MEXICO

Integration of the North American Market for Sensitive Agricultural Commodities

Policy Notes Overview and Corn Market - Implications for Mexican Producers and Consumers

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These notes were conceived in an environment where there was some fear that the final phase of opening under NAFTA would create pressure on local producers of corn, beans and sugar. In order to better understand and prepare for such impacts, the Government of Mexico invited the World Bank, together with the Instituto Mexicano para la Competitividad (IMCO), to analyze the potential effects on both producers and consumers of the tariff and quota phase-out on these markets. The study was highly consultative and input was sought from a number of sources including the Ministry of Agriculture (SAGARPA), the Ministry of Public Finance (SHCP), producers and entities from the private sector. The final result is a series of four publications. The first three, in English, include an overview of the policy notes for all three commodities (corn, dry beans and sugar cane) and one full length commodity policy note each. The fourth, in Spanish, gathers the executive summaries of all three policy notes.

Broadly speaking, the notes predicted that in the short term, the phasing out of tariffs and quotas would have very little impact on the trade of corn and beans, since these markets were already largely integrated. For sugar cane, the notes concluded that the industry could become competitive with the help of some policy changes.

In the event, the final elimination of tariffs occurred at a time when global commodity prices were at historically high levels. Although this was partly due to high input costs, it brought high profits for Mexican producers, while provoking a food price crisis among consumers. Both commodity and input prices have since fallen from their peaks in early 2008, but they remain high relative to levels of recent years.

While high prices may have sheltered producers for some time, now, nearly a year after the phase-out of trade barriers, we
can say that the impact on producers of corn and beans has gone largely as expected. For sugar, the Government of Mexico has begun to consider policy changes. It is currently proposing to dismantle the reference price for cane, although producers have opposed this measure. At the same time many mills face unsustainable debt levels, a problem which will eventually require further government policy decisions.

Since the messages of the notes relate primarily to how to increase competitiveness and productive efficiency, they remain highly relevant in the current environment. One of the main strategic objectives now is to “make the best of a good situation” by encouraging an efficient supply response to the high prices. In the past few years, growing demand for food within the country has led imports to rise faster than exports. Measures such as increasing the productivity of the land already farmed through the adoption of new technologies and better adjusting crop selection to domestic preferences will enable Mexican producers to satisfy a greater portion of domestic demand, while also taking better advantage of export prospects (for these or other products) in the US market.

In sum, we hope that these notes will serve to focus policymaking on creating the conditions necessary to maximize current market conditions and the opportunities offered by NAFTA.

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Country Director
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The countdown is over. Fourteen years after the North American Free Trade Agreement (NAFTA) was negotiated, remaining tariffs and quotas on U.S. and Canadian exports to Mexico will be history as of January 2008. For three sensitive agricultural products of corn, beans, and sugar, this is not an abrupt end to trade barriers but rather the final stage in a gradual phaseout. Nevertheless, given their important role in Mexican culture and diet, as well as their contribution to the rural economy and employment (Table 1), there is general concern about the impact the NAFTA may have. This study examines the probable effects on Mexican producers and consumers of this final step.

The focus of this study is competitiveness. The analysis considers several dimensions of competitiveness of Mexican producers vis-à-vis their counterparts in the United States, market structure in Mexico and the United States, the impacts of increased import competition on consumers, and most importantly policy options for the government to support producers in responding to increased competition and in taking full advantage of opportunities opened by NAFTA.

1 This paper synthesizes the main results and conclusions from three individual notes on the markets for corn, beans, and sugar. The work has been carried out at the request of the government of Mexico by the World Bank in collaboration with a team from the Instituto Mexicano para la Competitividad.

2 This study does not focus on poverty, as does much of the World Bank’s work in Mexico and elsewhere, including the 2005 report Income Generation and Social Protection for the Poor, which includes a special section on rural poverty. The ongoing agricultural public expenditure review for Mexico will also include equity concerns as a primary criteria for evaluation of spending programs.
The study analyzed the impact of partially reversing the policies agreed under NAFTA in these products (which is an option being proposed by some in Mexico), finding that this would on balance be quite costly to the Mexican economy. The notes also include estimates of location-specific production costs, aggregated into variable costs or "supply curves" for the nation as a whole, which can assist the government in identifying areas most at risk from competitive pressures from NAFTA or other sources.

### Selected Indicators of Employment and Value of Production

<table>
<thead>
<tr>
<th></th>
<th>Agriculture (primary sector)</th>
<th>Corn</th>
<th>Beans</th>
<th>Sugarcane</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production value, 2004 (billion pesos)</td>
<td>421.74</td>
<td>36.40</td>
<td>6.63</td>
<td>15.99</td>
<td>49.26</td>
</tr>
<tr>
<td>Percent of agricultural GDP</td>
<td></td>
<td>8.63</td>
<td>1.58</td>
<td>3.79</td>
<td>11.60</td>
</tr>
<tr>
<td>Employment / growers</td>
<td>5,772,000</td>
<td>1,868,950</td>
<td>570,000</td>
<td>165,120</td>
<td>450,000</td>
</tr>
</tbody>
</table>


**Note:** Data is mainly for 2004, but includes some data for 2006 depending on availability.

- **a.** Including agriculture, livestock, forestry, hunting, and fishing. The primary sector accounts for 3.5 percent of national GDP, while the agricultural food sector accounts for 8.1 percent.
- **b.** The secondary sector in corn processing and product manufacture is valued at 195 billion pesos, more than four times the value of primary corn production. It also generates 240,000 jobs (85 percent of which are production of tortillas and nixtamal), which represents almost 60 percent of total employment in the food industry.
- **c.** Employment in agriculture sector is an estimate of actual employment from ENOE 2007 (which accounts for about 13.5 percent of national employment). Data for corn, beans, and sugarcane is number of growers, not actual workers or employees. Number of workers for sugar is SAGARPA estimate of total direct employment in the sugar industry including growers, cane cutters, field workers, transportation, and mill workers (total mill employment is 30,775).

The final phase of implementation of NAFTA will affect each of the three product markets in a somewhat different way. For corn, the study found that the effects will be quite minimal, since the U.S. and Mexican markets have already become virtually fully integrated, as the government has not exercised its option to constrain imports over the course of the last 14 years, and in any case, the nation is self-sufficient in white corn for human consumption. In light of the current very high price of corn in the global markets, recent policy attention has focused more than in the past on consumer issues—avoiding another “tortilla crisis”—but there is still a need to make production and marketing more efficient.

For beans, an import tariff of 11.8 percent is still applied to imports, so when this tariff is eliminated there will be some effect, albeit modest due to the low level of the current rate. The impact will be further attenuated by the segmented nature of the beans market, in which U.S. exporters do not compete in a major market segment, light-colored beans, which accounts for about 48 percent of Mexico’s production. But as with corn, there are a number of opportunities to improve competitiveness and even to take advantage of opportunities for niche markets in high-value domestic and export products. Most of the policy issues for corn and beans are quite similar, so they are discussed together in this Overview.
Sugar is probably the most difficult market for which to predict the effect of the final phase of NAFTA. Despite provisions in NAFTA that progressively liberalized bilateral trade in sweeteners beginning in 1994, and in fact did increase that trade, persistent trade conflicts and countermeasures between Mexico and the United States in recent years distorted the trend. However, those issues were largely resolved during 2007— including the end of a controversial tax Mexico placed on soft drinks sweetened with high fructose corn syrup (HFCS). Open bilateral trade in sweeteners between the United States and Mexico will pose additional challenges to the Mexican sugar industry because of its structural problems.

Even so, it is difficult to predict exactly how the end of tariffs will affect trade because (a) the sugar policies in both countries are quite complex; (b) the availability of substitute sweeteners creates linkages with other markets; and (c) both maize and sugar can be used as feeder stock for biofuels. For these reasons, even a seemingly straightforward issue such as the direction of net trade depends on evolving political issues, non-NAFTA trade barriers, commercial and consumer trends, and the impact of emerging biofuel markets. The sugar sector is also challenging from a policy perspective, since many of the reforms that promise the greatest results are also fraught with political and social controversy.

A major objective of the notes was to present policy options to the government. The analysis purposely did not include the major agricultural subsidy programs (e.g., Procampo, Ingreso Objetivo), which have been and are the subject of several other pieces of analytical work, including an ongoing World Bank agricultural public expenditure review. It focused instead on policy options that have a special relevance for these three products, both sectoral policies and policies that are important for these products but are not normally considered “agricultural.” The benefits from taking action in many of these areas would extend to producers and consumers of other products as well, in some cases beyond agriculture. For such issues, it is beyond the purview of this study to undertake an in-depth analysis, but the notes attempt to lay out the issues and propose some options to be explored.

Crosscutting Policy Issues for Corn and Beans

High transportation costs

Obstacles to efficient and cost-effective transportation of corn and beans, both from production areas to markets and between different markets, increase consumer prices, decrease competitiveness of Mexican producers in markets to which U.S. producers have rail access, create excessive regional variation in prices, and prevent low-cost producers from competing in more distant consumption centers (including U.S. markets). The policy recommendations in the report regarding transport (which are explained in more detail at IMCO’s website, www.imco.org.mx) address three main problems: (a) lack of competition and the high transport costs of trucks, (b) limited use of the railroad system and problems among private rail companies, and (c) inefficiency at customs and port facilities in border areas. The notes suggest some options for both institutional reforms and public investment programs. Transport issues specific to the sugar industry are discussed later, in the product-specific policy options.

Recommendations for addressing lack of competition and high trucking costs involve (a) promoting competition in the sector, (b) renovating the cargo fleet, and (c) improving market information. The most important recommendations concerning the second
problem, rail transport issues, are to (a) create “last-mile services,” meaning the building of last mile railroad infrastructure to connect main railways to ports, warehouses, and other key locations to avoid intermediate transportation, (b) find reciprocal mechanisms to avoid disagreements between railway companies, and (c) publish tariffs for different cargos and volumes. Recommendations for the third issue, customs and port inefficiencies, involve (a) reducing paperwork, (b) improving inspection facilities and procedures, (c) better coordinating the work of different authorities in this area, and (d) improving intermodal facilities throughout Mexico.

It should be recognized that while reducing transport costs improves overall competitiveness, it could lead to price reductions in grain-deficit areas, with potential adverse effects on producers in these areas. The information on regional production costs in these notes may help to identify those areas that are both high-cost and deficit areas, which may be targeted for attention. Potential losses would of course need to be quantified to see if they are sufficient to justify intervention.

Lower barriers to imports from outside NAFTA

Under normal circumstances the United States is the lowest cost source of corn and beans imports for Mexico, implying that the risk of serious “trade diversion” from the NAFTA is low in these products. Nevertheless, the uncertain effects of ethanol demand, HFCS production, market speculation, crop shortfalls, and other factors can lead to spikes in the price of corn and tortillas that have a particularly high impact on the poor. In response to the “tortilla crisis” in early 2007, the government signed an agreement with corn producers and traders to set a maximum agreed price for tortillas and allowed more imports from non-NAFTA countries, in this case South Africa. But these sorts of ad hoc actions in response to crisis do not constitute a viable long-term policy.

