annual Avg. Employment	Labor Income	US GDP	Output
	<i>Full-time Equiv.</i>	<i>Million USD, 2022 dollars</i>		
Direct	-30	-\$44.54	-\$90.93	-\$521.48
Indirect	-213	-\$162.68	-\$335.56	-\$885.84
Induced	-163	-\$96.06	-\$170.43	-\$304.04
Total	-406	-\$303.27	-\$596.93	-\$1,711.37

Source: World Perspectives, Inc.

Impacts of Changes in the Corn Wet Milling Industry

As discussed earlier in this report, the U.S. corn wet milling industry suffers a net economic loss of \$7.65 billion over the 10-year forecast period due to lower product prices that are only partially offset by lower corn costs. Results from IMPLAN models indicate the combined direct, indirect, and induced impacts from these shocks would ripple through the economy to create a **net economic output loss across the U.S. economy of \$21.15 billion over the 10-year forecast period**. Additionally, 7,353 jobs would be lost annually in the U.S. economy and labor income (wages and salaries) would fall \$4.52 billion. Finally, U.S. GDP would contract \$7.791 billion over the forecast period (Figure 12).

Figure 12: Forecasted Cumulative 10-Year Impacts of Changes in Corn Wet Milling on the U.S. Economy

Impact	Annual Avg. Employment	Labor Income	US GDP	Output
	<i>Full-time Equiv.</i>	<i>Million USD, 2022 dollars</i>		
Direct	-352	-\$444.49	-\$1,116.53	-\$6,571.86
Indirect	-4,563	-\$2,637.83	-\$4,133.05	-\$10,043.41
Induced	-2,438	-\$1,432.76	-\$2,541.56	-\$4,533.80
Total	-7,353	-\$4,515.08	-\$7,791.14	-\$21,149.07

Source: World Perspectives, Inc.

Total Impact of All Shocks to the U.S. Economy

IMPLAN models of each of the specific industry impacts identified above offer specific insights as to how shocks to those sectors would create economy-wide impacts in the U.S. It is the summation of these individual impacts, however, that allows for examination of the full, collective shock to the U.S. economy. Figure 13 shows the total impact of

Mexico's GM corn ban on the U.S. economy by aggregating the shocks of 1) lost U.S. farm revenue, 2) contraction in the rail industry, 3) changes in the ethanol industry, and 4) changes in the corn wet milling sector.

IMPLAN results indicate that over the 10-years following a Mexican ban on GM corn, **the U.S. economy would lose \$73.89 billion in economic output and GDP would contract by \$30.55 billion over 10 years** (Figure 13). Additionally, the U.S. would lose 32,217 jobs annually during the forecast period and labor income would fall \$18.38 billion. Clearly, a policy by Mexico that would ban corn and corn product imports would have stark consequences for the U.S. economy, its consumers, and workers.

Figure 13: Forecasted Cumulative 10-Year Impacts of All Predicted Changes on the U.S. Economy

Impact	Annual Avg. Employment	Labor Income	US GDP	Output
	<i>Full-time Equiv.</i>	<i>Billion USD, 2022 dollars</i>		
Direct	-6,052	-\$3.36	-\$5.35	-\$23.57
Indirect	-16,196	-\$9.17	-\$14.81	-\$31.79
Induced	-9,969	-\$5.86	-\$10.39	-\$18.53
Total	-32,217	-\$18.38	-\$30.55	-\$73.89

Source: World Perspectives, Inc.

To provide additional clarity on the calculations of the total impacts on the U.S. economy, Figure 14 provides an overview of each of the individual impacts analyzed in this section.

Figure 14: Summary of Estimated Shocks to U.S. Economy and their Broader Impacts

Modeled Event	Direct Impact	Cumulative Impacts to American Economy ¹			
		Annual Avg. Employment Change	Labor Income	GDP	Economic Output
		<i>Full-time equivalents</i>		<i>Million USD, 2022 dollars</i>	
Changes in Corn Farming Revenue	-\$13.61 billion in lost output	-21,663	-\$11,255	-\$17,982	-\$43,255
Added Costs for Grain Segregation and IP ²	\$11.8 billion	N/A	N/A	N/A	N/A
Added Costs for Genetic Testing of Exports ²	\$70.33 million	N/A	N/A	N/A	N/A
Changes in Rail Export Volumes	-\$3.3 billion in lost output	-2,795	-\$2,311	-\$4,182	-\$7,780
Changes in Ethanol Industry	-\$521.5 million in lost output	-406	-\$303	-\$597	-\$1,711
Changes in Corn Wet Milling Industry	-\$7.65 billion in foregone output	-7,353	-\$4,515	-\$7,791	-\$21,149
Total	N/A	-32,217	-\$18,385	-\$30,552	-\$73,895

¹ Sum of direct, indirect, and induced impacts

² Due to the uncertainty of how these costs could be passed through the economy, the impacts on the broader U.S. economy were inestimable

Source: World Perspectives, Inc.

Impacts on Canada's Economy

The U.S. and Canadian economies are closely linked, and the farm sector is no exception. This reality means that shocks in the U.S. farm sector are transmitted across the border and create impacts on the Canadian economy as well. Consequently, a move by Mexico to ban GM corn would not only impact the Mexican and U.S. economies, but Canada's

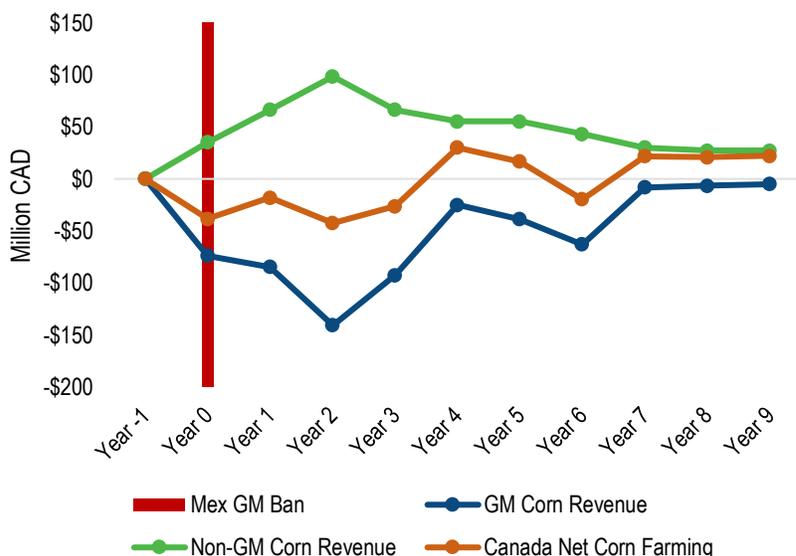
as well. Historically, Canada has only infrequently provided direct corn exports to Mexico, and at small volumes. Customs data, however, likely underestimates the volume of corn shipped from Canada to the United States that is then re-exported to Mexico.

Perhaps more importantly, the U.S. and Canadian grain handling systems are closely linked due to the importance of trade between the two countries. Academic research (McKnight, et al 2021) has found that these links allow for significant price transmission in the two countries' commodity markets. For the current study, that means that price impacts in the U.S. market due to a Mexican ban on GM corn would similarly be felt in the Canadian grain markets. As noted in the March 2022 Crop Life International study, "Mexico's new policy will adversely impact all three members of the U.S.-Mexico-Canada-Agreement on trade" (World Perspectives, Inc., 2022, p. 19).

Based on historic relationships¹³ between U.S. and Canadian corn prices, this study finds that Canadian GM corn prices would fall 2 percent each of the first three years after a Mexican ban on GM corn. Conversely, non-GM corn prices in Canada would rise 21 percent in the first year of the ban and 3 percent the next. As in the U.S., Canadian non-GM corn acres would expand modestly in the first two years before seed availability allows for a full adjustment. The Canadian GM corn farming sector would see acreage and production decline in Years 1 and 2 (the first two years in which farmers can alter planting decisions) before slowly trending higher, but the sector's production would remain below baseline forecasts through Year 9.

Over the 10-year forecast horizon, this study predicts the Canadian corn farming sector would suffer a net revenue loss of \$33.94 million. Net gains to the non-GM farming sector would offset losses in half of the forecast years, but the net losses early in the forecast period outweigh later gains (Figure 15).

Figure 15: Estimated Changes in Canadian Corn Farming Revenue Following Mexico's GM Corn Ban



Source: World Perspectives, Inc.

The economic impact of the lost \$33.94 million of revenue from the corn farming sector would have impacts on the broader Canadian economy. IMPLAN results indicate the net impact on Canada's economy would be \$39.73 million in lost GDP and \$92.85 million in reduced economic output over 10 years (Figure 16). Additionally, 44 full-time jobs would be lost annually, and Canadian labor income would fall \$15.23 million.

¹³ WPI estimates U.S. and Canadian corn prices have a 0.88 correlation coefficient and regression analysis indicates U.S. corn prices explain 77 percent of the variation in Ontario, Canada prices.

Figure 16: Forecasted Cumulative 10-Year Impacts to Canada's Economy from Changes in Corn Farming

Impact	Annual Avg. Employment	Labor Income	Canada GDP	Output
	<i>Full-time Equiv.</i>	<i>Million USD, 2022 dollars</i>		
Direct	-18	-\$3.59	-\$14.81	-\$41.21
Indirect	-19	-\$8.33	-\$17.76	-\$39.41
Induced	-7	-\$3.31	-\$7.16	-\$12.23
Total	-44	-\$15.23	-\$39.73	-\$92.85

Source: World Perspectives, Inc.

The Canadian farming and grain handling sectors would not only see changes in the acreage mix and prices, but also fundamental shifts in how corn is traded, handled, and transported. Despite Canada's historically lower volume of corn exports to Mexico, the linkages between the U.S. and Canadian grain industries dictate that Canadian firms would have to adopt measures to segregate and identity-preserve GM and non-GM grain. This is especially true if, as this study finds, that Canada exports small volumes of non-GM corn directly to Mexico during the years until the U.S. fully supplies Mexico's non-GM import needs. Given the small role that Canada has historically played – and is forecast to continue playing – in supplying Mexico with corn, it is doubtful the Canadian grain system would bifurcate into two systems for handling GM and non-GM corn. As noted in the March 2022 Crop Life International study, "This is a possible outcome, but it is uncertain that it is a necessary one" (World Perspectives, Inc. 2022, p. 20). Rather, the Canadian grain industry would likely adopt an approach that sufficiently segregates and identity-preserves non-GM corn via the easiest, least expensive option available.

As discussed in the March 2022 version of this study, the easiest method for Canada to achieve these goals would be by a "segregation by channeling" approach. That is, certain facilities handle non-GM corn on certain days or companies alternate which sites receive and ship the crop (Elbheri, 2007; World Perspectives, Inc., 2022). Consistent with the approaches in the earlier version of this study, WPI estimates this approach would cost the Canadian grain handling industry \$5.81/bushel for the first two years of implementation, after which the cost would fall to \$1.45/bushel. The decreasing cost would be expected to occur as operations become more streamlined and efficient.

The 10-year cost of adopting "segregation by channeling" in the Canadian grain industry is predicted to reach \$366.87 million. Note that the costs of segregation would be imposed on all corn originated and handled in Canada, not just non-GM corn. It is also important to remember that "these are costs incurred by Canadian firms to simply retain efficient trade capabilities with the U.S. and that Canadian firms do not receive additional marketing opportunities to offset the cost increase" (World Perspectives, Inc., 2022, p. 20).