One strategic option to minimize this problem in the future would be to reduce trade barriers that currently discourage the development of diversified sources of supply. (The option is probably most relevant for corn, but similar arguments would support action for beans as well.) Argentina, for example, is a very low-cost producer and major world market exporter of mainly yellow corn. Some production in that country could be switched to white corn if Mexico were an attractive market, but imports from Argentina are currently subject to a tariff of 194 percent, making them uncompetitive. Lowering this tariff or at least creating a tariff-rate quota would allow importers to buy from this source when terms are more attractive than imports from the United States and Canada. But other more comprehensive options for reducing barriers in this market might be even more effective.

The following actions would be ways in which the government could lower barriers to diversification of supplies, listed in decreasing order of potential benefits:

- Permanently remove non-tariff barriers and eliminate tariffs on an MFN basis for imports from all countries.
- Permanently remove non-tariff barriers and eliminate tariffs for imports from select countries (e.g., only Argentina and/or South Africa)
- Permanently open a low- or no-tariff quota for imports from select countries
- Have a contingency plan in place to quickly take one of the above actions in case of price spikes in the U.S. market.

The permanent actions would introduce more certainty and allow better planning by
private sector importers and users of corn, and the more comprehensive options would allow more diversification opportunities.

Weaknesses in the warehousing system

Warehouses have two roles: (a) assisting farmers in managing their production and sales and (b) facilitating access to credit. Currently, Mexican suppliers are constrained by a cash payment system while U.S. suppliers have access to financing mechanisms that allow them to use inventories as collateral, thereby deferring payments, and offering more attractive terms to buyers.

A key policy option recommended by this report is consideration of a new law on rural warehouses. SAGARPA in 2004 proposed a comprehensive reform of the system for licensing and regulating warehouses but the reforms still have not been passed into law. The options proposed need to be further explored with the goal of (a) lowering barriers to market entry to allow more competition, (b) creating a transparent public information system on prices and inventories, and (c) allowing the issuance of negotiable, endorsable warehouse receipts as a financial mechanism for stored commodities. At the same time the law should preserve supervision that ensures the integrity of financial instruments issued by warehouses, a role currently performed by the Comision Nacional de Bancos y Valores.

A possible model for reforms is the “reportos” system in the sugar sector, which allows producers to repurchase the receipt of their inventory at a certain time, paying a premium to the buyer for holding the receipt. Mechanisms related to storage markets that have proved successful in other countries should also be considered, such as the Cedula de Productos Rurales (CPR) in Brazil, which is a bond issued by rural producers, farmers associations, and cooperatives to obtain financing for production.

Technology and biotechnology

A major factor affecting the competitiveness of Mexican producers is that yields in Mexico are low relative to those in the United States. Increasing yields will require improved technology in general and especially the incorporation of biotechnology. Some problems that have impeded the more widespread adoption of improved seeds are addressed by the new Law for Seed Production, Certification and Commerce, which was approved in April 2007. Other options to promote the use of improved bean seed varieties in Mexico are:

- Promote public-private partnerships (for example with INIFAP) to develop technologies tailored for Mexican varieties and regions, and for tapping into niche markets.
- Make agricultural public research institutions fully autonomous, with independent governing boards that include private and producer organizations. This could help increase funding from producer organizations both for research and development and for seed distribution.
- Conduct a strong information and training campaign to familiarize farmers and agribusiness owners with the purpose and use of new technology.

In addition, technology transfer could be promoted by modification of some of the rules of Alianza Contigo to:

- Improve incentives for private providers of technical services, as these are the weakest link in the implementation chain. They are recruited on short-term contracts, have no entitlement to secure employment and receive few economic or moral incentives to do a good job.
Change the project selection process so that funding decisions are based on quality and cost-efficiency instead of on a first-come, first-served basis and completeness-of-documentation.

Non-GMO technology may have higher potential for improving the productivity of many Mexican producers than GMOs. But many of the policy issues that in the past have presented obstacles to development of this market have been resolved by the passage of the new seed law. Policy-making attention needs now to be focused on policy towards GMOs. While acknowledging that in the case of GMOs, it is necessary to first put in place a regulatory framework that includes appropriate safeguards against the well-known risks, we argue that high priority should be placed on putting in place and making operational the regulatory process required to introduce GMOs. In particular, it would be helpful to reduce the very long lead times currently required to take genetically modified varieties through biosafety protocols and develop and distribute adapted transgenic varieties to market.

**Taking advantage of economies of scale**

One of the main characteristics of both corn and bean production in Mexico is its high degree of land fragmentation, owing, inter alia, to a long history of rigidities in the land market. More than 85 percent of corn farmers have landholdings smaller than five hectares and about 57 percent are smaller than two hectares. Since most producers have small landholdings and market their own crops, it is difficult for them to gain access to credit and improved production technology and to integrate into the supply chain. A fluid land market should in principle encourage efficient consolidation, but even the constitutional reforms of 1992 have had only a small degree of success in developing this market.

Although there is little analysis of the effect of increasing the size of landholding on cost of production in Mexico, a FIRA analysis of a pilot program for wheat producers in Sonora found that increasing mean landholding in irrigated areas from 2.4 to 7 hectares resulted in average cost savings of 17 percent, with economies of scale particularly high in preparation of land and control of invasives and pests.3

Apart from physically consolidating landholdings, a good starting point to help producers take advantage of scale economies is to foster producers associations that can gain better access to credit, information, and agricultural contracts. Associations of bean producers are relatively new and quite small, and many of them are more closely related to political groups than to concerns about efficiency.

To facilitate the organization and work of associations truly oriented toward member services, the Agricultural Cooperatives and Associations Organization Law (Ley para la Organización de Cooperativas y de Asociaciones Agrícolas) needs to be reviewed with an eye toward reducing red tape and loosening requirements that currently make it difficult for producers to create new associations. A draft reform of this law, which was proposed in the upper house in 2002, seeks a democratization of agricultural organizations and a more crucial role in agricultural policy and practices. It also promotes integration of supply chains to encourage investment and reduce risk for individual producers. This proposal was dismissed by the Senate’s Rural Development Commission without being discussed at the plenary session, and no further reforms have been promoted since then.

3  FIRA, Proyecto de compactación de Tierras para la producción de Trigo en el valle del yaqui, Tetabiate empresa social, s.p.r. de r.l, 2005
Reconversion

In some of the most inefficient corn and bean growing areas, reconversion to more productive crops is probably the best medium term option for many farmers. This is a complicated task, particularly in the case of subsistence agriculture, and specific recommendations are beyond the scope of this note. But when the government designs reconversion programs, the notes recommend beginning with an analysis of “economic densities”—the return obtained per hectare from different uses—as a first step, rather than only considering agro-climatic suitability, as has sometimes been the case in the past.

Because crop reconversion requires considerable amounts of investment, technical assistance, and market information, a successful reconversion plan must be based on a cost-benefit analysis that includes a register of arable land, its current use, environmental constraints, access to markets, and possible alternative land uses considering soil, rainfall, geography, technology, land tenure, demographics, and prices. These factors need to be considered in the future for all government programs to support reconversion, even if only in the form of extension advice and services.

Technology has also played an important role in reconversion, including the use of improved seeds, more resistant crops, and greenhouses, which have had a number of very successful outcomes for both producers and workers. Future research and government sponsored programs directed towards reconverting land should include a technological component.

Improving market intelligence

Integration of the North American market creates new opportunities for producers, especially in selling unique and high-value products to the Hispanic population of the United States. Mexico has tapped very little of its competitive advantage in niche markets such as blue corn, red corn, cuitlacoche (corn fungus), specialty foods such as dried tortillas and tostadas, and packaged or processed bean products. (Some important Mexican agroindustrial firms are planning on opening bean canning plants in the United States.)

But to seize such market opportunities producers need more information about consumer preferences and habits as well as knowledge on how to meet consumer demands, position a product in the global market, manage resources, minimize costs, maximize profits, and use new information technology to support efficient decisionmaking. While trying to document and find figures on niche markets for processed beans, we found that neither the Ministry of Agriculture nor FIRA has such information, either for Mexico or for the United States, nor do they systematically provide information on corn niche markets.

Market information has some characteristics of a public good, but in well-developed markets considerable information and training may be provided to producers by firms farther along in the supply chain. However, it is important to improve the public market intelligence system to provide such information and skills for small agricultural producers and agribusinesses that currently are not well integrated into supply chains. A good model for such a system is Fundación Chile, which works with both the private and public sector in Chile to develop and expand foreign markets for small-scale producers.

4 There are two basic reasons for this: low quality of Mexican beans and cheaper transport costs to serve the Hispanic population in the United States. Both of these constraints are addressed in other recommendations in this report.
Planning for climate change

Long-term policy-making in all agricultural markets will have to cope with many uncertainties, foremost among them the specter of climate change. Mexico may suffer especially from reduction in water availability, with serious consequences for its agricultural production overall. The implications of this for competitiveness in the NAFTA market are not clear, however, since some of the most productive areas of the United States are also expected to suffer, and the impact on global markets is just beginning to be explored. Given the huge uncertainties involved in all of these forecasts, the most prudent path for the government is probably to establish early on a consultative process with stakeholders to monitor and review the evidence on the impacts of climate change in order to stay abreast of the most recent developments and start to build early consensus on necessary policy actions and investments.

Water policy

Even though irrigated areas have much higher yields and lower financial production costs, the true social costs of production are much higher than the financial costs, given the high economic value of water in Mexico. Promotion of efficient water use is urgently needed to help avoid future water scarcity problems, particularly in the face of increasing urbanization and the effects of climate change.

Water allocation and pricing policy is a critical area for review since (a) it currently does not capture the environmental, economic, or social costs of this resource nor balance demand from agriculture with that of other sectors and (b) it is critical to both the sustainability of production and the competitiveness of producers. Appropriate pricing of water is necessary to encourage production of crops which have the greatest value added for society as a whole, which may in some cases mean encouraging producers to switch from growing low-value crops like maize or beans to growing higher value crops. Thus, appropriate pricing of water would support the reconversion effort.

The World Bank and the Mexican government have amassed a large body of analysis on options for reform in the water sector; what is needed now is an action plan. A full discussion of this topic goes far beyond the purview of this study, but in broad terms there are a number of options for placing an economic value on water. One is for the public sector to charge an appropriate price for water that comes from public investments (dams and large irrigation projects). But other options—such as the assignment (without charge to the recipient) of tradable water rights—also effectively put a price on water and encourage its conservation and efficient use, while not imposing any cost on the initial water users. In any case, a good first step is to phase out current implicit subsidies on electricity use for pumping (Tarifa 9) that encourage over-use of water.

Policy Issues in the Sugar Sector

Because of the nature of the industry and its historical importance in the economy, the government has continued to play a larger role in this sector than in most other product markets. Although most decisions regarding production, trade, and investment are made by the private sector, the government can influence outcomes by (a) modifying existing laws and regulations, (b) conditioning the sale of mills remaining under government management, (c) conditioning the terms of debt held by the government, and (d) most importantly, using its convening power to draw on expert opinion and form consensus among
stakeholders. A common element of many recommendations is the need for stakeholders at different stages of the production cycle to collaborate better in working out transparent solutions that improve the entire value chain and increase trust, predictability, and earnings rather than merely competing over how to divide profits.

Support industry restructuring

While the investments needed to restructure mills and reduce overstaffing should come from the private sector, the government could encourage this through its convening authority and helping to mitigate the burden of adjustments on local communities and smallholder growers through appropriate investments and social safety net programs.

Lower energy expenses

The government could encourage the use of bagasse to generate electricity by removing barriers that currently limit the ability of mills to sell electricity to the Federal Electricity Commission (CFE) or other industries. In addition, reconsideration of CFE’s formula for pricing the electricity it buys from mills could support development of this market for alternative energy.

Transportation

The sugar industry could also benefit from the kinds of general improvements to the transportation system discussed above in relation to the corn and beans markets. But in addition, this industry suffers from the problem of elevated costs and congestion caused by a lack of coordination in transporting cane to the mills. The government could work with the industry to improve roads and coordinate transportation to eliminate redundant vehicles, improve efficiency, and reduce both delivery delays and crowding of deliveries at the mills.

Technology and improved varieties

The government and the industry could work in partnership to upgrade research and extension services related to development and use of improved sugarcane varieties targeted to specific regions and growing conditions. This could increase yields in both the fields and the mills.

Plot size and fragmentation

The government could encourage growers and millers to work together in a way that takes advantage of economies of scale, either by consolidating landholdings of sugarcane growers into larger, more efficient plots, or by creating mechanisms through which growers with small plots can better coordinate their activities to increase mechanization and efficiency.

Pricing cane

The government could work with the industry to explore technologies and management procedures that directly link the quality of cane delivered to the mill with revenue received by the individual grower.

Revenue sharing

Working with industry, the government could explore alternative, transparent ways to share revenue based on the true value of the sugar and to create sharing rules that reward industry participants for improvements in field and mill efficiencies.
Vertical integration

The Mexican sugar sector would be more competitive if it were organized more in line with the prevailing model elsewhere in the world. This would require (a) modifying Mexican law to allow mills greater freedom to own land and produce their own sugarcane and (b) creating mechanisms through which growers and mills can form partnerships that improve their efficiency and link their incentives for achieving common goals.

Government ownership

In the government’s efforts to complete the privatization of government-managed mills it might reconsider some practices which did not lead to long-term solutions in the past, such as selling mills on a highly leveraged basis or in bundles. In deciding whether to close down or privatize each mill, a key decision parameter will be whether the mill will have the financial wherewithal to comply with environmental norms as well as meet its other obligations.

Costs and Benefits of Policy Options

Ideally, options for policy reform would be obvious, fast, easy, low-cost, high-impact, and face low political resistance. Realistically, of course, we have to recognize that most such options—when they ever existed at all—have been previously exercised. In making well-informed decisions going forward, the government will need to weigh the trade-offs among these various criteria. This study has tried to identify and highlight some of the most critical areas in which appropriate policy actions can enhance competitiveness of producers of these three products and improve aggregate welfare.

The table below summarizes how we believe some of these options rank with respect to the criteria mentioned above, with the exception of political feasibility, which is a judgment that policy-makers themselves are best positioned to make. However, having said that, it would appear that some of the options are not likely to encounter great political opposition and at the same time promise significant benefits, with modest technical requirements and fiscal costs. While other more controversial actions (on GMOs, for example) may promise greater benefits in the longer term, these may be areas that the government could target for quick action. A list of these “low-hanging fruit” could include:

- Revising rules and regulations in the transport sector
- Passing a law on warehouses
- Investments in research to improve production technology
- Improving the environment for technology transfer by amending the rules of Alianza Contigo
- Passing a law on Agricultural Cooperatives and Associations Organization (Ley para la Organización de Cooperativas y de Asociaciones Agrícolas)
- Improving the market intelligence system
- In the sugar sector, convening a high-level stakeholder panel to consider reform options for the sector
## Summary Matrix of Policy Options

<table>
<thead>
<tr>
<th>Policy option</th>
<th>Time horizon</th>
<th>Likely impact</th>
<th>Technical difficulty/risks</th>
<th>Fiscal cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Implementation</td>
<td>Effects</td>
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<tr>
<td>Crosscutting</td>
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<td>Transport</td>
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<tr>
<td>Regulations</td>
<td>S</td>
<td>M/L</td>
<td>H</td>
<td>M</td>
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<tr>
<td>Investments</td>
<td>L</td>
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<tr>
<td>Warehousing</td>
<td>S</td>
<td>M</td>
<td>M</td>
<td>L/M</td>
</tr>
<tr>
<td>Technology, general</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>S</td>
<td>M</td>
<td>H</td>
<td>M/H</td>
</tr>
<tr>
<td>Scale economies&lt;sup&gt;a&lt;/sup&gt;</td>
<td>S/ M</td>
<td>M/L</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Reconversion</td>
<td>M/L</td>
<td>L</td>
<td>M</td>
<td>M/H</td>
</tr>
<tr>
<td>Market intelligence</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Lower trade barriers</td>
<td>S</td>
<td>S/M</td>
<td>L/M</td>
<td>L</td>
</tr>
<tr>
<td>Sugar industry</td>
<td></td>
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<tr>
<td>Sugar restructuring</td>
<td>M/L</td>
<td>M/L</td>
<td>H</td>
<td>M</td>
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<tr>
<td>Lowering energy costs</td>
<td>S/M</td>
<td>M/L</td>
<td>M</td>
<td>M</td>
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<tr>
<td>Transport</td>
<td>S</td>
<td>S/M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Technology</td>
<td>M/L</td>
<td>L</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>M</td>
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<tr>
<td>Pricing cane</td>
<td>S</td>
<td>M</td>
<td>H</td>
<td>M</td>
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<tr>
<td>Revenue sharing</td>
<td>S</td>
<td>M</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Vertical integration</td>
<td>M</td>
<td>M/L</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Design of privatization</td>
<td>S</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
</tbody>
</table>

Implementation term: Short (< 2 years), generally associated with changes in laws or regulations; Moderate (2-5 years), requiring some institutional changes; Long (> 5 years).

Effects term: Short (< 2 years); Moderate (2-5 years); Long (> 5 years).

Impact: High, medium, low (relative to other policy options proposed in these notes, not relative to other more general reform options).

Technical difficulty/risks of undertaking the options suggested: High, moderate, low.

Fiscal cost to government: High (large public investment programs), moderate (some public program expenditure required), low (little or no public expenditure).

<sup>a</sup> Scale economies through encouraging cooperatives.
INTEGRATION OF THE NORTH AMERICAN CORN MARKET: IMPLICATIONS FOR MEXICAN PRODUCERS AND CONSUMERS

EXECUTIVE SUMMARY

Corn is not only the most important staple food and leading agricultural crop in Mexico, it is also more deeply intertwined with the national identity, culture, and history than in any other country. However, over the past several decades, Mexico has come to rely increasingly on U.S.-grown corn. When corn prices spiked in early 2007, largely as a result of U.S. ethanol demand, the resulting “tortilla crisis” dominated national news and politics in Mexico, reflecting the importance of understanding, anticipating, and addressing the impacts of trade in this increasingly integrated market on consumers and producers in Mexico.

This report analyzes the effect of the final phaseout in 2008 of Mexican tariffs on imports of U.S. corn under the North American Free Trade Agreement (NAFTA). It finds that U.S. and Mexican markets are already essentially integrated and makes recommendations for how to maximize the benefits of this integration and improve the competitiveness of Mexican producers. These recommendations are based on the results of a

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1 NAFTA also includes the Canadian market, but since corn trade with Canada is minimal the report discusses the integration in terms of Mexico–U.S. trade. U.S. and Canadian tariffs on Mexican corn were eliminated when NAFTA went into effect in 1994.

2 The focus of this study is competitiveness, not poverty alleviation per se. Much of the World Bank’s work in Mexico and elsewhere is focused on poverty, including the 2005 report Income Generation and Social Protection for the Poor, which includes a special section on rural poverty. The ongoing agricultural public expenditure review will also include equity concerns as a primary criteria for evaluation of spending programs.
quantitative analysis showing the effects of market integration.

**Main Issues for Mexico**

In broad terms, Mexico’s main concerns related to open corn markets are (a) the competitiveness and sustainability of Mexican producers, (b) affordability of corn and tortillas for consumers, and (c) impacts on production and prices of other commodities such as beef, pork, chicken, and eggs. The balance among these three concerns has shifted over the period of NAFTA implementation, and indeed even over the period during which this study has been carried out. The government’s original concern was largely focused on the first of these—possible negative impacts that cheap corn imports would have on domestic producers. But as global corn prices have risen in the last few years (Figure 1)—driven at first by increased demand for fodder for meat production in rapidly growing economies, and more recently for use in ethanol production—the balance has shifted more towards the latter two.

**Main Policy Focus of the Report**

In terms of consumption issues, since Mexico has reversed its past policies of domestic price controls and import barriers for corn, the government’s key goals in light of recent international price movements are how to mitigate market volatility and limit the adverse impacts on consumers of possible future price increases or supply constraints. Policy options in this regard focus mainly on (a) import policy for corn from non-NAFTA countries, particularly white corn for human consumption, (b) efforts to lower production and marketing costs for domestic corn production thereby increasing competitiveness and lowering prices, and (c) support programs for poor subsistence farmers who depend on small-scale local production for the corn they consume directly.

In the area of production and competitiveness issues, the report focuses on policy options for (a) increasing yields through introduction of new technology and particularly of genetically modified corn varieties, (b) addressing transport and storage problems that currently put Mexican producers at a competitive disadvantage and raise prices, (c) decreasing fragmentation of commercial corn production, (d) reconverting some land from corn to more economically productive and competitive uses, (e) improving financial mechanisms to reduce transaction costs and risks and make the terms of financing more attractive, and (f) strengthen producers’ marketing and entrepreneurial skills.

**Figure 1. International Corn Prices**

Source: CEESP, with information from CNA.

**Corn Supply and Demand in Mexico**

Corn is the most important staple crop in Mexico, with consumption of corn and tortillas accounting for about 47 percent of average caloric intake. It is the fifth largest producer in
the world (22 million tons) and the third largest importer (8.8 million tons).\(^4\)

Since the early 1990s Mexican production has moderately outpaced population growth, but over the same period there were dramatic increases in total consumption and imports, largely to meet demand for corn as animal feed (Figure 2). Imports, virtually all of which come from the United States, went from about 7 percent of domestic production in 1991-93 to nearly 40 percent in 2005-07 and are expected to increase even more in the next five years. Similarly, animal feed accounted for less than 5 percent of total consumption prior to 1990 but now represents about half of all consumption and is still rising. In the meantime, human consumption has essentially remained steady since 1990 despite population growth because per capita consumption has been slowly declining.