Just as in the U.S. grain handling industry, it is unclear how the \$366.87 million of segregation and IP costs would be transmitted through the Canadian economy. Canadian grain originators may lower bids to farmers for grain or may charge higher prices to downstream customers, with the latter likely ultimately resulting in higher prices for Canadian consumers. Some of these costs could be passed directly to Mexico via higher prices or surcharges for direct exports to the country or possibly offset in similar manner with exports to the U.S. Ultimately, determination of who or which economic sector would bear these costs is complex and inestimable in the presence of myriad possible outcomes (Desquilbet and Bullock, 2009).

Impacts on Future Innovation

A significant impact of a policy by Mexico that intentionally limits GM traits or crop production is the suppressive effect on future genetic technological innovation. Mexico is currently withholding approval of 21 GM traits, which is causing technology companies to question future research and trait deployment schedules. The negative impacts of reduced technology development and utilization would not only accrue to the farming or seed industries, but are net societal

losses collectively experienced by producers and consumers alike. As noted in the March 2022 version of this study (World Perspectives, Inc., 2022), there are three particularly important factors to consider in this analysis:

1. The industry's ability to develop genetically improved varieties has accelerated over time due to low-cost genome sequencing and "high-throughput molecular phenotyping technologies. Practically, this means that the *opportunity cost to society of GM trait approvals or suspensions increases over time* (World Perspectives, Inc., 2022).
2. Regulatory uncertainty can divert research and development efforts away from crops and asynchronous approvals over the 2005-2015 period caused regulatory costs to increase 50 percent (Cossey, 2016; Kalaitzandonakes, et al. 2016).
3. Larger regulatory costs affect small market crops and small, innovating firms disproportionately, leading to greater industry concentration and a possible lack of competition (Sachs 2016; Fuglie, et al., 2011).

Environmental Impacts

GM and non-GM crops each have their own impacts on the environment, and researchers have studied, compared, and detailed these environmental considerations for decades. This wealth of literature allows for extrapolations to be made about the possible environmental impacts that could occur if Mexico bans GM corn. Notably, however, a ban on GM crops would likely stifle innovation of new genetic traits, which would create larger, adverse environmental impacts in the long run than is estimated below.

Intensive GM Versus Extensive non-GM Agriculture

Depending on the crop and variety in question, GM crop yields are generally higher than their non-GM counterparts. GM corn yields tend to average 8-24 percent more than non-GM varieties, though certain trait selection (drought tolerance, for instance) may reduce yields in exchange for other agronomic benefits. Using an average yield difference of 10 percent, however, it requires 3.84 million acres (2.556 million hectares) of land under GM corn to fill Mexico's 17.3 MMT import program. If those imports were required to be non-GM, the resulting yield loss would require an additional 0.396 million acres (160,000 hectares) of cropland area. For context, this is roughly the summed area of three of Mexico's larger national parks (*the Reserva de la Biosfera El Pinacate y Gran, Nevado de Toluca National Park, and the La Malinche National Park*).

Chemical Input Usage

Broadly speaking, while GM cropping systems typically use pesticides and herbicides, the compounds they use are often less environmentally damaging than those employed in non-GM or organic systems. Additionally, the chemicals used in non-GM and organic cropping systems are typically more expensive than those for GM production systems. Klumer and Qaim (2014) found that GM cropping systems reduce overall chemical input use by 37 percent and Romeis, et al. (2019) found that *Bacillus thuringiensis* (Bt) crops "can contribute to more effective biological control of both target and non-target pests." Further, Benbrook (2012) estimated that Bt-corn reduced insecticide application by 0.2 kg per hectare (0.174 pounds per acre). Extending the findings of Benbrook (2012) to predict the increased chemical application across the land (baseline acres plus the additional area that would be required to compensate for lower non-GM yields) that would be used to fill Mexico's proposed policy change, the pesticide burden would increase by 1.76 million pounds.

No-Till Agriculture

Adoption of GM crops has allowed farmers around the world to reduce or avoid tillage practices that increase greenhouse gas emissions and topsoil loss. Among other benefits, no-till farming (or other conservation tillage practices) reduces nitrous oxide (N₂O) emissions by 57 percent from conventional tilling approaches (Omonode, et al. 2010). Nitrous oxide emissions from corn farming range from 1-3.2 tons of carbon dioxide (CO₂) equivalent per hectare with no-till emissions falling at the low end of that range (Omonode, et al. 2010). In the U.S., no-till cultivation accounts for 20 to 48 percent of various cropping systems, with some 27 percent of corn farms using no-till or reduced-till

approaches. If Mexico were to adopt a ban on GM corn imports, the expansion of U.S. non-GM (and, by extension, full-till) acres would likely cause 1.03 million acres (0.42 million hectares) to lose conservation tillage status and be subject to greater topsoil loss potential and greenhouse gas emissions. Specifically, this study estimates that N₂O emissions from land formerly in no-till practices would likely add 653,000 tons of carbon dioxide-equivalent N₂O emissions¹⁴.

Impacts on Mexico's Economy and Consumers

Key Takeaways

Almost 70 percent of the Mexican diet contains some amount of corn and would be impacted by the GM corn ban.

Mexico's proposed GM corn ban would likely result in a 19 percent increase in the average cost of corn over the 10-year forecast period. This would have a direct impact on consumers, including tortilla prices that are 16 percent, on average, from their baseline value over 10 years.

Over 15 percent of daily energy intake is from tortillas (likely higher for low-income consumers) and tortilla prices would increase up to 30 percent.

Processing commodities makes them safer, more affordable, nutritious, abundant, and durable – it increases variety and ensures food security. Almost half the Mexican diet is comprised of processed and ultra-processed foods, typically containing some element (starch, protein, fiber, and oil) of corn, and their costs would rise.

Most corn is fed to livestock and poultry as the most widely consumed animal protein, especially by those with lower incomes. The cost of feeding poultry would rise by nearly 35 percent.

Poultry consumption is highly elastic, rising or falling based on its share of disposable income. The cost of poultry would rise by 66.7 percent, causing consumption to fall by 78 percent down to 29.79 kilos per capita. That is a return to the level of poultry consumption from 13 years ago.

Mexico has the highest per capita consumption of eggs in the world. Like other livestock products, their costs would rise under a GM corn ban but the impact on the industry would be split. Higher income consumers would substitute higher cost animal proteins for eggs, but poorer Mexicans would go from viewing eggs as a necessity to a luxury good.

Mexican per capita consumption of animal protein is well below that of other North Americans, and consumption would fall as its cost rises, risking human health, particularly for pregnant and lactating women.

Imports currently account for about 18 percent of total domestic chicken meat consumption. Because cheaper conventional corn would be used to feed animals in other countries, Mexican consumer preferences would switch to imported meat, poultry, and other products. This would cause a contraction in Mexico's \$25 billion livestock industry.

Components of corn (starch, oil, fructose, dextrose, etc.) are used in hundreds of non-food products, potentially adding GM/non-GM corn segregation costs. GM corn is used in the production of pharmaceuticals and their importation and production in Mexico could be adversely impacted.

The GM corn's impact on food prices would adversely impact most of the Mexican population, especially the nearly half of the population (55.7 million people) considered to be living in poverty.

¹⁴ Based on 1.03 million acres being converted from no-till practices to full-till with a 57 percent increase in N₂O emissions from a baseline emission rate of 0.404 tons of CO₂-equivalent emissions per acre.

Corn in the Mexican Diet

The importance of corn in both the Mexican diet and Mexican culture is highlighted by the many sayings around this important grain, including “*Sin maíz, no hay país*” (“without corn, there is no country”), “*somos la gente del maíz*” (“we are the people of corn”), “*el maíz es vida*” (“corn is life”), “The food with which the gods chose to feed mankind,” among others. Corn is a symbol of Mexico itself.

So important is corn in Mexico that there are multiple words for it: including *maíz*, *mazorca*, and *elote*. It is important in urban and rural populations alike. There are three major components in the Mexican diet that are dependent on corn: tortillas, processed foods, and livestock products.

Tortillas: Most tortillas in Mexico are made of corn; they are one of the most direct sources of corn-based calories in the Mexican diet, delivering 300-372 calories or one-eighth to one-fifth of daily energy intake. It is estimated that an average of six tortillas per capita are consumed each day with a value of over 50 billion pesos a year.

Processed Foods: Almost half the average daily caloric consumption in Mexico (902.3 calories) is composed of processed and ultra-processed foods (fats and oils, sweeteners, breads, cheeses and other dairy products like yoghurt, snacks, baked goods, tomato-based products, etc.) The average dietary composition as curated by the Mexican National Health and Nutrition Survey is in [Appendix B – Average Composition of Mexican Diets](#).

Importantly, some estimates find that up to three-quarters of processed and ultra-processed food products contain some derivative from corn (starch, oil, fructose, dextrose, etc.). [Appendix C – Uses of Corn Wet Milling Products](#) lists more than 60 food, pharmaceutical, and industrial uses of wet-milled corn products.

Most agricultural commodities are processed to some degree before reaching consumers. Various processes are used to make food safer, more nutritious, tasteful, and more durable. Processing foods also provides consumers with greater variety and increased food security. Corn is heavily used in processed foods because it has a long shelf life and is relatively inexpensive. Its use in food processing fundamentally enables the feeding of the masses affordably, deliciously, abundantly, and conveniently.

The GM corn ban would not only raise the price of corn but also its components - starch, protein, fiber, and oil. This means that the thousands of processed foods distributed by tens of thousands of Mexican food retailers would all incur price increases. Even a GM corn ban applied just to food would cause increases in the price of processed foods because the component parts of corn would have to be segregated, traced, and labeled to ensure a bifurcated system. This would be especially challenging and costly in the use of corn oil since it generally contains only trace amounts of low-quality genetic information (DNA and RNA) after treatment with heat and pressure.

Moreover, if GM corn is limited to non-food use, there are hundreds of industrial products utilizing corn, including products derived from corn-fed animals. These include soaps, fine bone china, beer filtration, cement, instrument strings, tires, fireworks, plastics, pharmaceuticals, shoe polish, sandpaper, carpeting, diapers, toothpaste, shampoo, etc. Again, corn keeps these products more affordable, sustainable, biodegradable, etc.

While corn-derived ingredients may sometimes be only a small part of the price of a finished product, they still contribute to the relative cost of the Mexican diet. Moreover, the price of food has a greater impact on lower income countries, specifically on lower income consumers. It is estimated that 20 percent of the Mexican population lacks access to food, and over 43 percent are considered in poverty. The lower the income, the more important corn is to the diet.

Meat in the Diet: Approximately one-fifth of Mexican daily dietary intake is from livestock products (Figure 17). Meat is an important source of protein, and its consumption is subject to change based on price and income. Mexicans in general - especially poorer Mexicans - consume more chicken than beef or pork, a consumption that has increased in recent decades as prices have fallen due to improved technology.

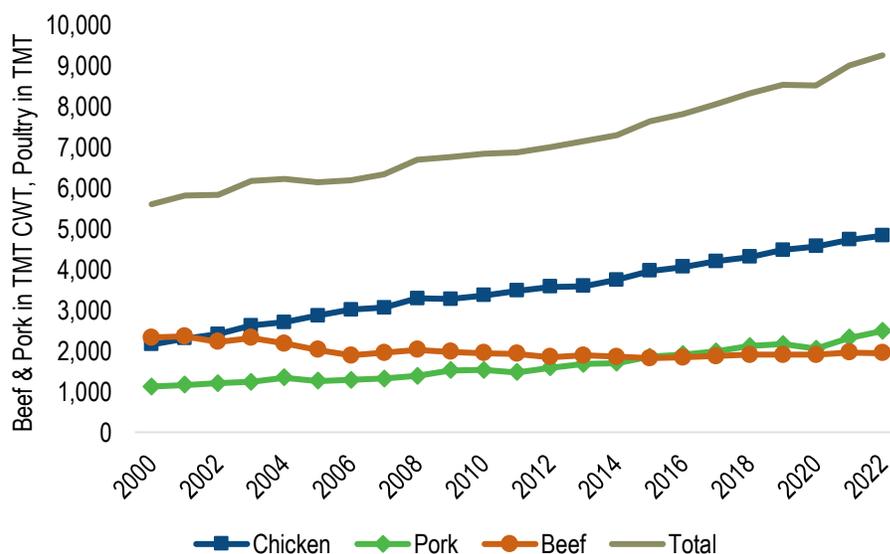
Figure 17: Caloric Intake in Mexican Diets from Livestock Products

Caloric Source	Calories
Red Meat	105.2
Milk	81.9
Poultry	74.2
Eggs	39.3
Cheese	45.1
Yoghurt	30.5
Sausages/Processed Meat	31.2
Ultra-Processed Cheese	10.5
Livestock Products Total	417.9
Non-Livestock Products	1,505.3

Source: Cambridge Core

Over the past 20 years, the consumption of chicken has increased more than 84 percent, pork disappearance is up by 101 percent, while beef demand has fallen by 16 percent (Figure 18). Part of the increase in poultry demand is due to the 30 percent increase in population, but per capita consumption has mostly grown due to improved affordability. Due to inflation, there has only been a small increase in real income and thus purchasing power for a large share of the population.

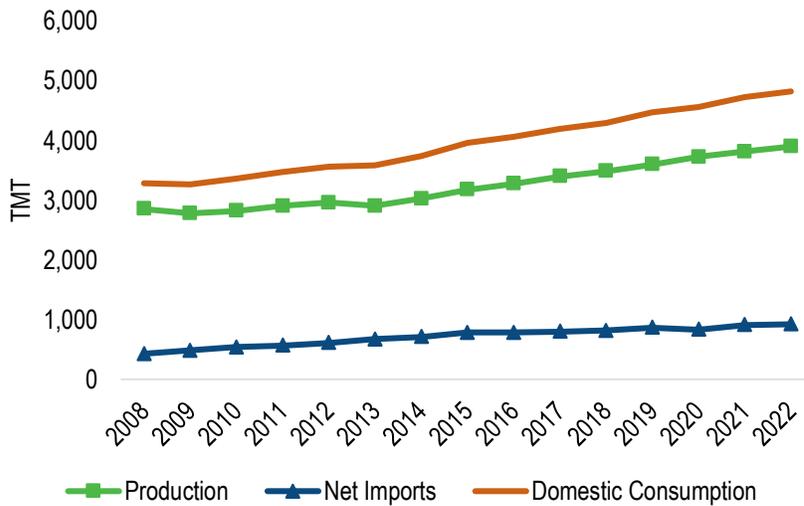
Figure 18: Meat Consumption Trends in Mexico



Source: USDA FAS, World Perspectives, Inc.

Since 2008, increased poultry production, combined with imports, have worked to lower the relative price of poultry meat, and thus boosted consumption by 29 percent to over 38 kilograms per capita (Figure 19). Chicken meat represents nearly 60 percent of the total muscle meat consumed in Mexico.

Figure 19: Mexican Poultry Market Trends



Source: USDA FAS

The Impacts of Inflation on Consumers

Between 2000 and 2020, the UN Food and Agriculture Organization (FAO) calculates that food price inflation in Mexico averaged 3.37 percent annually. That is around half the rate of general inflation in the economy. In real terms, chicken was more affordable in 2018 than it was in 1998.

Since the covid-19 pandemic began in 2020, meat and egg price inflation has exceeded that of core inflation. More recently, chicken meat prices have been inflating at a smaller rate to that of beef, pork, or even eggs. Additionally, the price of corn hit record highs in Mexico in 2022 (Figure 20), due largely to the impact of Russia's invasion of Ukraine and production issues in major exporting countries.

Figure 20: Monthly Mexican Corn Prices, July 2002 - June 2022

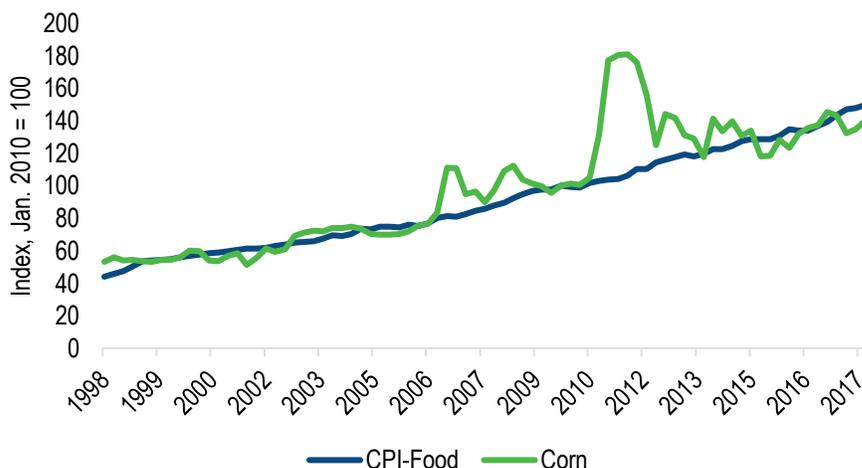


Source: USDA, World Bank

Corn prices play an important role in Mexico's food inflation rate and the two metrics are highly correlated. Regression analysis indicates a 1 percent increase in the average white corn prices in Mexico's primary producing states of Jalisco

and Sinaloa, corresponds to a 0.81 percent increase in Mexico’s country-wide Consumer Price Index (CPI) for food¹⁵ (Figure 21). The relationship between imported yellow corn prices and Mexico’s food CPI is not as strong, but linkages between yellow and white corn prices still have implications for food inflation. Specifically, a ban on GM corn would cause an increase in yellow corn prices, which would impact white corn prices and, by extension, Mexico’s food CPI. Additionally, the relationship between imported yellow corn prices and poultry meat, discussed in detail later in this report, indicate Mexico’s food inflation would also increase due to higher meat values under a GM corn ban.

Figure 21: Relationship Between Mexican Corn Prices, and the Consumer Price Index for Food



Source: St. Louis Fed, SNIIM, World Perspectives, Inc.

Note: Corn prices are the average of those in Jalisco and Sinaloa.

The Inflationary Impact of the GM Corn Ban

The Mexican government is highly attuned to the impact of inflation on the population. Earlier this year, it presented 16 measures to bring down food costs, especially for the poorest populations. This included removing import duties on maize. Price controls were even considered. As noted in the modeling section of this report, the GM corn ban would increase the cost of corn by an average of 19 percent over the 10-year forecast period.

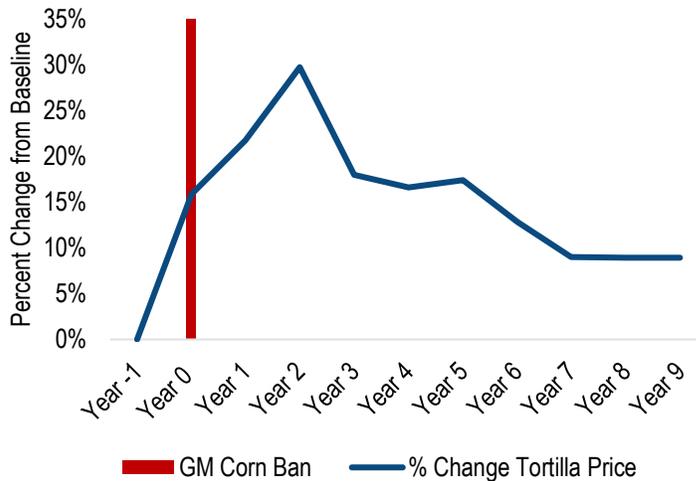
The Impact on Tortillas

According to a national survey conducted by Reforma, 77 percent of Mexicans eat tortillas daily and the overwhelming majority are made from corn. It is estimated that an average 6 tortillas are consumed daily. At approximately 52 calories per tortilla, they represent more than 15 percent of daily energy intake, and likely a more significant source for lower income Mexicans.

Wise (2012) found that “a 20% increase in corn prices... transmitted to the Mexican market for white corn, raises tortilla costs by 14%” (pp.10) Following our earlier approach (World Perspectives, Inc. 2022), WPI uses this finding to estimate the impact a Mexican ban on GM corn would have on tortilla prices. Our findings indicate that **in the first year of a GM corn ban, tortilla prices would rise 16 percent, followed by a 22 percent increase the following year and a 30 percent increase in the third year of a ban, versus what would have otherwise occurred. On average, under the GM corn ban, tortilla prices would increase by 16 percent from baseline forecasts** (Figure 22).

Figure 22: Mexican Corn Tortilla Prices Predicted Percent Change from Baseline Price Forecast

¹⁵ Based on ordinary least squares regressions. Coefficients were significant at the 5% level with an R² value of 0.85.



Source: World Perspectives, Inc.

The Impact on Processed Foods

Because processed foods are a significant part of the Mexican diet and most contain some element of corn (starch, oil, fructose, dextrin, etc.), their prices would increase under the GM corn ban. Additionally, there may be significant segregation and traceability costs applied.

Non-Food Products

Corn is not only ubiquitous in food but is also used in many non-food products, including pharmaceuticals and construction materials. [Appendix C – Uses of Corn Wet Milling Products](#) lists more than 60 food, pharmaceutical and industrial uses of wet-milled corn products. They include plastics, batteries, cosmetics, paper, packaging, baby diapers, vitamin C, textiles, adhesives, toothpaste, dish detergent, paper, clothing dyes, and soaps, etc. All these products could be impacted because the decree calls for the banning of GM corn imports for human consumption, and the Mexican government has ceased approving new GM traits for use in imported corn. Products containing traits unapproved in Mexico would eventually become more dominant.