\(^4\) Source: USDA Production Supply and Distribution (PSD) online database. The 2006/07 marketing year in Mexico begins in October 2006 and ends in September 2007.

The markets for human consumption and animal feed in Mexico correspond closely to the distinct markets for white and yellow corn (including cracked corn). White corn can substitute for feed corn, particularly when prices are favorable, but rarely is yellow corn used for human consumption. Almost all Mexican production is white corn and almost all imports are yellow and cracked corn. This is partly because U.S. producers have a comparative advantage in growing yellow corn and partly because Mexican producers have continued their long history of growing white corn and participating in a familiar market. Although the government has continued to apply over-quota tariffs on white corn imports (except for the beginning of 2007), Mexico has generally been self-sufficient in white corn and has even used part of its production as fodder. In 2008 a surplus of white corn is expected to bring down prices and make it unlikely that there will be significant white corn imports.

![Figure 2. Mexican Corn Production, Consumption, and Imports](source)

Source: USDA PSD Database

Note: Years refer to marketing years (MY). MY2006 begins in October 2006 and ends in September 2007. Data for 2007 is projected.
One finding of this research is that barriers to imports of corn from the United States have already been largely eliminated (see below). In yellow corn, the marginal source of supply for the Mexican market is imports; in white maize, Mexico is self-sufficient, with the exception of unusual years like 2007, when imports were needed. This has important implications for price formation in the Mexican market. If white and yellow corn were completely separate products, this market structure would imply that yellow corn follows U.S. prices, while white corn's price is determined by supply-demand conditions in Mexico. But although they are not perfect substitutes, these two markets are fairly closely linked on the supply side (since their production requirements are very similar) and the demand side (through substitutability in livestock feed). This implies that while the price of yellow corn should very closely track U.S. prices, in white maize there is room for some deviation of domestic price from import parity (adjusted for transport costs, quality differences, etc.). But for both, the supply and demand conditions in the United States are very relevant, as are general global market conditions.

**Mexican Production**

Unlike the relatively homogenous, large-scale, industrialized corn industry in the United States, producers in Mexico vary dramatically—from small, rainfed, subsistence plots with very low yields and high costs, to large, irrigated farms with yields and costs comparable to those of U.S. producers. There is an extreme range in terms of technology use, growing conditions, costs, and competitiveness, and less than 5 percent of Mexican corn farmers are commercial producers. Of the roughly 1.9 million corn producers registered in the PROCAMPO roster in Mexico in 2004, more than 55 percent were smaller than 2 hectares and only 4 percent were larger than 10 hectares (Table 1). By comparison, a typical U.S. corn farm is about 270 hectares, according to the USDA Economic Research Service (ERS). While even over the course of one year the data clearly reflects a trend toward decreasing numbers of small producers and increasing numbers of larger ones in Mexico, fragmentation of production is still one of the main constraints on productivity in the corn sector.

Compared to the United States, average yields in Mexico are much lower and are also growing more slowly, while average costs of production are much higher. Figure 3 compares average yields and the compound annual growth rate (CAGR) of yields for the top four producers (not including the EU, which has yields of 6.5 tons per hectare). Another country worth noting is Argentina, which is the sixth largest producer and second largest exporter (exporting more than half of production), and has yields of about 7 tons per hectare.
Table 1. Size Distribution of Corn Producers

<table>
<thead>
<tr>
<th>Size of plot (hectares)</th>
<th>Number of Growers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2003</td>
</tr>
<tr>
<td>1 or less</td>
<td>530,392</td>
</tr>
<tr>
<td>1 – 2</td>
<td>549,201</td>
</tr>
<tr>
<td>2 – 5</td>
<td>577,594</td>
</tr>
<tr>
<td>5 – 10</td>
<td>207,139</td>
</tr>
<tr>
<td>10 – 18</td>
<td>45,363</td>
</tr>
<tr>
<td>18 – 50</td>
<td>23,882</td>
</tr>
<tr>
<td>50 – 100</td>
<td>3,788</td>
</tr>
<tr>
<td>More than 100</td>
<td>1,155</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,938,514</strong></td>
</tr>
</tbody>
</table>

Source: Apoyos y Servicios a la Comercialización (ASERCA), 2006.

However, Mexico’s average yields mask dramatic difference in yields between irrigated and rainfed corn production (Figure 4). Average yields for irrigated corn (6.7 tons per hectare) are more than three times higher than for rainfed (2.1 tons), and they are increasing much faster as well. On average, from 1996 through 2006, the 14.5 percent of corn fields that were irrigated accounted for 36 percent of all production.\(^5\) Production in Sinaloa alone, which is almost all irrigated, accounted for 20 percent of national production, 65 percent of all irrigated production, and had average yields as high as those in the United States.

Another major difference between irrigated and rainfed production is their production seasons. In 2006 more than half of irrigated corn was grown for the autumn/winter harvest and accounted for nearly 88 percent of autumn/winter production. In contrast, nearly 95 percent of rainfed corn was produced in the summer season and accounted for about 75 percent of the summer harvest.

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\(^5\) SIAP.
While irrigation is a critical factor for increasing yields, not all gains can be attributed to irrigation alone since it also tends to correspond to larger farm size, higher degrees of commercialization, and greater use of mechanization and other technologies. In addition to increasing yields, irrigation is also critical because it allows more corn to be grown (a) during the winter, (b) in areas that are unsuitable without irrigation, and (c) during
years of low rainfall. It is important to note that the cost of irrigated production in Mexico does not include the cost of water, which could be an important consideration in its long-term sustainability and profitability as well as in determining how to allocate water if there is competing demand from other users.

Production costs follow a similar pattern—while average costs in Mexico, not including subsidies and rents, are about 3.5 times higher than in the United States, the average costs of irrigated commercial growers are only 20 percent higher. For many of the higher-cost producers, corn growing may not be the best or most economically rational use of their land. Subsistence producers, and even commercial producers in rainfed areas (whose costs exceed the national average), must make considerable expenditures just to remain barely productive.

Despite passage of a law permitting the introduction of genetically modified (GMO) corn in Mexico, the regulatory provisions have not been drafted and published that would permit experimental trials to proceed as a first step toward eventual approval for commercial use. Non-GMO hybrid corn varieties, which have also been shown to increase yields, are used for most production in Sinaloa, but have not been widely adopted in most other areas due to a combination of legal and technical issues. However, their use is expected to increase because of the passage of a new “Law for Production, Certification, and Commerce” in April 2007 that addressed many of the legal and marketing issues related to hybrid seeds.

Transportation, storage, and marketing are another source of unnecessarily high costs and bottlenecks in the Mexican corn sector. Long distances from fields to consumption centers, reliance on expensive trucking costs, inadequate road infrastructure, and lack of direct railroad links at key transport hubs such as ports and markets, make it difficult to create an integrated market in which stocks can be moved economically between different production and consumption centers. Furthermore, Mexico has a substandard storage network that lacks competition and effective instruments for financing inventories in warehouses.

Main Findings

Market integration. In practice the U.S.-Mexico corn market is already integrated because Mexico accelerated the transition period by expanding its tariff-free quotas to meet domestic demand. Therefore, the formal end of tariff barriers will not signifi cantly affect prices in Mexico’s main consumption centers nor trends in trade and consumption. Although over-quota tariffs were in principle in effect for imports of white corn, the impact of ending tariffs, if any, is expected to be modest since Mexico has been and is expected to continue to be virtually self-sufficient in white corn. Although there is some substitutability between yellow and white corn, yellow corn is preferred as fodder, where demand is increasing rapidly.

Effects of NAFTA. The report shows that integration of the North American corn market has increased Mexico’s imports and significantly reduced corn prices. These increased imports, almost three-quarters of which are feed corn, have also improved food consumption patterns by lowering the cost of producing poultry, pork, and eggs, thereby increasing demand for these animal products while lowering tortilla prices. It is clear that without such large-scale, duty-free imports of U.S. corn, Mexico would experience a general loss of welfare, a decline in agricultural GDP, and poorer diets for a majority of Mexicans. Such a scenario would increase the price of corn and tortillas as well as other commodities that use corn as an input, compete with corn in markets, or would be displaced by corn in terms of allocating land and other production inputs. In addition to the substitution effects of
the higher price per se, loss of real income from the higher prices could shift Mexican diets away from “superior goods” causing significant economic losses for the pork, chicken, and egg industries.

Consumption and demand. While human consumption per capita is declining, corn remains the single-most important agricultural commodity in Mexico and is the largest element in the average Mexican’s diet, and total demand has remained steady. At the same time, the rapid increase in demand for yellow corn as animal feed is not expected to abate in the foreseeable future, leading to rising overall demand for corn and increasing ratio of imports to total supply. While prices are expected to rise in the short-term as markets adjust to the increase in demand for corn ethanol, in the mid-term prices are projected to begin dropping again and return to more normal levels within 10 years.

Yields and costs. Average Mexican yields are less than one-third of U.S. yields and costs are more than three times greater, but the yields and costs of larger-scale, irrigated commercial operations are on par with U.S. producers and with marginal improvements could even compete in U.S. markets. Among low-cost, high yield growers a key constraint to increased production and competitiveness is the lack of GMO corn in Mexico. For the corn sector overall, efficiency and productiveness are limited by the fragmentation and small plot size of growers, slow expansion of irrigated production, underuse of technology (including GMO and hybrid seeds), and use of land ill-suited to corn production. A large majority of Mexican producers are dedicated to subsistence production and are constrained by many of the same dynamics, but face different priorities and limits than commercial producers in terms of addressing them.

Water. For large-scale, irrigated, commercial producers, the economic value of water can be as much as all their other production costs combined, yet they only pay transaction costs (and even those are currently subsidized by cheap electricity6). Scarcity of water, environmental impacts of water use, and competing demand from other sectors could affect the sustainability of production and competitiveness of irrigated production in the long-term term if allocation and pricing issues are not adequately addressed.

Transportation and storage. Transportation, storage, and marketing are another source of unnecessarily high costs and bottlenecks in the Mexican corn sector. Long distances from fields to consumption centers, reliance on expensive trucking costs, inadequate road infrastructure, and lack of direct railroad links at key transport hubs such as ports and markets, make it difficult to create an integrated market in which stocks can be moved economically between different production and consumption centers. Furthermore, Mexico has a substandard storage network that lacks competition and effective instruments for financing inventories in warehouses. The competitiveness of Mexican producers is also reduced relative to U.S. imports by the fact that almost all imports come via rail and/or ship, whereas most internal movement of Mexican production is by higher-cost trucking.