The Impacts on Crop Production, Food Security, and Human Health

Impact on Crop Production

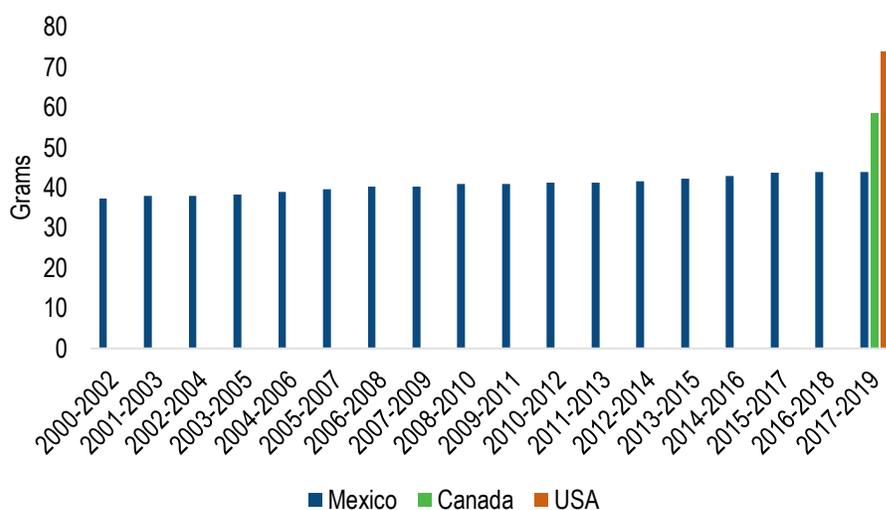
The University of Saskatchewan [studied](#) Mexico's proposed corn ban and made several conclusions:

- The “agroecology” approach to producing corn now favored by the Mexican government yields, on average, 31 percent less than conventional corn production practices.
- The policy would hurt Mexico's livestock feed markets and meat production facilities.
- The last time an agricultural transformation of this level occurred in Mexico (ejido reform in 1992), an average of 400,000 Mexicans (mostly from poor rural areas) migrated to the US annually for the following five years.

Adverse Impacts on Health

Over the past couple of decades, Mexico's available supply of animal origin protein has risen by nearly 18 percent to an average of 44 grams per capita per day (Figure 23). However, that is still well below levels achieved by other North Americans and below the daily recommended protein intake levels of 56 grams for men, 52 grams for teenage boys, and 46 grams for women and teenage girls. Because products would become significantly more expensive and meats like poultry are highly elastic in the Mexican diet, consumption is likely to decline.

Figure 23: Daily Per Capita Animal Protein Consumption in North American Countries



Source: UN FAO, *World Perspectives, Inc.*

Impact on Food Security

According to the USDA FAS, at least 10 percent of the Mexican population lacks access to adequate food (USDA FAS, 2010). This number doubles or triples in the nine poorest Mexican states, mostly in the south. The price of corn is the single largest indicator of access to food for this segment of the population, and the proposed GM corn ban would increase the price of tortillas by an average of 16 percent over the 10-years following a ban.

Mexico's National Survey of Household Income and Expenditure (ENIGH) evidences the vulnerability of lower income deciles to food price increases. With the lowest income decile spending an average of 52 percent of their total expenditures on food, plus the fact that corn and corn-derived products represent a significant share of calories, the rise in corn prices in Mexico would have a more severe adverse impact on food security for Mexico's poorest people.

Impacts on Mexico's Livestock Operations

Feed costs represent the largest cost for livestock operations and account for 50-70 percent of expenses, depending on the type of operation. Consequently, a Mexican ban on GM corn would have important implications for the livestock industry. Faced with higher prices for corn and feedstuffs to substitute for DDGS, livestock producers would see profit margins fall to the point where future production intentions would be altered. This section examines the likely impacts on the Mexican livestock industry that would arise from a policy banning imports of GM corn and corn products.

Corn plays a key role in feed rations for North American livestock operations. In the U.S. and Mexico, broiler (i.e., meat chicken) feed rations typically contain 59-64 percent corn and 25-30 percent soybean meal (Mavromichalis, n.d.). Similarly, swine diets in Mexico are composed of 57-77 percent corn, 16-20 percent soybean meal, and 0-5 percent DDGS. Finally, WPI's research indicates feedlot cattle diets are made up of 56 percent corn and 24 percent DDGS, with the balance being vitamins, minerals, and other feed additives. Dairy cattle rations are similar to beef cattle, with the exception that corn inclusion is lower (40 percent) and hay or other roughage sources compose 15-20 percent of the ration. Given these statistics, it is clear that corn supplies and prices are critical to the outlook for the Mexican livestock industry, and access to cost-effective grain is a benefit for producers.

There are two primary factors to consider when evaluating the impact of a policy shift restricting GM corn and corn product imports on the Mexican livestock industry: higher corn prices and the need to substitute alternative feedstuffs for DDGS. The first impact, higher corn prices, has already been detailed earlier in this study and needs only be incorporated into estimates of how livestock feed ration prices would change. For the second impact, substituting

DDGS, WPI assumes livestock rations would revert to formulations used before the expansion of ethanol and DDGS production in the U.S. For example, before DDGS were commonly included in swine diets, soybean meal composed 14-29 percent of rations with corn or other energy feeds contributing 65-80 percent (Reese, et al., 2000; van Heugten, Schell, and Jones, 2006). The balance of the ration was composed of vitamins and minerals, or other protein meals (e.g., alfalfa meal). For this study, WPI assumes Mexico's livestock sector would suspend use of DDGS in rations and increase corn and other protein meals (e.g., soybean meal or cottonseed meal) consumption. Note that the increased use of corn in the livestock diets would exacerbate the impact of higher non-GM corn prices.

Based on the feed rations noted above and predicted price changes in substitute feed ingredients (including soybean meal), this study finds that **the Mexican livestock sector would see an average increase in feed costs of 13.7 percent over the 10-year forecast period** (Figure 24). This accounts for the increased price of corn as the industry switches to non-GM grain, the cost of substituting soybean meal for DDGS, as well as other substitution effects (e.g., feeding sorghum to replace a portion of corn in the diet). The cost increases would be the greatest in the first three years of a ban on GM and non-GM corn. Notably, broiler ration costs would average 23 percent more than the baseline forecast in the first three years.

Academic research on the influence of higher feed prices on livestock production is highly mixed. Some studies (Hee Suh and Moss, 2014) find that livestock production may be unresponsive or even increase relative to feed price increases, due partly to producer beliefs that the price increases would be short-lived, as well as the biological time lag to make production adjustments. Still, others (Kapombe and Coyler, 1998; Taheripour, Hertel, and Tyner, 2009; Deppermann, et. al, 2018) find that higher feed prices indeed cause reductions in livestock production and increase prices for meat, poultry, and dairy products. In nearly every case, the elasticity of livestock production – including broilers, hogs, and beef and dairy cattle – has been proven to be highly inelastic relative to feed cost increases. That is, a 1 percent increase in feed costs creates a much smaller decrease in livestock output.

While a great body of research exists detailing the influence of meat and grain prices on demand for each of those products, there seems to be a lack of recent work examining the influence high feed costs exert on producers' forward-looking production intentions. Further, there seems to be no research examining the point at which high feed prices cause producers to exit the industry. Despite the lack of literature relevant to this precise topic, WPI was able to draw from some publications (Kapombe and Coyler, 1998; Taheripour, Hertel, and Tyner, 2009; Deppermann, et. al, 2018; O'Malley and Searle, 2021) and our own proprietary research to estimate the Mexican livestock sector's likely response to a ban on GM corn and corn products.

In response to higher feedstuff prices that would be created, **Mexican livestock production falls by an average of 1.2 percent annually over the 10-year forecast period**. Due to shorter biological production times and lower relative ability to substitute corn in feed rations, the poultry and hog sectors see the greatest contraction over the forecast period. The beef and dairy sectors, due to the multi-year time lags in expanding or contracting production, see smaller overall output losses. Over the 10-year forecast period following a possible ban on GM corn, **poultry production in Mexico would likely fall 17 percent in total while hog production would contract 13 percent**. Both the **beef and dairy sectors see their industry's output fall 9 and 8 percent**, respectively. The details of each industry's predicted feed cost and output changes are detailed in Figure 24. WPI estimates that the **lost production from the Mexican livestock sector would cost the industry a cumulative \$3.69 billion in revenue over 10 years**.

Figure 24: Predicted Changes in Mexican Livestock Feed Ration Costs and Industry Production

10-Year Avg. Annual Pct. Change	10-Year
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	Feed Cost vs. Baseline	Industry Output	Cumulative Output Change
Poultry	14.7%	-1.7%	-16.6%
Hogs	16.7%	-1.3%	-13.1%
Beef	12.6%	-0.9%	-8.7%
Dairy	11.0%	-0.8%	-8.0%

Source: World Perspectives, Inc

Finally, it must be noted that the reduction in livestock production would likely cause consumer prices for livestock products to increase. Determination of exactly which products would see price increases is exceptionally complex as it depends not only upon the supply of specific products, including domestic and imported sources, but upon Mexican consumers' purchasing decisions. In the presence of significant declines in disposable income (as expenditures on corn-based staple products, like tortillas, increase), the Mexican consumer income matters a great deal. These combined effects of lower livestock product supplies and reduced consumer purchasing power make determination of the price impacts beyond the scope of this study.

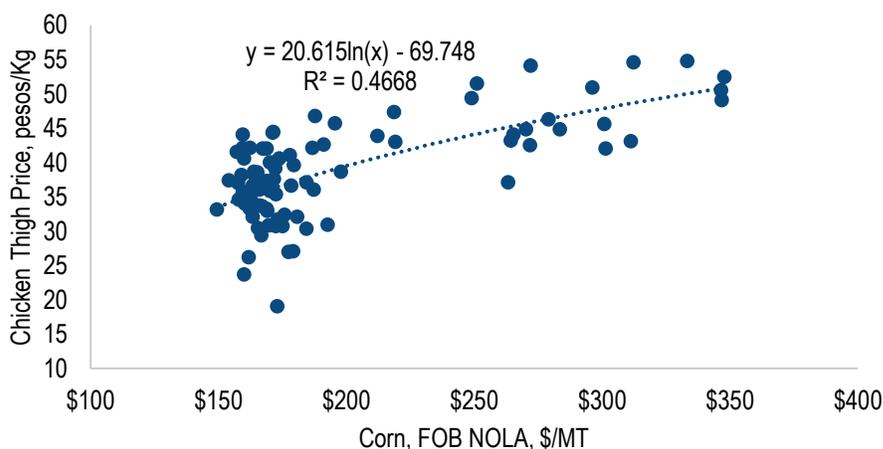
While precise determination of the impact on all livestock products is beyond this study's scope, it does briefly analyze the impact to two products important to Mexico: poultry meat and eggs. An analytical focus on eggs and poultry is important as poultry meat is the largest animal protein in the average Mexican diet and because Mexico has the highest per capita consumption of eggs.

The Impact on Poultry Meat

This analysis focuses specifically on poultry leg meat as a mid-priced product affordable to a larger share of the population. As noted previously, the price of corn and overall food prices in Mexico are highly correlated (Figure 25). Corn represents 60-73 percent of the broiler chicken feed ration and the National Union of Poultry Producers (UNA) estimates that feed represents 61 percent of the cost of producing broilers in Mexico. Since corn is a key component in growing chickens, its price is also highly correlated to what Mexican consumers pay for chicken.

Researchers at the Universidad Autónoma del Carmen, Universidad Autónoma Chapingo and the Colegio de la Frontera Sur-Unidad Campeche used an almost ideal demand system (AIDS) and parsed the data from the FAO and SAGARPA (Vargas-Lopez, et al 2022). They estimated that the Hicksian own-price elasticity of demand for chicken meat in Mexico was 1.171, which means a 1 percent change in price creates a 1.171 percent change in demand. Since most of the population is lower income (63.5 percent earn less than two minimum wages), and chicken meat is their primary protein source, it is notable that the elasticity is higher for poultry than for beef or pork. Based on estimates of the feed costs increases and using the 1.171 percent own-price elasticity for poultry meat, this study estimates the **purchase cost of poultry meat would rise by 66.7 percent**. Higher poultry prices mean that **poultry meat consumption could fall by 78.1 percent** under a GM corn ban. Additionally, **average per capita poultry meat consumption would drop from 38.15 kilos to 29.79 kilos, the same level it was 13 years ago**.