Policy Options

Non-NAFTA imports

Although the United States is generally the lowest cost producer of corn, the uncertain effects of ethanol demand, HFCS production, market speculation, crop shortfalls, and other factors can lead to spikes in the price of corn and tortillas that have a particularly high impact on the poor. In response to the “tortilla crisis” in early

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6 Electricity subsidies are the subject of ongoing sector work by the World Bank.
2007, the government signed an agreement with corn producers and traders to set a maximum agreed price for tortillas and allowed more imports from non-NAFTA countries, in this case South Africa. But these sorts of ad hoc actions in response to crisis do not constitute a viable long-term policy. One strategic option would be to remove trade barriers that currently discourage the development of diversified sources of supply. Argentina is a very low-cost producer and major world market exporter of mainly yellow corn. Some production in that country could be switched to white corn if Mexico were an attractive market, but imports from Argentina are currently subject to a tariff of 194 percent, making them uncompetitive. Lowering this tariff or at least creating a tariff-rate quota would allow importers to buy from this source when terms are more attractive than imports from the United States and Canada. But other more comprehensive options for reducing barriers in this market might be even more effective.

The following actions would be ways in which the government could remove barriers to diversification of supplies, listed in decreasing order of potential benefits:

- Permanently remove non-tariff barriers and eliminate tariffs on an MFN basis for imports from all countries.
- Permanently remove non-tariff barriers and eliminate tariffs for imports from select countries (e.g., only Argentina and/or South Africa).
- Permanently open a low- or no-tariff quota for imports from select countries.
- Have a contingency plan in place to quickly take one of the above actions in case of price spikes in the U.S. market.

The permanent actions would introduce more certainty and allow better planning by private sector importers and users of corn, and the more comprehensive options would allow more diversification opportunities.

Transportation

Obstacles to efficient and cost effective transportation of corn, both from production areas to markets and between different markets, increase consumer prices, decrease competitiveness of Mexican producers in markets to which U.S. producers have rail access, create excessive regional variation in prices, and prevent low-cost producers from competing in more distant consumption centers (including U.S. markets). Improvements are needed in three main areas: truck transport, rail transport, and efficiency at ports and borders.

Improvements are needed throughout Mexico to address constraints involving road transport, including (a) increasing investment in roads, (b) optimizing truck cargo capacity, (c) allowing transport fleets to carry cargo on return trips, (e) creating incentives for renovating the cargo fleet, (f) increasing competition in the sector, (g) creating market information to help understand demand, bottlenecks, and location and prices of freight transport, and (h) modernizing customs, bridges, ports, and export-oriented infrastructure linked to road transport.

In some areas, particularly consumption centers with higher transport costs, improvements to railroad systems are also critical, including (a) building railroad infrastructure that creates “last-mile services” directly linking main railways to ports, warehouses and other key locations thereby eliminating the need for intermediate transportation, (b) finding reciprocal mechanisms to avoid loss of cargo due to disagreements, (c) establishing tariffs for different cargos and volumes, (d) creating
intermodal facilities, (e) enabling tracks to handle the weight of standard U.S. rail cars.

Policy options to improve efficiency at port and borders include (a) reducing paperwork, (b) providing adequate facilities and staff, (c) improving inspection procedures, (d) better coordination between different authorities, and (e) planning for peak traffic and transit periods. More detailed information can be found on IMCO’s website.

It should be recognized that while reducing transport costs improves overall competitiveness, it could lead to price reductions in grain-deficit areas, with potential adverse effects on producers in these areas. The information on regional production costs in these notes may help to identify those areas that are both high-cost and deficit areas, which may be targeted for attention. Potential losses would of course need to be quantified to see if they are sufficient to justify intervention.

Storage

While the quality of storage facilities needs to be improved and competition between warehouses increased, the most important reforms of the storage system in Mexico are to improve the regulations governing storage facilities and create new instruments for financing inventories. This would reduce transaction costs, improve liquidity in the Mexican corn market, make domestic corn more attractive to buyers, and help create incentives to improve other aspects of storage facilities. Currently, due mainly to a poorly functioning warehouse receipts system which makes it difficult to use warehoused goods as collateral, Mexican suppliers are constrained by a cash payment system while U.S. suppliers have access to financing mechanisms that allow them to use inventories as collateral, thereby deferring payments, and offering more attractive terms to buyers.

Under current law, the system of government-issued permits limits the number of storage facilities (almacenes generales de depósito) in operation. This in turn limits competition, leads to unnecessarily high transaction costs and reduces incentives and capacity to minimize the cost of inventories over time. A key policy option recommended by this report is consideration of a new law on rural warehouses with the objectives of (a) lowering barriers to market entry to allow more competition, (b) creating a transparent public information system on prices and inventories, and (c) allowing the issuance of negotiable, endorsable warehouse receipts as a financial mechanism for stored commodities. The law also should continue to provide for efficient financial regulation and supervision that ensures the integrity of financial instruments issued by warehouses, a role currently performed by the Comision Nacional de Bancos y Valores. SAGARPA in 2004 proposed a comprehensive reform of the system for licensing and regulating warehouses, and the proposed options need to be explored. A possible model for such reforms is the “reportos” system in the sugar sector, which allows producers to repurchase the receipt of their inventory at a certain time, paying a premium to the buyer for holding the receipt. In this way producers can store their crop and sell it when the market is favorable.

Mechanisms related to storage markets that have proved successful in other countries should also be considered, such as the Cedula de Productos Rurales (CPR) in Brazil, which is a bond issued by rural producers, farmers associations, and cooperatives to obtain financing for production. There are many variations and benefits to the CPR that are explained in more detail in the full report, but in basic terms the CPR provides crop financing for the production of the crop and manages the producer’s price risk by linking the debt...
to the product, thereby transferring price risk to the buyer. Traders and the agroindustry also benefit through the guarantee and better planning of commodity supply. The most important attribute of the CPR is, by far, the reduction of risks to the buyers, because it provides for out-of-court settlements in case of nonperformance or breach of contract. However, for this to work the judiciary must be prepared to guarantee the success of such suits and there must be sustainable and accessible agricultural and credit insurance to mitigate risks.

Water policy

As described earlier, irrigation not only improves yields but allows expansion of corn production both geographically and seasonally. However, the cost of irrigated production in Mexico does not include the cost of water, for which growers only need to pay the pumping and transaction costs, and even these are subsidized through below-market prices for electricity. Water allocation and pricing policy is a critical area for review since (a) it currently doesn't capture the environmental, economic, or social costs of this resource nor balance demand from agriculture with that of other sectors and (b) it is critical to both the sustainability of production and the competitiveness of producers. Appropriate pricing of water is necessary to encourage production of crops which have the greatest value added for society as a whole, which may in some cases mean encouraging producers to switch from growing low-value crops like maize to growing higher value crops. There are a number of options for placing an economic value on water. One is for the public sector to charge an appropriate price for water that comes from public investments (dams and large irrigation projects). But other options—such as the assignment (without charge to the recipient) of tradable water rights—also effectively put a price on water and encourage its conservation and efficient use, while not imposing any cost on the initial water users. In any case, a good first step is to phase out current implicit subsidies on electricity use for pumping (Tarifa 9) that encourage over-use of water.

**Technology, biotechnology, and GMO corn**

The main factor affecting the competitiveness of Mexican producers is that yields in most corn growing areas are both lower and increasing more slowly than in competing countries. Increasing yields will require improved technology in general and especially the incorporation of biotechnology. Non-GMO technology may have higher potential for improving the productivity of many Mexican producers than GMOs. But many of the policy issues that in the past have presented obstacles to development of this market have been resolved by the passage of the new seed law. Policy-making attention needs now to be focused on policy towards GMOs. While acknowledging that in the case of GMOs, it is necessary to first put in place a regulatory framework that includes appropriate safeguards against the well-known risks, we argue that high priority should be placed on putting in place and making operational the regulatory process required to introduce GMO corn. Mexican law requires that before GMO varieties can be permitted for commercial use they first be (a) tested in an experimental stage in research centers and (b) planted outside research centers in a pilot program under strict surveillance for a year. The entire process takes three years from initial permits to harvesting of the first commercial crop.

Modeling the impacts of GMO use in commercial Mexican corn production found that on average yields would increase by 13 percent and costs decrease by 14 percent. This would not only improve competitiveness and
lower prices at Mexican consumption centers, but could even enable low-cost producers in some areas to compete for the business of U.S. ethanol plants or lead to construction of more export-oriented ethanol plants in Mexico.

It is also important to continue the development and promotion of other technologies and practices currently being explored by commercial growers in Mexico to cut costs and increase yields—such as improved seeds, irrigation techniques, biologic fertilizers, mechanization, and crop rotation. The actions recommended to achieve this include granting experimental permits, making funds for research and development more transparent, allowing producers to organize and tap into such funds more easily, and incorporating the private sector into technology transfer strategies. Specific steps include:

- Fostering public-private-partnerships (for example with INIFAP) to develop particular technology for Mexican corn varieties and regions, tapping into corn niche markets.
- Encouraging producer associations to fund technology projects and distribute seeds. To motivate such groups requires full autonomy of public research institutions, with independent governing boards representing key stakeholders.
- Conducting a strong information and training campaign for ejidatarios and agribusiness owners on the use of new corn varieties and technologies to help facilitate their dissemination, as well as a retraining program for agricultural workers displaced by new technology.
- Making public research funds publicly available through competitive and contractual mechanisms to encourage participation and accountability. This could foster more interaction between the academia, the private and the public sector for technology diffusion and technology transfer.

In the case of GMOs specifically, Mexico could strengthen its own research capabilities by creating a joint agricultural research system with other key Latin American countries, or creating closer links to existing CGIAR institutions like CIMMYT. However, since the private sector has a much stronger model and track record for delivering and promoting GMOs, key government objectives to facilitate private efforts should be (a) reducing the transaction costs of market entry and particularly obtaining of biosafety clearances, (b) protecting intellectual property rights, and (c) helping grow and deepen seed markets, with farmer participation.

In addition, some of the programs within Alianza Contigo need to be changed to promote technology transfer, including:

- Strengthening the motivation of private technical services providers—who currently are the weakest link in the implementation chain—by giving them longer contracts, more secure employment, and greater economic and moral incentives to do a good job.
- Changing the project selection process so that funding decisions are based on quality and cost-efficiency instead of on a first-come, first-served basis and completeness-of-documentation.

Finally, for both corn and other sectors, promoting decentralization of rural policy could help technology transfer by forcing state governments to internalize all costs and benefits, thus promoting efficiency and equity in resource use. For example, transferring most of the funds of production-oriented R&D programs to the states in the form of block grants could facilitate the application of a more locally tailored approach to rural development. The national
government would still reserve funds for itself, to carry out national-level execution of R&D that is considered strategic in nature.

**Taking advantage of economies of scale**

One of the main characteristics of corn production in Mexico is its high degree of land fragmentation, owing, inter alia, to a long history of rigidities in the land market. A fluid land market should, in principle, encourage efficient consolidation, but even the Constitutional reforms of 1992 have had only a small degree of success in developing this market. According to information from the Ministry of Agriculture (Procampo's records) in 2003 there were 1.9 million corn producers. More than 85 percent of them had landholdings smaller than five hectares and about 57 percent were smaller than five hectares. In Veracruz and Oaxaca more than 75 percent of growers were smaller than two hectares. Even in Sinaloa and Jalisco, the states with the least fragmentation, only 57 percent and 45 percent of producers were larger than five hectares.

Although there is barely any analysis of the effect of increasing the size of landholding on cost of corn production in Mexico, a FIRA analysis of a pilot program for wheat producers in Sonora found that increasing mean landholding in irrigated areas from 2.4 to 7 hectares resulted in average cost savings of 17 percent, with economies of scale particularly high in preparation of land and control of invasives and pest.

However, in order for programs aimed at achieving economies of scale to work best, (a) agricultural contracts need to be established so that producers are guaranteed part of the demand, (b) price hedging and insurance mechanisms need to be in place, (c) financial guarantees need to be accessible for producers (d) the government should foster provision of technical assistance, (e) input and service supplies should be available, and (f) the law should promote vertical integration of supply chains, which will require modifications to the “Ley para la Organización de Cooperativas y de Asociaciones Agrícolas.”

While a case-by-case analysis is required for each situation, a good starting point for most commercially viable corn producing areas is to foster producers associations that can gain better access to credit, information, and agricultural contracts. This is already working with a group of more than 700 producers from the Confederación Nacional Campesina (CNC) in Sonora and Sinaloa with 5,000 hectares of land, who as a group have gained access to better credit and insurance conditions, can buy fertilizers and pesticides at discounted rates, and have even signed some agricultural contracts in advance. An interesting aspect of this model, based on the European experience known as “association with participation,” is that some producers who only rent land have given the landowners an incentive to maintain and improve the land by sharing a small part of the profits with them.

**Reconversion**

In many of the most inefficient corn growing areas reconversion to more productive crops is of the utmost importance. However, it is a complicated subject, particularly in the

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7 Even though in 2005 Procampo's records show 1.6 million producers 2003 records are more reliable according to authorities at Aserca.

8 FIRA, Proyecto de compactación de Tierras para la producción de Trigo en el valle del yaqui, Tetabiate empresa social, s.p.r. de r.l, 2005

9 A draft reform of this law, which was proposed in the upper house in 2002, seeks a democratization of agricultural organizations and a more crucial role in agricultural policy and practices. It also considers an integration of the supply chains to allow greater investment and reduce risk for individual producers. This proposal was dismissed by the Senate's Rural Development Commission without being discussed at the plenary session, and no further reforms have been promoted since then.
case of subsistence agriculture, and specific recommendations are beyond the scope of this note. An analysis of “economic densities”—the return obtained per hectare from different uses—is a key consideration, but not the only one. Use of “economic density” is at least a first step towards including economic analysis in recommendations on reconversion, rather than only considering agro-climatic suitability, as has sometimes been the case in the past. Because crop reconversion requires considerable amounts of investment, technical assistance, and market information, a successful reconversion plan must be based on a cost/benefit analysis that includes a register of arable land, its current use, access to markets, and possible alternative land uses considering soil, rainfall, geography, technology, land tenure, demographics, and prices.

Technology has also played an important role in reconversion, including the use of improved seeds, more resistant crops, and greenhouses, which have had a number of very successful outcomes for both producers and workers. Future research and government sponsored programs should be directed towards reconverting land including a technological component. But investments and risks acceptable to a commercial producer may not make sense for a subsistence farmer with few market opportunities who depends on his field for corn to make tortillas.

Financial markets

In the wake of the financial sector crisis, rural credit largely collapsed and still has not recovered. The main problem is not lack of liquidity. The Fideicomisos Instituidos en Relación con la Agricultura (FIRA), one of the main funds created to provide credit in the agricultural market, still has not invested a large share of its resources, in part because producers are not perceived to have feasible projects and have limited collateral due to the low value of land in the overall cost of production. The gradual migration of support programs from subsidies to guarantees may improve the creditworthiness of producers and should be continued. Development of a well-functioning storage and warehouse receipts market will also improve producers’ ability to offer collateral, as mentioned above.

Transaction costs in credit processing can be reduced by having multi-annual credit programs that allow producers to have access to credit in certain regions and for certain crops without a lot of red tape so that they would have money when needed rather than having to borrow from friends and family at higher rates while waiting for the credit to be approved.

Another way to improve creditworthiness is to improve the insurance instruments available to producers. A number of innovative products that improve upon the traditional crop insurance are being developed or piloted. Another option is to target income insurance policy instead of just crop insurance, in other words, insuring both quantity and price, which would require regulatory changes by the National Insurance Commission. A joint venture between ASERCA and Agroasemex (the agricultural insurance institution of the government) could help create such an instrument.

Improving market intelligence

Integration of the North American corn market creates new opportunities for producers, especially in selling unique products and native types of corn to the Hispanic population of the United States. Mexico has tapped very little of its

10 The traditional crop insurance model – which reimburses losses based on individual claims – has a number of shortcomings that limit its usefulness, especially in developing countries. For innovative alternatives, see World Bank, 2005 Managing Agricultural Production Risk: Innovations in Developing Countries, Agriculture and Rural Development Department, and World Bank, Rural Finance Innovations, Topics and Case Studies, Report No. 32726-GLB, The World Bank, April 2005.
competitive advantage in niche markets such as blue corn, red corn, cuitlacoche (corn fungus), and specialty foods such as dried tortillas and tostadas. But to seize such market opportunities producers need more information about consumer preferences and habits as well as knowledge on how to meet consumer demands, position a product in the global market, manage resources, minimize costs, maximize profits, and use new information technology to support efficient decisionmaking.

Market information has some characteristics of a public good, but in well-developed markets, considerable information and training may be provided to producers by firms farther along in the supply chain. However, improvement of the public market intelligence system to provide such information and skills for small agricultural producers and agribusinesses that are not currently well integrated into supply chains is very important. The Ministry of Agriculture and FIRA currently provide no information on corn niche markets in Mexico or the United States. A good model for such a system is Fundación Chile, which works with both the private and public sector in Chile to develop and expand foreign markets for small-scale producers. The key to its success has been a highly trained and appropriately compensated professional staff. In contrast, Mexico’s Ministry of Agriculture has only a small, inefficient, understaffed information system that lacks the resources or capacity to provide the information on potential markets, consumption trends, marketing technology, and other issues needed to foster agricultural competitiveness.

Consensus building to cope with uncertainty of climate change

Long-term policy-making in these and other agricultural markets will have to cope with many uncertainties, foremost among them the specter of climate change. Mexico may suffer especially from reduction in water availability, with serious consequences for its agricultural production overall. The implications of this for competitiveness in the NAFTA market are not clear, however, since some of the most productive areas of the United States are also expected to suffer, and the impact on global markets is just beginning to be explored. Given the huge uncertainties involved in all of these forecasts, the most prudent path for the government is probably to establish early on a consultative process with stakeholders to monitor and review the evidence on the impacts of climate change in order to stay abreast of the most recent developments and start to build early consensus on necessary policy actions and investments.

11 Impacts on the Latin America and the Caribbean region will be investigated in depth in the next flagship study of the Latin American and Caribbean Region of the World Bank.
I. INTRODUCTION

When the North American Free Trade Agreement (NAFTA) was negotiated, corn was considered one of the “sensitive” commodities for which there would be a more gradual reduction of tariffs. The 14-year period agreed between Mexico and the United States for phasing out corn tariffs ends on January 1, 2008. In anticipation of this open bilateral market it is important to thoroughly assess:

1. How the Mexican corn market is affected by the international market.
2. What is happening in the international and national corn market.
3. How the final phaseout of tariffs under NAFTA will affect Mexican producers and consumers.
4. The competitiveness of Mexican corn producers in both domestic and international markets.
5. Strengths and challenges of Mexican corn producers.
6. Constraints to maximizing the benefits of a fully integrated North American corn market.
7. Public policy options that could benefit Mexican consumers and improve the competitiveness and profitability of Mexican corn producers. Options discussed in this report include those that have special relevance for the corn market, but not general subsidy programs, such as Procampo or Ingreso Objectivo, which will be taken up in the ongoing agricultural public expenditure review.

The focus of this study is competitiveness, not poverty alleviation per se. Much of the World Bank’s work in Mexico and elsewhere is focused on poverty, including the 2005 report Income Generation and Social Protection for the Poor, which includes a special section on rural poverty. The ongoing agricultural public
expenditure review will also include equity concerns as a primary criteria for evaluation of spending programs.

This policy note is divided in five chapters. Following the introduction, the second chapter analyzes current events in the international corn market and their implications for Mexico's domestic market and future corn prices. This chapter also describes the Mexican corn market and the effects that recent changes in the price of corn have had on other agroindustrial production chains, particularly livestock and animal products. It also describes the main causes for the relative stagnation of Mexican corn production over the past 15 years.

The third chapter examines the effects of NAFTA’s final phaseout of tariffs in 2008, which is projected to have little effect on corn prices because Mexico already effectively integrated its market with the United States and Canada mainly by increasing its tariff rate quotas for U.S. and Canadian corn. The chapter quantifies the impact of tariff-free corn imports under NAFTA by using a General Equilibrium Model (GEM) to estimate the economic effects of reducing corn imports. The last part of this chapter constructs supply curves to examine the competitiveness of Mexican corn producers in the ten most important consumption markets in Mexico. This analysis allows a detailed comparison of the cost structure of producers in rainfed versus irrigated areas, shows the possible consequences of not properly pricing water for irrigation, and describes the competitiveness of producers in each consumption market. The analysis of competitiveness highlights the impact of logistics on corn prices and shows where the least competitive producers are located for each market.

Chapter 4 offers a set of policy options for removing obstacles that could prevent Mexico from maximizing NAFTA's benefits and for buffering markets against price volatility. The three main constraints identified are high transport costs, lack of competition and overregulation of warehouses, and failure to make the Mexican market more open to competitively priced imports from non-NAFTA countries.

The final chapter presents a set of options that could increase the competitiveness of Mexico's commercial producers in both domestic and international markets and help raise the incomes of farmers. The four main areas addressed are (a) improving production technology (b) improving efficiency through economies of scale, (c) reconverting land to other uses, and (d) improving financial mechanisms, marketing, and entrepreneurial skills. In the first area, the report identifies an urgent need for broader dissemination of technologies currently in use that improve yields and reduce costs, adoption of new technologies, and particularly the introduction of biotechnology that has not yet been implemented in Mexico. In the second area, economies of scale can be achieved by increasing mean landholdings or creating producers' associations to improve the competitiveness of small growers in the short run. In the third, the report offers a methodological approach (based on the economic density of different crops and a range of other factors) for cost-benefit analysis of reconverting land from corn production to other uses. Fourth, the policy note addresses other areas where change could strengthen the corn sector, such as (a) improving financial mechanisms by cutting down transaction costs and including income insurance and (b) building producers' marketing and entrepreneurial skills by creating a market intelligence system similar the one used in Chile.
The most recent significant event in the international corn market was the sharp price increase that began in late 2006 (Figure 1), with profound effects on various regional and national markets, including in Mexico, which is the world fourth largest corn producer and third largest importer (imports account for about 30 percent of total consumption). The impacts of this price escalation in Mexico reach well beyond the cost of tortillas and other corn products because roughly one-half of Mexican corn consumption and three-quarters of imports are used as animal feed in the production of pork, chicken, and eggs (Figure 2). It also affects the price of substitute feed commodities such as sorghum and soy.