Figure 25: Correlation Between U.S. FOB NOLA Corn and Mexican Poultry Meat Prices



Sources: DTN; SNIIM, World Perspectives, Inc.

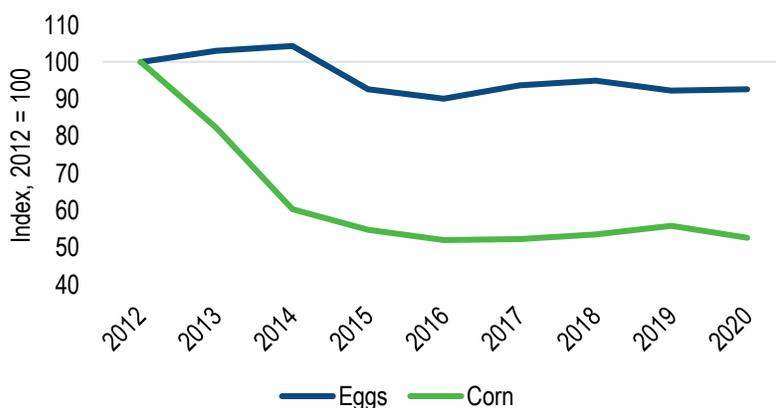
This policy is likely to hurt the state of Veracruz the most since its broiler producers are the most dependent on imported corn and are also the largest producers in Mexico. Producers in Aguascalientes and Queretaro are closer to markets but face higher freight costs for feed.

The Impact on Eggs

Mexico is the third largest producer of eggs in the world and has the highest per capita consumption of eggs (409/year). According to the Unión Nacional de Avicultores, Eggs are the second largest source of protein (17 percent) in the Mexican diet following poultry meat (39 percent). Eggs are the lowest cost source for protein in Mexico because they are the most efficient conversion of grain into animal protein. The feed conversion ratio (FCR) for eggs at 2:1 is only surpassed by some species of farmed fish.

The FCR for eggs in Mexico would be slightly less efficient since production includes backyard hens that are not fed an optimal diet. But the dynamic in Mexico that egg prices are highly correlated with corn prices is a dynamic that is true around the globe (Figure 26).

Figure 26: Index of Global Corn and Egg Prices



Source: UN FAO, CME Group, World Perspectives, Inc.

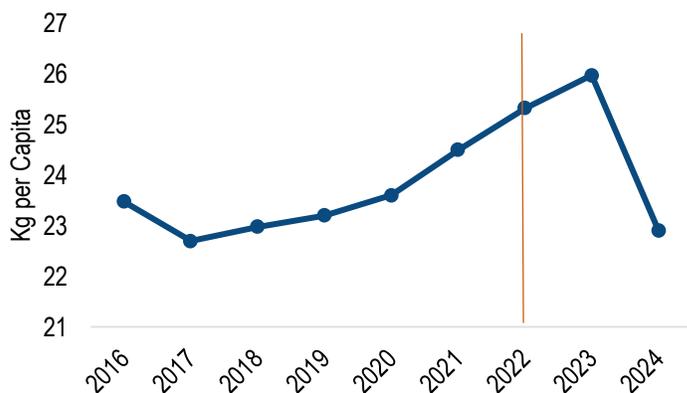
Mexico's consumers are considered extremely sensitive to food pricing, and a ban on GM corn would impose a shock on Mexico's egg industry. The pandemic introduced a similar shock where access and utilization of food was adversely

impacted. Although Mexican per capita egg consumption rose 1.7 percent in 2020, even as the economy fell 8.2 percent, part of the increase was the result of more affluent consumers trading down from costlier protein sources. Mexico’s poorer consumers are more dependent on low-cost eggs as a primary protein source given their relative lower purchasing power.

One study of 525 Mexican consumers found that demand elasticity for eggs rose during the covid-19 pandemic from 0.898 (inelastic) to 1.126, meaning the product shifted from being a “necessity” before the pandemic to a “luxury” food during the crisis. This shift was particularly acute for households with expenditures below the median.

The GM corn ban could increase Mexican egg demand as consumers switch from costlier proteins, but it could also, once again, turn eggs into a luxury good for lower income consumers. The ban is estimated to raise poultry feeding costs by 17.2 percent and reduce industry output. If Mexican consumers spent 44 billion pesos on eggs before the GM corn ban, they would spend 48.6 billion pesos after the ban just on increased feed costs. Because all livestock product prices increase under a GM corn ban, higher egg prices would more severely impact consumption by Mexico’s poorest consumers. Assuming just the passthrough of the additional feeding costs and ignoring the price impact of the impending supply-demand squeeze, the increased cost of eggs could cause the first drop in egg demand since 2017 (Figure 27). Either way, the consumption of Mexican-produced eggs would decline.

Figure 27: Mexican Per-Capita Egg Consumption



Source: SAPI, UNAF, World Perspectives, Inc.

Imported eggs (minus exports) are currently just 2.9 percent of Mexican consumption but are likely to rise due to the lower production costs using conventional feed in supplying countries. An area identified by foreign suppliers for growth in Mexico is the baking and food processing sector. Currently, less than 5 percent of Mexican produced eggs are utilized in this fashion. Because Mexican eggs would be priced higher under the GM corn ban, growth in the value-added sector would be filled by imported egg products.

Total Impacts on the Mexican Economy

To estimate the total impacts of a policy banning GM corn imports in Mexico, IMPLAN economic input-output models are used for each of the three key economic shocks examined in this study: the impact of higher tortilla prices, the impact of grain segregation, IP, and genetic testing costs, and reduced output from the Mexican livestock sector. Each shock was run separately in IMPLAN, and their results were subsequently summed to ascertain the full impact to the Mexican economy.

The increase in corn prices would increase the price of tortillas paid by Mexican consumers under a GM corn ban. As noted earlier in this report, tortilla prices would rise 16 percent, on average, from their baseline values. Using current population estimates, tortilla prices, and daily tortilla consumption, this study finds **a GM corn ban would cause**

Mexican consumers to pay \$9.37 billion more for tortillas over the 10-year forecast period than would otherwise occur. WPI models the increase in tortilla prices as a reduction in household income, as Mexican consumers would pay more for a staple food item, thereby reducing income available for other purchases. While not a true reduction in household income, this approach was selected as it allows for estimating the economy-wide effects of decreased disposable income.

IMPLAN models indicate **the economy-wide impacts of higher tortilla prices and reduced household income would reduce Mexico's GDP by \$7.44 billion over 10 years**, or the equivalent of 0.69 percent of 2021 GDP. Additionally, economic output would fall \$11.734 billion over 10 years and 22,992 jobs would be lost annually, creating a reduction in labor income of \$2.106 billion.

Costs related to grain segregation and IP as well as genetic testing of corn imports would be passed to Mexican consumers (see the sections "Costs of Physical Grain Segregation and IP" and "Cost of Specific Risk Mitigation in IP Grain Markets") which would create significant negative impacts on the Mexican economy. Specifically, **Mexico's GDP would fall by \$894.38 million over 10 years**, and economic output would contract by \$1.41 billion. Moreover, 27,632 jobs would be lost annually, and the employment reduction would reduce labor income by \$253.2 million over 10 years.

IMPLAN analysis of the \$3.69 billion shock to the livestock industry suggests the **impact to Mexico's broader economy would be a loss of 31,375 jobs annually along with a contraction of \$3.43 billion in GDP and \$6.33 billion in economic output**. Mexican labor income would be fall \$646 million over the 10-year period (Figure 28).

Figure 28: Predicted Economic Impacts of Contraction in the Mexican Livestock Sector

Impact	Annual Avg. Employment	Labor Income	Mexico GDP	Output
	<i>Full-time Equiv.</i>	<i>Million USD, 2022 dollars</i>		
Direct	-21,737	-\$286.40	-\$1,849.73	-\$3,685.37
Indirect	-8,792	-\$282.23	-\$1,310.44	-\$2,215.21
Induced	-846	-\$77.53	-\$273.92	-\$431.88
Total	-31,375	-\$646.16	-\$3,434.10	-\$6,332.45

Source: World Perspectives, Inc.

In total, **this study finds that a Mexican policy banning GM corn and corn products would cost Mexico's economy 56,958 jobs annually and cause a contraction of \$11.72 billion in GDP over 10 years**. Additionally, economic output would fall \$19.39 billion over the forecast period, and Mexican labor income would fall \$2.99 billion. The cumulative impacts of the specific shocks modeled in this study are summarized, along with their 10-year cumulative impacts on the Mexican economy, in Figure 29.

Figure 29: Summary of Estimated Shocks to Mexican Economy and their Broader Impacts

Modeled Event	Direct Impact	Cumulative Impacts to Mexican Economy ¹			
		Annual Avg. Employment Change	Labor Income	GDP	Economic Output
		<i>Full-time equivalents</i>	<i>Million USD, 2022 dollars</i>		
Higher Corn Purchase Prices ²	-\$9.73 billion in added costs	N/A	N/A	N/A	N/A
Higher Tortilla Costs	-\$9.37 billion in reduced HH income	-22,992	-\$2,106	-\$7,442	-\$11,734
Costs of Grain Segregation/IP and Genetic Testing	-\$1.056 billion in reduced HH income	-2,591	-\$237	-\$839	-\$1,322
Reduced Livestock Industry Output	-\$3.69 billion in lost revenue	-31,375	-\$646	-\$3,434	-\$6,332
Total	N/A	-56,958	-\$2,990	-\$11,715	-\$19,388

¹ Sum of direct, indirect, and induced impacts.

² IMPLAN models were not run for this shock as its impacts ultimately land with higher consumer prices for tortillas and increase livestock feed costs.

Source: World Perspectives, Inc.

V. An Alternative Outlook

One of the cornerstone assumptions of this study is that a Mexican ban on GM corn would apply to food, industrial and animal feed uses equally. That may not be the case, however, as the Mexican government has yet to issue specific guidance on the matter or finalize the details of how such a ban would be implemented. Consequently, it is worth examining what the impacts would be to the U.S., Canadian, and Mexican economies if a Mexican ban on GM corn were to exempt GM corn imports for livestock feed and/or industrial use. This section details the probable impacts of two scenarios:

1. GM corn is explicitly permitted for import and use *only* in livestock feed, and
2. GM corn is explicitly permitted for import and use in livestock feed *and* industrial uses.

Before examining the details of these two possible scenarios, additional background on the composition of Mexico's corn market and consumption, as well as U.S. export trends, is needed. Yellow corn for human and household consumption accounts for just 1.6 percent of total corn consumption in Mexico (Figure 30), or about 770 TMT (based on 2021/22 total utilization of 48.13 MMT). In contrast, white corn for human and household use is predicted to total 18.3 MMT for 2021/22 – roughly 23 times the volume of yellow corn allocated for this use.

Feed and industrial use of yellow corn is vastly larger, and most of Mexico's imports go to service these sectors. Use of yellow corn for livestock feed is forecast to total 13.1 MMT in 2021/22, while the starch sector (corn wet milling) would likely use near 2.9 MMT. These two uses of yellow corn total 16.1 MMT, a figure slightly larger than U.S. total corn exports (15.6 MMT) to Mexico in 2021/22.

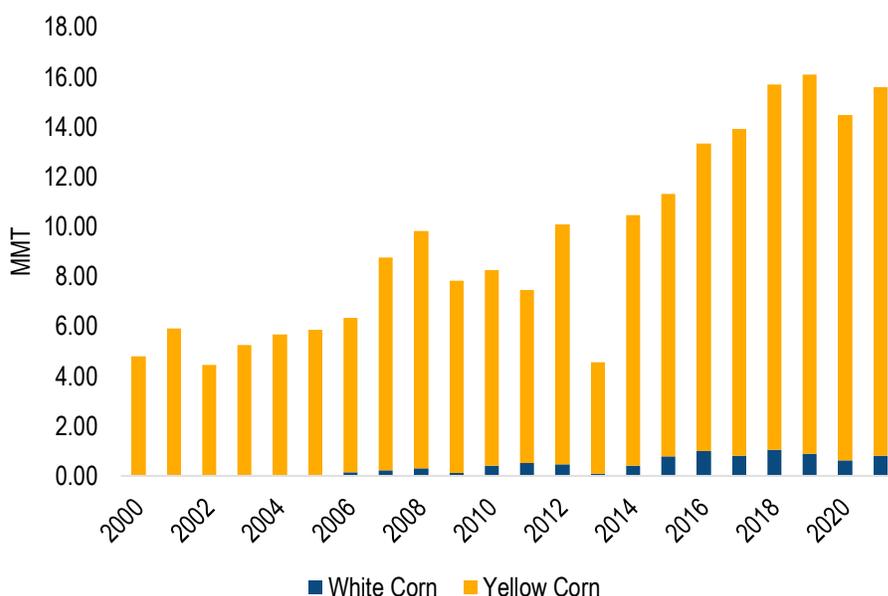
Figure 30: Estimated Composition of Mexican Corn Demand by Variety

Use Category	% Total Use		Total
	White	Yellow	
Human & Household	38.1	1.6	39.7
Livestock Feed	10.0	27.3	37.3
Ending Stocks	4.4	6.6	11.0
Exports	2.8	0.0	2.8
Losses	2.1	0.6	2.7
Seed	0.4	0.0	0.4
Starch Industry	0.0	6.0	6.0
Total	57.8	42.2	100.0

Source: USDA ERS, *World Perspectives*.
Numbers may not add due to rounding.

Given the current usage patterns in Mexico's corn markets, if a GM corn ban *were to specifically exclude imports for feed and industrial use*, such a policy would effectively only apply to U.S. white corn exports. Over the past 10 years, the U.S. has, on average, exported 840 TMT of white corn to Mexico, which is 6 percent of all U.S. corn exports to the country. The USDA does not track white corn production specifically, but industry estimates suggest approximately 1 percent (100-150 million bushels) is produced in the U.S. annually. White corn exports to Mexico are estimated to account for 0.22 percent of the U.S. total corn crop annually (Figure 31).

Figure 31: U.S. Yellow and White Corn Exports to Mexico by Marketing Year



Source: USDA FAS GATS, World Perspectives, Inc.

Scenario 1: GM Corn Permitted for Livestock Feed

If Mexico’s ban on GM corn were to explicitly exempt GM yellow corn for livestock feed, the impacts on the North American economies would be vastly different. For the purposes of this scenario analysis, it is assumed exempting yellow corn for livestock feed would also exempt DDGS, CGM, and CGF. Essentially, the corn and corn products still subject to the ban would be white corn for human consumption, yellow corn for industrial use (i.e., corn wet milling), and corn wet milling products, including corn starch and sweeteners.

Were Mexico’s policy to exclude GM corn for use in direct human food (i.e., tortillas, hominy, etc.) and industrial use (corn wet milling), then 7.3 percent of Mexico’s consumption would be replaced with non-GM corn. That volume would equate to 3.7 MMT of additional demand for non-GM corn, likely to be supplied by the United States. This volume exceeds U.S. non-GM ending stocks in the baseline scenario, meaning the U.S. cannot simply drawdown existing supplies to meet the increased export demand. Instead, U.S. domestic consumption or exports to other countries would have to decrease, Mexico would have to secure non-GM corn from outside the U.S., or some combination of both approaches.

This study finds that the 3.7 MMT of added non-GM corn import demand from Mexico would represent a 13 percent increase from baseline U.S. total consumption. This would likely **cause non-GM corn prices to rise by 9.5 percent on average over 10 years**. Mexican importers and end users would bear this cost increase, and **Mexico is predicted to pay \$173.96 million more** for its corn imports than would otherwise occur.

The price increase would set off a series of events like identified earlier in this study, whereby U.S. producers respond to the higher non-GM prices and expand production by 2-3 percent in each of the first two years of a policy change. Due to the smaller size of the shock and the ability to secure small volumes of non-GM corn from other suppliers (likely Argentina and Brazil), however, the market adjusts relatively quickly and the large shifts in farm trends and the grain handling industry are not predicted. This study finds negligible changes in GM corn and other crop plantings and prices. Additionally, models indicate modest reductions in domestic consumption and rest-of-world exports allow the U.S. to supply 90 percent or more of Mexico’s added non-GM corn demand in the first year of the ban, largely eliminating

negative impacts on the U.S. rail transportation sector. Additionally, the fact that DDGS would be permitted for export means that impacts on the U.S. ethanol sector are essentially eliminated.

The U.S. **grain handling sector would incur costs of approximately \$118.03 million** over the forecast period to accommodate Mexico's policy, the **majority of which would be passed to Mexican importers and end-users**. Notably, that figure is starkly lower than the estimated \$11.8 billion in costs that would occur if all GM corn and corn product exports to Mexico were banned. **In total, Mexico would pay an additional \$291.99 million (\$173.96 million in higher non-GM prices plus \$118.03 million in segregation and IP costs) to purchase the added 3.7 MMT of non-GM corn over 10 years.**

Critically, however, if the ban were to still restrict exports of milled products derived from GM corn (e.g., corn starch), the 909.5 TMT of non-feed corn wet milling products would be affected. Because corn wet milling feed product exports to Mexico represent such a small share of the corn wet milling industry's output, their export in this scenario creates a negligible change in the industry's response. This study finds that the impacts of the lost export market for products like corn starch and sweetener are more important to the industry. Additionally, in this scenario, the industry does not have the ancillary benefit of purchasing GM corn at lower prices to offset the impacts of restricted exports to Mexico. In this scenario, the **negative effects on the U.S. corn wet milling industry increase to \$17.08 billion over 10 years (versus a net loss of \$7.6 billion in the full-GM corn ban case)**. The **impact of this shock to the corn wet milling industry would cause the loss of 16,447 jobs annually over 10 years and a contraction in U.S. GDP of \$17.43 billion**. Additionally, total economic output in the U.S. would decrease \$47.31 billion and labor income would fall \$10.1 billion.

Scenario 2: GM Corn Permitted for Livestock Feed and Industrial Uses (e.g., Corn Wet Milling)

Under a policy scenario where Mexico bans GM corn for domestic production and human food uses but allows the import for livestock feed and industrial uses, the impacts are significantly less consequential. This scenario analysis assumes that if GM corn is permitted for import for industrial uses, import of products derived from GM corn would similarly be allowed. This assumption, however, oversimplifies the reality that many products from industrial corn processing (i.e., corn wet milling) are directly intended for human consumption (foods, seasonings, pharmaceuticals). If Mexico's policy is to be consistent in its stated goal – as published in the December 2020 decree – of “contributing to food security... and the health of Mexican men and women¹⁶”, then excluding GM corn-derived products from human consumption would be necessary. For the purposes of this analysis, however, we assume that food and human consumption products from industrial processes (corn wet milling), would be exempt from the ban. In such a policy scenario, only corn imported and intended to be minimally processed (e.g., tortillas, hominy) for food use would be subject to restrictions on GM events.

Mexico imports approximately 5 percent of its annual corn-for-food use needs, with the U.S. filling the bulk of those imports. Under such a policy, Mexico would need to replace approximately 778 TMT of yellow corn that is currently imported for use in human foods. This would equate to approximately 3 percent of the estimated U.S. non-GM crop currently in production and represent a 2.6 expansion in non-GM corn demand for the U.S. Based on export demand elasticities from Fosu, Wahl, and Lau (2020) and WPI's own proprietary models, this study estimates that U.S. non-GM corn prices would rise between 11-14 cents/bushel over the 10-year forecast period. This price increase is not predicted to be sufficient to alter U.S. production decisions or acreage and the added costs would be passed onto Mexican importers and consumers. In total over 10 years, Mexico would pay \$36.6 million in added costs (excluding genetic testing) to secure non-GM corn from the U.S. This figure stands in stark contrast to the \$571 million of additional import costs Mexico would pay *in the first year alone* if all corn and corn products were required to be non-GM. Moreover, the \$36.6 million represents just 0.38 percent of the added import cost of \$9.73 billion from higher prices that is estimated in a full-GM corn ban scenario.

¹⁶ The original decree is available here: https://www.dof.gob.mx/nota_detalle.php?codigo=5609365&fecha=31/12/2020#gsc.tab=0

VI. Conclusions

This study updates and expands upon earlier research (World Perspectives, Inc., 2022) that examined the likely economic impacts of a possible policy change by Mexico whereby GM corn would be banned for domestic production and import. The previous analysis estimated that such a ban would have significant negative impacts on the Mexican economy, notably the loss of 138,000 jobs across the nation and a GDP contraction of \$4.3 billion over a 10-year period. Using similar research and econometric approaches, this study confirms these negative impacts that would accrue to Mexico and further details the implications for Mexico's consumers. Additionally, the impacts to the U.S. and Canadian economies are reevaluated in light of recent changes in world grain and oilseed markets.

Using USDA baseline, long-term projections and WPI's proprietary supply and demand models, this study estimates how a Mexican ban on GM corn and corn products would affect U.S. crop acreage and prices. In the short run, this study estimates that U.S. GM corn prices would fall 10 percent from baseline forecasts over 3 years while non-GM corn prices increase as much as 42 percent from their baseline during the same period. The ban would also prevent Mexico from importing corn from its primary supplier – the United States – as U.S. non-GM production could only satisfy 17 percent of Mexico's import demand in the first year. Critically, Mexico's policy would create higher prices around the world for non-GM corn and Mexican importers and end-users would cut corn use. Mexico's total corn imports would likely fall by 12 percent in the first year of the ban and 26 percent in the second year, compared to the baseline scenario.

In the U.S., the sudden suspension of corn and corn product exports to Mexico would affect the U.S. corn farming sector, rail transportation industry, ethanol sector, as well as the corn wet milling industry. The corn farming industry would see net losses of \$13.61 billion over 10 years while the U.S. rail transportation sector would see economic output fall by \$3.33 billion over the same period. The U.S. ethanol industry would see some benefit from lower GM corn prices used as inputs in the ethanol manufacturing process, but the industry would still face a net revenue loss of \$521.5 million over 10 years. Finally, the impacts to the U.S. corn wet milling industry – which occur due to the loss of exports of corn starch, animal feeds, and other products to Mexico – of \$7.65 billion over 10 years. Collectively, these impacts would be transferred through the U.S. economy and cause the loss of \$30.55 billion in GDP and \$73.89 billion in economic output over 10 years. Similarly, the Canadian corn farming industry would see a net revenue loss of \$33.94 million over 10 years that would create a net contraction in the broader economy of \$39.73 million in GDP.