Figure 1. International Corn Prices

Source: CEESP, with information from CNA.

12 Information from ASERCA in the Ministry of Agriculture (SAGARPA)
According to the “Consejo Nacional Agropecuario,” a 41 percent increase in the price of yellow corn led to an increase of 40 percent in the price of sorghum between January 2006 and April 2007. In turn, these increases have raised production costs for chicken, beef, and pork by about 14.3 percent. The 34 percent increase in the price of soybean paste (the main protein source in feedstock)—another result of higher corn prices—has further increased production costs for poultry (by 4.4 percent) and pork (5.5 percent).13 This effect has also been seen in other countries, such as the United States, where some experts state that an increase of 10 cents in the price of corn shaves 5 cents from the potential earnings per share of major companies in the meat industry, such as Tyson.14

Another indication of the potentially serious impact that high corn prices have in Mexico is that tortillas provide 47 percent of average caloric intake in Mexico.15 Although per capita tortilla consumption fell 16.5 percent between 1998 and 2004 (from 78.5 kilograms to 65.5 kilograms), it is still the most important component of the Mexican diet.16

Even though in recent years yellow corn has accounted for about 95 percent of imports and almost all tortillas in Mexico are made from domestically produced white corn, the increased price and demand for yellow corn throughout 2006 led feedstock buyers to substitute yellow corn with white corn, triggering increases in the price and the international basis of white corn in December 2006 (see Figure 3). This was one of the main reasons for the “tortilla crisis” in early 2007, when average tortilla prices suddenly jumped by nearly 54 percent, from 6.5 pesos to 10 pesos.

15 Minsa with information from Instituto Nacional de Nutrición Javier Zubirán
16 INEGI-Encuesta Nacional de Ingreso Gasto de los Hogares 1998 and 2004
per kilogram. To control the social and political consequences of the crisis, the government and producers negotiated a maximum price of 8.5 pesos per kilogram, bringing the price back down to about 30 percent above the pre-crisis level.

While Mexico’s dependence on foreign corn has been increasing in fits and starts since the early 1970s, the gap between consumption and production began widening much more steadily beginning in the early 1990s as the use of corn for animal feed rapidly increased (Figure 4). Over the past five years domestic production grew at a compound annual rate (CAGR) of 1 percent, while demand grew at a CAGR of 3.8 percent. The Centro de Estudios Económicos del Sector Privado (CEESP), a private research institute, projects that by 2012 Mexican corn demand will be 38.9 million tons while production will reach only 24.6 million tons, which reflects a rate of growth for demand that is more than twice that of domestic production. This trend is creating even greater need to import corn at a time when world demand is also growing faster than supply and inventories are declining sharply, particularly in the United States and China, which together account for about 60 percent of world production (Figure 5).

Figure 3. Chicago Board of Trade International Basis for Corn Delivery in the Gulf of Mexico

While Mexico’s dependence on foreign corn has been increasing in fits and starts since the early 1970s, the gap between consumption and production began widening much more steadily beginning in the early 1990s as the use of corn for animal feed rapidly increased (Figure 4). Over the past five years domestic production grew at a compound annual rate (CAGR) of 1 percent, while demand grew at a CAGR of 3.8 percent. The Centro de Estudios Económicos del Sector Privado (CEESP), a private research institute, projects that by 2012 Mexican corn demand will be 38.9 million tons while production will reach only 24.6 million tons, which reflects a rate of growth for demand that is more than twice that of domestic production. This trend is creating even greater need to import corn at a time when world demand is also growing faster than supply and inventories are declining sharply, particularly in the United States and China, which together account for about 60 percent of world production (Figure 5).

Figure 4. Mexican Corn Production, Consumption, and Imports

Source: USDA PSD Database
Note: Years refer to marketing years (MY). MY2006 begins in October 2006 and ends in September 2007. Data for 2007 is projected.

17 CAGR calculated by IMCO with information of Consejo Nacional Agropecuario
18 IMCO with information of ASERCA
20 FAS USDA 2006
Integration of the North American Corn Market

This scenario suggests that there will be strong inflationary pressures on corn prices, which are projected to continue increasing in the short term before gradually falling back to 2006 levels by about 2015 (Figure 11). Although SIAP forecasts that production will increase at a compound annual rate of 1.6 percent between 2006 and 2012, this is mainly because the area harvested is projected to increase by 1.5 percent per year while yields will increase by only 0.1 percent annually.21

Mexican corn yields are lower than in other major corn producing countries and are increasing at a slower rate than the world average (Figure 6). Even though gains in average yields over the past 10 years more than offset the decline in acreage harvested (which fell at an annual rate of 1.3 percent between 1994 and 2005), this is in large part due to the 70 percent expansion of corn acreage and 50 percent increase in average yields in Sinaloa, which raised its share of total national production from about 12 percent in 1996 to 25 percent in 2006. While there are exceptions (such as Jalisco, where rainfed yields increased by 58 percent), in most other areas without irrigation average yields increased only modestly, signaling that it is of utmost importance to improve the competitiveness of these producers in the short run.

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21 SIAP, Situación Actual y Perspectivas del Maíz en México, 1996-2012 (page 34).

Source: IMCO with information from USDA, Aserca
It is important to note that behind the data on average yields there is a dramatic difference between rainfed and irrigated production. As reflected in Figure 7, yields in irrigated areas (virtually all commercial) are three times higher and are increasing twice as fast as in rainfed areas. This of particular concern in light of the fact that about 80 percent of the land used for corn production is not irrigated.

**Figure 7. Irrigated and Rainfed Corn Yields in Mexico**

![Graph of irrigated and rainfed corn yields in Mexico](image)

Source: IMCO with information from SAGARPA Information System (SIAP)

*CAGR is the Compounded Average Growth Rate

Technological approaches for improving yields, other than irrigation, include using better seeds, biological fertilizers, and other enhanced inputs and techniques. Most technological means for improving yields have been tried to at least some degree in Mexico. For example, hybrid corn is common if not the norm for high-yield commercial growers, but should be used more widely and could be particularly effective in the better rainfed areas. The technology that has the greatest potential for increasing yields and reducing costs in Mexico is genetically modified (GMO) varieties of corn, which will be addressed in more detail later in the report.

A common view is that the solution to meeting increasing demand is to expand corn acreage. This is already taking place in Mexico and other countries. SAGARPA’s agricultural information service (SIAP) expects the area planted in corn in Mexico to increase by an average of about 140,500 hectares per year through 2012 (compound annual growth of 1.7 percent) and the area harvested to increase by about 114,000 hectares per year (compound growth of 1.5 percent). Experts at the University of Tennessee forecast a much more rapid expansion in Mexico of about 1.6 million additional hectares in 2007 alone. This is a risky solution for a number of reasons. If most Mexican production continues to be white corn, as is currently the case, there could be an oversupply of white corn in 2008, particularly if Mexican feedstock buyers prefer to buy yellow corn under better financial conditions (deferred payments) in the U.S. market rather than buying white corn in Mexico. Expanding the area sown with corn also may reduce the area used for other crops prices thereby reducing their supply and driving up their price (as is

22 Situación Actual y Perspectivas del Maíz en México, 1996–2012. SIAP-SAGARPA.

23 Argentina is expected to increase the area planted with corn by 30 percent, Canada by 20–25 percent, and Brazil is expected to increase its production by 5.6 million metric tons. In Darryl Ray, Global Agri-Food Forum 2007, University of Tennessee.
the case for sorghum and beans in the United States). From an environmental perspective, in many areas expanding corn acreage could put additional pressure on already scarce water resources. However, the largest rural producer organization, Confederación Nacional Campesina (CNC), says this should not be a major concern because in recent years there has been a contraction in the area used for corn cultivation.

II.1. Why Corn Productivity has Stagnated

To evaluate the soundness of different approaches to raising yields and production, it is first necessary to understand the underlying causes of the corn sector’s sluggish growth in the recent past. While there is clear evidence that this stagnation is due to lack of technology and mechanization, limited use of improved and transgenic corn varieties, a high rate of land fragmentation (particularly in ejidos), and cultural practices that perpetuate inefficient production, the interesting question is why this has been going on for so long. According to some experts, for most growers corn is a cultural rather than commercial crop. This explains why less than 5 percent of all growers are commercial producers, with the rest mostly oriented toward producing for self-consumption.

Production of corn for self-consumption (and possible sale of excess corn or tortillas) is based on the premises of:

1. Ensuring family supply.
2. Using the corn varieties that are best suited for local conditions and that produce the best tortillas.

In addition, there are few if any options for reconverting the land to other uses as well as a lack of skills and information. This is why most subsistence producers plant traditional varieties, mainly criollo and mestizo corn, and are located in the least productive growing areas in the states of Chiapas, Guerrero, México, Morelos, Puebla, Oaxaca, Veracuz, and Yucatan. Other factors contributing to the slow pace of change and persistence of low yields include attachment to tradition, an aging population, low tolerance for risk, lack of alternatives, and lack of information.

In contrast, commercial producers get higher yields, most use irrigation, and they are mainly located in Sinaloa, Sonora, Jalisco, Tamaulipas, and Guanajuato. Commercial producers have been able to lower costs and increase yields and production by improving their efficiency, using capital more intensively, scaling up the size of operations, integrating with main markets, and using hybrid corn varieties.

The rising productivity of growers (mainly commercial) since the late 1990s has largely been brought about through increased efforts by the federal government to support the massive introduction of technology, training and technical assistance, mechanization, and improved seeds and fertilizers. Government programs such as technified irrigated lands, subsidies for commercialization (ASERCA), price hedging (cobertura de precios) from ASERCA, mechanization, and intense programs of technology adoption by INIFAP as well as the kilo-por-kilo program have been important tools in helping to improve commercial yields.

On the other hand, according to SAGARPA’s own studies, gains in productivity may actually be hindered by the federal Procampo program,

25 This program promotes using improved corn varieties in place of traditional criollo varieties where appropriate. Overall the program has increased yields in targeted areas by 80 kilograms per hectare.
which gives farmers an incentive to continue cultivating land regardless of productivity so that they are eligible for government subsidies.  

**II.2. Main Drivers of Corn Prices**

To understand how the future will look and the main challenges that lay ahead for commercial producers in Mexico, it is vital to understand the underlying factors affecting corn prices in the international market.