While the impacts of the U.S. and Canadian economies are significant, perhaps the greatest implications of a ban on GM corn lie within Mexico's borders. Corn is critically important to Mexico, both as a food and feed ingredient and a cultural symbol, and over the 10-year forecast period, Mexico would cumulatively pay \$9.73 billion in higher prices to import non-GM corn, an increase of 19 percent. Moreover, the prices for Mexico's most-consumed corn derivatives – tortillas – would increase dramatically. In the first year of a GM corn ban, tortilla prices are estimated to rise 16 percent, followed by a 22 percent increase the following year and a 30 percent increase in the third year of a ban. Under a GM corn ban, tortilla prices would increase by 16 percent from baseline forecasts, on average over 10 years. Additionally, the Mexican livestock sector would see feed prices increase by 13.7 percent, on average, over 10 years and this added cost would curtail livestock product (i.e., meat and dairy) output by 1.2 percent annually. The poultry and swine sectors would see the largest cuts to production and are predicted to fall 17 percent and 13 percent, respectively, if imports of GM feed corn were banned. Again, the contraction in the livestock sector would create negative implications for the Mexican economy and 31,375 jobs would be lost annually along with \$3.43 billion of GDP and \$6.33 billion of economic output due to that shock alone.

For Mexico, the total impacts of added costs for consumers, higher grain import costs, and the contraction in the livestock sector mean that a policy banning GM corn would cost Mexico's economy 56,958 jobs annually. Additionally, the policy would reduce GDP by \$11.72 billion and cut economic output by \$19.39 billion over 10 years.

The implications of two scenarios whereby Mexico either did not ban GM corn or applied the ban only to imports directly intended for food use were also examined. In a scenario where GM corn is permitted for feed use only, Mexico would likely need to secure 3.7 MMT of additional non-GM corn, 90 percent of which could be sourced from the U.S. In

response, U.S. non-GM corn prices would rise by 9.5 percent, on average, and Mexico would pay \$173.96 million more in import costs. Further, the added costs to the U.S. grain handling sector would be passed to Mexican importers and end users, increasing their costs \$118.03 million above what they would otherwise pay. In total, Mexico would pay an additional \$291.99 million to purchase the added 3.7 MMT of non-GM corn over 10 years. Finally, under a scenario where GM corn is permitted for livestock feed and industrial uses (including processing GM corn into food products such as corn starch), this study predicts U.S. non-GM corn prices would rise 11-14 cents over the 10-year forecast period. In this case, Mexican importers and end users would pay an additional \$36.6 million to secure non-GM corn, a figure that is 0.38 percent of the cost increases estimated if all GM corn were banned.

This research also identifies secondary and tertiary impacts that are significant but for which precise economic modeling is either not feasible or beyond the scope of this study. These impacts include environmental impacts of higher agricultural chemical use in non-GM cropping systems as well as the impacts on future agricultural technology innovation. Perhaps more importantly, this study also notes the impact on human health and Mexican consumer food security that would result from a ban on GM corn.

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VIII. Appendix A – Data and Methods

For the sake of brevity in the main body of this report, the details of the data and economic approaches and assumptions are provided in this appendix. This section is broken into the following sections: a description of data used in the analysis, a conceptual framework for approaching the analysis, a description of creating the baseline scenarios, and, finally, the details of some of the econometric approaches used.

Data Used in the Analysis

WPI leveraged our proprietary datasets to obtain FOB price and ocean freight rate data for corn from the U.S. Gulf, Argentina, Brazil, and Ukraine. DTN's ProphetX platform was used to secure additional price data and freight rates as needed. USDA's long-term projections datasets for corn supply and demand balance sheets in significant producing and exporting countries (e.g., the U.S., Brazil, and Ukraine) were used to help establish the "baseline" scenario for the 10-year forecast horizon. Due to the time lag between when USDA's international long-term forecasts are created and the publishing of this report, WPI used our proprietary models and in-country sources to update supply and demand forecasts, so they reflect current conditions. Notably, with the situation in Ukraine remaining highly dynamic and subject almost entirely to the outcome of the Russian invasion, WPI's proprietary models were used to forecast the country's corn balance sheet.

Additionally, WPI secured data on Mexican corn and poultry prices from *Secretaría de Economía/Systema Nacional de Información e Integración de Mercados* (SNIIM, 2022), as well as data on food security trends from the UN's Food and Agriculture Organization (FAO).

Conceptual Model

Should Mexico follow through on its decree banning GM corn for import, there would be multiple shifts and changes to the U.S., Mexican, and global corn and feed grain markets. One of the major impacts would be that the new policy would require segregation and identity preservation of all imported corn to make sure it does not contain GM material. This, in essence, would create two separate commodities – GM and non-GM corn – each with their own individual balance sheets. For Mexico, this distinction matters less as all corn in the country would be non-GM. For the U.S. and other corn-exporting countries, however, the distinction would be significant as it would necessitate the segregation and identity preservation (IP) of grain in ways not currently required by law.

This idea of Mexico's policy goal essentially bifurcating the U.S. and world grain handling system into two commodities was central to this study's approach. WPI created two commodity balance sheets for U.S. corn – GM and non-GM – and examined the impacts to each "commodity" separately. Broadly speaking, the individual impacts and market developments that required analysis are outlined as follows:

Conceptual Framework for Examining First-Year Impacts

1. Assume that Mexico's ban would apply to all corn (not just yellow, feed corn) and that U.S. and global producers cannot alter production in the first year of the ban (Year 0).
2. Estimate U.S. domestic and contracted export demand for non-GM corn in Year 0 and estimate the exportable surplus that could be shipped to Mexico.
3. Estimate U.S. GM corn export and ending stocks changes amid the loss of a major export market.
4. Estimate the new price for U.S. non-GM and GM corn based on estimated ending stocks levels and demand elasticities from peer-reviewed research papers.
5. Estimate global non-GM corn supply and the potential for non-U.S. countries to fill Mexico's import needs.
6. Use peer-reviewed demand elasticities to examine changes in Mexico's corn import demand for Year 0.
7. Examine how Canada's corn prices and market would change based on historic U.S./Canada price relationships.

While in the short-run, the world would be constrained in its ability to respond to Mexico's policy shift, the global marketplace would start to adjust production of non-GM corn in accordance with the resulting price signals. Over the 9 years following the presumed implementation of Mexico's GM corn ban (Years 1-9), WPI estimates long-run market equilibria according to the following outline:

Conceptual Framework for Examining Long-Run Impacts

1. Forecast U.S. non-GM and GM corn and other crop acreage responses to prices changed in Year 0.
2. Estimate Mexico's production and import demand response to the changes in U.S. and global corn prices.
3. Estimate U.S. non-GM and GM corn supply, domestic consumption, exports, ending stocks and prices based on prior year prices and demand elasticities.
4. Estimate non-U.S. non-GM corn exports to Mexico and determine what price Mexico would pay, including freight, for non-GM corn.
5. Estimate Mexican livestock producers' gross margins in light of changing feed costs and determine if the industry would expand or contract and to what degree.
6. Evaluate the impact of higher import costs on the Mexican economy, consumer prices, and food security.

Baseline Analysis

For the purposes of this study, WPI models the impact of the GM corn ban starting as if it starts in the middle of the 2022/23 marketing year. This assumption was made for several reasons, including the fact that it allowed for full use of USDA's latest 10-year long-term agricultural baseline projections dataset. The latest projections cover the period from 2022-2032. Notably, USDA's data projects Mexico's total corn imports through 2032 but does not identify the source of these imports. Historically, the U.S. has supplied 92 percent of Mexico's annual corn imports and WPI assumes that market share is unchanged for the duration of the 10-year baseline projections.

GM corn has accounted for all but roughly 10 percent of U.S. corn acres for decades, according to data from the USDA NASS. On average from 2014-2021, 92.25 percent of U.S. corn acres were planted to biotech varieties with little variation in the past 7 years. WPI assumes that the ratio of biotech to non-biotech corn acres would continue for another 10 years in the baseline scenario.

As noted in the first version of this study (the March 2022 work for Crop Life International), U.S. corn is typically offered in the FOB market at a significant discount to other major exporting countries. Specifically, FOB NOLA corn is offered at a \$2.46/MT discount to Brazil and is priced \$5.80/MT less than Ukrainian offers FOB Black Sea ports. This study continues the assumption used in the earlier version of this work that Mexico would pay an additional \$4.60/MT for non-GM corn imports non-U.S. exporters (World Perspectives, Inc. 2022).

Additionally, the proximity of the U.S. Gulf to Mexico offers importers significant advantages in ocean freight rates. There is no direct rail access from South America to Mexico, which necessitates shipment of any grain exports to Mexico going by ocean vessel. As noted in the first version of this study, ocean freight from the U.S. Gulf to Veracruz, Mexico ranged from \$25-30/MT during the 2021 freight market rally, freight rates from Argentina and Brazil ranged from \$60-70/MT. Finally, ocean freight from the Black Sea (notably, Ukraine's Port of Odessa) to the Mexico varied between \$80-100/MT during 2021 (World Perspectives, Inc. 2022). WPI includes ocean freight rates in the landed cost of importing corn into Mexico and current (2022) ocean freight rates are assumed to persist for the duration of the forecast period.

Estimating Non-GM Corn Prices

Price reporting on non-GM and organic commodities remains sparse at best. In the U.S. Industry sources indicate that non-GM corn supplies increased substantially during the prolonged commodity price downturn of 2015-2020 as producers sought to diversify production options (Murray Wise Assoc. LLC, 2021). In 2020 and 2021, reported premiums for non-GM corn were 5-7 percent above non-GM corn prices. On a \$7.07/bushel corn price (the current

Midwest average as of 24 August 2022), a 5 percent premium would equate to 35.3 cents and a 7 percent premium converts to 49.5 cents. Additionally, based on analysis by WPI, U.S. white corn exports to Mexico were priced at a \$0.62/bushel (13.3 percent) premium to yellow corn. For this study, WPI assumes that non-GM corn is priced at a minimum 7 percent premium to GM corn to offset the impacts of lower yields and greater yield variability when growing non-GM grain.

Non-GM Corn Balance Sheet Estimation

Data on the production and distribution of organic and non-GM foods remain limited in the U.S., despite a recent uptick in popularity (Fernandez-Cornejo, 2014). Some price reporting data is available from USDA but there exists minimal production data on non-GM and organic crops, specifically. Moreover, WPI was unable to secure, despite significant desk research and interviews with U.S. grain industry contacts, any grain balance sheet information on non-GM or organic corn production. Some estimate of a non-GM corn balance sheet was required, however, due to the analytical approach selected in this study. Consistent with the Crop Life International study (World Perspectives, Inc. 2022), this study assumes the fact that 92 percent of U.S. corn plantings are GM means that 92 percent of the U.S. all-corn balance sheet is also GM. This approach is far from perfect and suffers the flawed assumption that GM and non-GM corn are perfect substitutes in U.S. consumption patterns, but it is believed to be the best approach available.

Short-Run Response to Mexico's GM Corn Ban

As noted in the introduction, this research assumes supplies are fixed in the first year of the ban and that no additional production or changes in production can occur before the next marketing year. Further, due to the uncertainty around Mexico's ban application to food and feed corn, this research (as noted earlier) assumes *all* Mexican corn imports would be non-GM. Consequently, based on latest USDA's long-term projections, 17.7 MMT of non-GM corn are forecast to be imported into Mexico the first year of the GM corn ban (for analytical purposes, 2022/23). WPI's proprietary models also predict that 2.7 MMT of corn-derived feed products (DDGS, corn gluten feed, and corn gluten meal) would be imported by Mexico during the first year of the ban. Finally, and in a supplement to the first version of this study, WPI estimates that 0.9 MMT of corn starch and corn-based sweeteners would be exported to Mexico in the first year of the ban.

This study estimates the initial exportable surplus of non-GM corn from the U.S. is 5.2 MMT, of which 2.7 MMT could be exported to Mexico. The balance, approximately 2.5 MMT, would be purchased by Japan and South Korea. These two countries have long histories of forward contracting and importing non-GM corn from the U.S. Moreover, their comparative wealth would allow them to outbid Mexican buyers as prices rise. Collectively, Japan and South Korea currently import more than 2.5 MMT of non-GM corn from the U.S. annually, but their minimum import requirement is thought to total 2.5 MMT¹⁷. WPI's models assume that only the minimum purchases are made in the first year of the ban as prices would likely rise sharply.

Finally, Mexico's corn import demand would fall during the first year of the ban as the price of non-GM corn rises on the U.S. and world markets. Mexico's corn import demand is known to be inelastic and WPI estimates that the country's Year 0 imports would fall to 15.5 MMT, 2.1 MMT (12 percent) less than the baseline forecast. That leaves a balance of 10.6 MMT of non-GM corn that would have to be imported from non-U.S. sources. WPI estimates that Year 0 non-GM exports from Brazil would total 4.2 MMT while shipments from Argentina and Canada account for 2.8 and 0.17 MMT, respectively. Ukraine is the final major supplier of non-GM corn to Mexico and is estimated to be capable of shipping 3.4 MMT in Year 0. Note that the volume required of Ukraine would account for roughly one-quarter of its estimated total exports for the year (assuming, with the ongoing Russian invasion, that Ukraine's total export program is near WPI's estimate of 14 MMT). While Ukraine's corn production is believed to be 98 percent non-GM (ISAAA, 2019), there is speculation that the country's GM production is much larger than officially recognized. Some industry participants have noted Ukrainian non-GM corn may not be able to meet a 1 percent tolerance threshold if tested by importers.

¹⁷ According to industry sources interviewed by WPI.

There are also reports that the war's impact has lowered confidence in Ukraine's phytosanitary certifications. Consequently, while Ukraine is assumed to be capable of providing 3-4 MMT of exports annually to Mexico, the country's actual ability to participate in a non-GM Mexican market may be significantly less.

Finally, it's important to note that the 10.6 MMT of "new" import demand for Brazilian, Ukrainian, and Argentine corn would siphon corn supplies from buyers who traditionally procure imports from these nations. WPI's models assume U.S. GM corn imports would shift to fill this void and help offset the impacts of losing the Mexican market to GM corn.

Econometric Methods

Supply, Demand, and Price Forecasting Models

As a commodity analysis and forecasting firm and consultancy, WPI has developed proprietary models for predicting grain market supply and demand and prices. These models were used to assess the long-run impacts of Mexico's decree banning GM corn imports. As noted earlier, WPI relies, partly, on USDA's long-term forecasts to help establish baseline scenarios for production, trade, and demand. These USDA data include price forecasts, but WPI re-estimated these price forecasts using our own models to reduce any possible "noise" or error when comparing our post-ban prices with baseline scenario forecasts.

Economic Input-Output Models

Finally, WPI used economic input-output models to estimate the economic "ripple effects" of these changes to the U.S., Mexican, and world corn markets. The U.S. (and other countries) corn farming sector connects to other industries through both forward and backward economic linkages. For example, corn farming is linked to industrial manufacturing through the purchase of farm equipment and machinery. Economic input-output models estimate these linkages and assess how changes in one industry would affect others. In essence, these models look at how \$1 spent in one industry would travel through other linked economic sectors.

WPI elected to use IMPLAN - a well-regarded economic input-output model software - that has been used in myriad research projects for this study. IMPLAN models were initially developed by the U.S. government and have since found widespread application in government, academic, and industry research efforts. IMPLAN models estimate industry spending linkages (how expenses in one industry link to revenues in another), labor income (wages and salaries), employment, and the total "value added" by given industry(ies). The "value added" metric can be thought of as the industry's contribution to the U.S. Gross Domestic Product (GDP). IMPLAN models also have the useful application of estimating how taxes at the local, state, and federal levels would change based on impacts in various economic sectors.

IMPLAN models estimate different three types of economic impacts:

- **Direct impacts** are those felt by the industry in which a shock occurs. For this study, the direct impacts are those incurred by the U.S. corn farming industry due to the Mexican GM corn ban. Mexico would also incur direct economic impacts to its corn-consuming sectors through supply reductions and price (cost) increases.
- **Indirect impacts** are those incurred by economic sectors linked to the industry in which the direct impacts originate. In the example of GM corn farming, indirect impacts would occur in the fertilizer and agro-chemical industries, among others, as the corn farming sector reduces purchases from these linked industries.
- **Induced impacts** are those created by changes in employee spending by a certain economic sector. For example, employees of corn farming operations that experience a revenue loss would likely see reduced wages or salaries. Consequently, workers would alter their own spending patterns and create induced impacts in industries where they typically spend wages, such as restaurants, retail shops, and the housing sector.

For each type of impact, IMPLAN can estimate the changes in total employment, labor income, "value added" (e.g., GDP), and economic output. Additional data, such as tax implications, are also available. Note that to obtain the total economic impact of a shock to a specific industry, one need only sum the direct, indirect, and induced impacts.

Notes on Interpreting IMPLAN Economic Input-Output Results

Notably, IMPLAN results must be interpreted considering some specific caveats. First, IMPLAN models are linear and unbounded, which means they do not account for non-linear responses or relationships between industries and have no programmed “stopping point”. The linear nature of IMPLAN models mean they cannot account for non-linear relationships such as might exist, for example, due to diminishing marginal returns to increasing output, or efficiencies of scale or scope. Second, IMPLAN models assume wages and prices cannot be adjusted during the impact period. These two points mean that IMPLAN results should be viewed as the upper bound on expected impacts. Models and economic approaches that can incorporate non-linear responses or adjust wages and prices dynamically (such as computable general equilibrium models) may offer results nearer to the mid-point or lower bound of the results that would occur.

IX. Appendix B – Average Composition of Mexican Diets

The following table showing the composition of the average Mexican consumer's diet is taken from the Mexican National Health and Nutrition Survey.

Food group/main item within each group	Absolute intake (kcal/d)		% of total energy intake	
	Mean	SE	Mean	SE
Unprocessed or minimally processed foods	1020.9	12.2	54.0	0.4
Corn tortilla	354.6	6.9	19.0	0.3
Red meat	105.2	5.4	4.9	0.2
Milk	81.9	2.2	4.9	0.1
Cereals (except corn)	89.2	3.4	4.6	0.1
Fruits	75.9	2.6	4.2	0.1
Poultry and game	74.2	4.4	3.6	0.2
Beans	58.3	3.5	3.1	0.1
Eggs	39.3	1.1	2.3	0.1
Vegetables	37.1	0.9	2.0	0.0
Corn	33.4	2.4	1.6	0.1
Starchy vegetables	27.8	1.9	1.4	0.1
Other natural or minimally processed foods*	19.0	1.4	0.9	0.1
Coffee and tea	13.3	0.7	0.8	0.0
Seafood	11.7	1.5	0.7	0.1
Processed culinary ingredients	202.9	4.9	10.2	0.2
Oils and fats	134.1	3.9	6.5	0.1
Sweeteners	62.1	2.9	3.3	0.1
Other processed culinary ingredients†	6.7	1.0	0.4	0.0
Processed foods	120.7	4.8	6.0	0.2
Bread	46.8	2.2	2.7	0.1
Cheeses	45.1	2.5	2.2	0.1
Undistilled alcoholic beverages	19.6	3.0	0.6	0.0
Other processed foods‡	9.2	0.9	0.5	0.0
Ultra-processed foods	578.7	9.8	29.8	0.4
Cookies, pastries and sweet bread	182.3	5.0	9.5	0.2
Carbonated sugar-sweetened beverages	77.7	2.5	4.0	0.1
Salty snacks	68.4	3.5	3.2	0.1
Industrialized tortilla and bread	48.2	2.9	2.5	0.1
Other ultra-processed foods§	43.7	1.9	2.2	0.1
Candies and sweets	36.1	1.9	2.0	0.1
Yoghurt and milk-based beverages	30.5	1.3	1.9	0.1
Sausages and other ultra-processed meats	31.2	1.8	1.5	0.1
Non-carbonated sugar-sweetened beverages	22.3	1.1	1.3	0.1
Breakfast cereals	17.8	1.0	1.0	0.1
Ultra-processed cheeses	10.5	1.0	0.5	0.0
Distilled alcoholic beverages	10.0	3.0	0.2	0.1
Total	1923.2	18.9	100.0	0.0

Source: Mexico National Health and Nutrition Survey

X. Appendix C – Uses of Corn Wet Milling Products

The Many Uses of Wet-Milled Maize					
INDUSTRIAL STARCH USES	INDUSTRIAL SWEETENER USES	INDUSTRIAL FERMENTATION PRODUCTS	FOOD AND DRUG USES	FOOD AND DRUG SWEETENER USES	FOOD AND DRUG FERMENTATION PRODUCTS
Paper, recycled paper Cardboard	Acetic acid Charcoal briquettes	Acetic and amino acids Blankets and bedding	Aspirin Baby food	Alcoholic beverages and brewing Baby foods	Antibiotics Baker products
Textiles Glues and adhesives Batteries	Dyes and inks Enzymes	Carpet tile Cosmetics	Baked goods Baking powder	Bacon Baked goods	Citric acid Drugs
Bookbinding	Insecticides	Electroplating and galvanizing Food packaging	Cake, cookie, dessert mixes Candies	Caramel color	Enzymes
Cleaners, detergents	Laminated building materials Matches	Disposable cold drink cups, plates and cutlery Industrial chemicals	Cereals	Carbonated and fruit beverages Canned fruits, fruit fillings	Food acids Pharmaceuticals
Coatings on paper, wood and metal Color carrier for printing Crayons and Chalk Dyes Fireworks	Metal plating	Leather tanning	Coffee whitener	Cereals	Wine
Industrial filters and water recovery Lubricants Ore and oil refining Paints	Organic solvents Paper	Mannitol	Dried soups	Cheese spreads	
Plastics Rubber tires Surgical dressings	Plasticizing agents Rayon	Organic solvents Paper	Drugs	Chewing gum	
Wallboard and wallpaper	Shampoo	Plastics	Gravy mixes Instant breakfast foods Instant pudding mixes	Condiments Confections, chocolate	
	Shoe polish Textiles	Plasticizers Soaps and cleaners	Instant tea Salad dressings	Drugs	
	Theatrical makeup	Sports and active wear Textiles	Spray cooking oil	Food coloring Frosting and icing	
			Powdered mixes Powdered sugar Precooked frozen foods Salt	Frozen and dried eggs	
			Seasoning mixes Yeast	Hams Hot dogs, bologna Ice cream, sherbets, and frozen puddings Jams, jellies, preserves	
				Marshmallows Peanut butter Pet food Pickles and relishes Sausage Soups Spices Tomato sauces Vegetables Vinegar Worcestershire sauce Yeast	

Source: Iowa Corn Growers Association