While the main reason for rising corn prices is increased production of corn-based ethanol in the United States (Figure 8), other factors are also putting upward pressure on prices, including both long-term trends such as increasing demand for corn in Asia and rising feedstock demand in Latin America and shorter-term events such as the temporary disruption of U.S. exports due to Hurricane Katrina and the 2006 drought in Argentina.

As shown in Figure 8, the share of U.S. corn being used for ethanol production roughly tripled in the past 10 years. There are already 106 ethanol plants in operation in the United States, 48 more under construction, and 7 undergoing expansion. The Renewable Fuels Association projects that consumption of corn for ethanol production will grow at a compound annual rate of about 12 percent during the next three years. This means that annual U.S. ethanol production will reach about 7 billion gallons by 2010 (Figure 9).

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27 Galarza Juan Manuel, op cit

This pressure on corn demand was behind the recent movement in future prices at the Chicago Board of Trade (CBOT), where contracts for the months of August, September, and October 2007 rose substantially since the end of 2006 (Figure 10). Demand for corn will continue to rise in the medium term despite the expected increase in imports of Brazilian sugarcane ethanol.

**II.3. Future Corn Prices and Production**

One important finding of this research is that barriers to imports of corn from the United States have already been largely eliminated. In yellow corn, the marginal source of supply for the Mexican market is imports; in white maize, Mexico is self-sufficient, with the exception of unusual years like 2007, when imports were needed. If white and yellow corn were completely separate products, this would imply that yellow corn follows U.S. prices, while white corn’s price is determined by supply-demand conditions in Mexico. But although they are not perfect substitutes, these two markets are fairly closely linked on the supply side (since their production requirements are very similar) and the demand side (through substitutability in livestock feed). This implies that while the price of yellow corn should very closely track U.S.
prices, in white maize there is room for some deviation of domestic price from import parity (adjusted for transport costs, quality differences, etc.). But for both, the supply and demand conditions in the United States are very relevant, as are general global market conditions.

Because the United States accounts for most of the world’s exports of maize, global market forces largely determine U.S. and, consequently, Mexican maize prices. In recent years, international maize prices have grown steadily, due in part to a growing demand for feed stocks worldwide and an increased use for ethanol production in the United States. A record South American crop in 2006 only partially limited prices and world maize stocks dropped to near-record lows. Projections by the World Bank suggest that prices will continue to increase in real terms through 2008 and will remain above price levels generally experienced over the past 15 years.
The high prices that are driving the rapid increase of U.S. corn plantings are also leading producers in Mexico and most other countries to expand their corn acreage. Drought-resistant varieties developed in laboratories may be particularly advantageous in many areas of China, Africa, and South America and have great potential to limit short-term price surges related to drought. As prices begin to fall from their peak, excess acres will be slowly brought out of production.

This trend will also depend on future demand for corn ethanol after the initial ramping up of production that is currently underway. In the longer term, more efficient technology, increasing production of biodiesel, and competing sources of ethanol production will pose major limits on demand for U.S. corn ethanol. Other crops have better ethanol yields per hectare than corn, as shown in Figure 12. In addition, the energy needed to produce ethanol from sugarcane is lower than for corn, giving Brazilian ethanol another cost advantage. Emerging technologies such as cellulosic ethanol could also compete with current ethanol feedstock crops in the long term and increase yields for ethanol crops, particularly those that produce large quantities of leftover biomass.

![Figure 12. Ethanol Yield](Image)

Source: Presentation Patrick McDonnell 14 June 2007, Terranova Bioenergy
III. IMPLICATIONS OF FINAL PHASEOUT OF TARIFFS UNDER NAFTA

This chapter analyzes the effects that NAFTA has already had on Mexican markets for corn and other commodities and the implications of the complete elimination of import tariffs on corn in 2008.

The first section describes and evaluates the extent to which NAFTA has already integrated the corn market in North America. The second section describes the effect that increased corn imports after the implementation of NAFTA has had on the Mexican economy by using a general equilibrium model to analyze a scenario with less imported corn. The third section measures the effect of corn prices on supply chains that use corn as a key input, based on estimating the cross-elasticity of demand for chicken, pork, and beef in relation to corn prices. The last section describes the competitiveness of commercial corn producers at each of the main consumption markets.

III.1. Integration of the North American Corn Market under NAFTA

Mexico negotiated a 14-year transition period under NAFTA for opening its domestic market to imported corn. Tariff rate quotas (TRQs) were established that would allow a minimum quantity of corn to be imported duty free, beginning with 2.5 million tons in 1994 and increasing by 3 percent every year through 2007. Over the same period the maximum allowable tariff on imports over the quota would be progressively reduced to zero. However, in practice the Ministry of Economy has essentially allowed tariff-free import of as much U.S. corn was needed to meet demand (Figure 13) by issuing additional import permits (cupos). This means that
the North American corn market is already integrated because all demand has been supplied and no tariffs have been paid on over-quota imports.

Figure 13. Corn Import Quotas (Cupos) under NAFTA and Actual Imports (1994–2006)

Therefore, prices are not expected to change due to the end of the NAFTA transition period. No longer requiring government approval for tariff-free imports could, in theory, reduce the risk of short-term scarcity caused by delays on the part of the Ministry of Economy to respond to shifts in demand. However, if the Ministry had in fact proved slow at assigning quotas during NAFTA it would have been reflected in greater price volatility in Mexico than in the United States. As shown in Figure 14, in general price volatility in Mexico was actually lower than in the United States, suggesting that such delays did not exist. 29

Figure 14. U.S. and Mexico Corn Prices, 1998-2006

29 Standard deviation divided by the mean.
III.2. Modeling the Benefits of Tariff-Free Corn under NAFTA

To analyze the effects that integration of the North American corn market has already had, this section presents a general equilibrium model (GEM) based on reducing corn imports by 5 million tons (for methodology of the GEM see Appendix 1). The results of this scenario, as shown in Figure 15, are:

- Corn prices would increase relative to other products and crops.
- General welfare for all consumers would be reduced by 0.8 percent and the value of agricultural GDP would decline by 2.65 percent.\(^{30}\)

\(^{30}\) The agroindustrial GDP in the GEM is proxied by production of corn, wheat, beans, and sugar.

Figure 15. Effect of Restricting Corn Imports on General Welfare, Selected Agricultural GDP, and Relative Crop Prices

![Figure 15: Diagram showing the effect of restricting corn imports on welfare, agricultural GDP, and relative crop prices.](image)

*Welfare is estimated through the social utility function of Samuelson-Bergson. Source: IMCO with information from SAGARPA, INEGI, USDA, and others.

Figure 16 shows the effect that limiting corn imports would have on the prices other agroindustrial products that use the crops in Figure 15 as main inputs to production. The prices of most such commodities, such as meat, chicken, pork, milk, sugar, and others, would fall relative to corn flour and tortillas. In other words, without an open corn market Mexicans would be poorer and consumption of animal protein would decline.
The impacts would be greatest on the poorest rural Mexicans who spend more on food (mainly tortillas, chicken, and eggs) than they earn from agricultural activities, so that higher commodity prices would increase their expenses more than their incomes. In addition, while tortillas represent 47 percent of average caloric intake in Mexico (National Institute of Nutrition Salvador Zubiran), it is probably much higher for the rural poor. The poorest 20 percent of rural Mexicans spend almost 30 percent of their income on food, yet earn only 15 percent of their income from agricultural activities (Figure 17).

![Figure 16. Relative Change in Price of Agroindustrial Products if Corn Imports are Restricted](image)

Source: IMCO with information from SAGARPA, INEGI, USDA, and others.

![Figure 17. Sources of Income for the Rural Poor (bottom quintile)](image)

<table>
<thead>
<tr>
<th>Income source</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other transfers *</td>
<td>29.7</td>
</tr>
<tr>
<td>Remittances</td>
<td>19.5</td>
</tr>
<tr>
<td>Oportunidades</td>
<td>10.2</td>
</tr>
<tr>
<td>Procampo</td>
<td>3.8</td>
</tr>
<tr>
<td>Agriculture</td>
<td>15.0</td>
</tr>
<tr>
<td>Other activities</td>
<td>21.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* Other transfers include pensions, unemployment stipends, education grants, and gifts from other homes


31 Ministry of Development 2006.
III.3. Analysis of Average Variable Cost Curves

This section analyzes the competitiveness of producers at each of the main consumption centers in Mexico, the strengths and weaknesses of producers in different areas, and which commercial producers are most sensitive to price changes. This is done by constructing a set of average variable cost curves based on estimates of the producers’ cash costs at the field level (considering prevalent technologies for each region) then adding transport, storage, and financial costs. The analysis did not consider subsidies and rent because of lack of information.

The two main benefits of this analysis are that it:

1. Permits a detailed understanding of the cost structure of corn producers in Mexico and a general comparison between the cost structures of Mexican and U.S. producers.

2. Allows the construction of a supply curve at each of the consumption centers, which in turn helps understand the producers’ competitiveness, challenges, and weaknesses at current and future prices.

The first step of the analysis is to compare the average cash cost of producing corn in Mexico and the United States, using information from the U.S. Department of Agriculture (USDA) and Mexico’s Ministry of Agriculture (SAGARPA). As shown in Figure 20, the average cost of producing corn in Mexico (1,750 pesos per ton) is almost 3.5 times higher than in the United States (506 pesos per ton). The average amount Mexican producers spend on fertilizers alone is more than 80 percent of the total average costs of U.S. producers. Other important differences include the low expenditures on technical services and drying in the United States and the high financial costs in Mexico, which reflect a relative lack technology in much of Mexico’s corn production.

Figure 20. Average Cash Cost of Corn Production in Mexico and the United States (2006)

Source: IMCO, with data from Aserca. Mexico costs based on 2005 data adjusted for 2006 prices (see Appendix 2)

Notes: Does not include rent. Columns are not to scale.
However, as is the case with data on yields, average production costs in Mexico show the dramatic variation between different kinds of producers, particularly between rainfed and irrigated production (which also tend to have different growing areas, growing seasons, production scale, and technological inputs). As shown in Figure 21, the average cash costs for commercial rainfed production ($1,916 pesos per ton) are more than three times higher than for irrigated production ($611 pesos).

Three of the most important insights that can be drawn from these results are:

- Production in rainfed areas is not only much more costly, but also requires greater investment in inputs such as fertilizer (which on average are equal to 70 percent of total costs in irrigated areas) to remain even marginally productive.

- Because production costs in rainfed areas are much higher than in irrigated areas, producers of rainfed corn must seek nearby markets to minimize transportation costs.

- Although water is a critical input in irrigated areas it does not represent a major cost because in Mexico water is not properly priced to reflect its scarcity. Proper pricing of water could dramatically change the cost structure of producers in irrigated areas.

III.4.1. Economic Value of Water in Irrigated Areas (Sinaloa)

Agriculture accounts for almost 75 percent of all water consumption in Mexico, but the proper price of water has never been determined for this sector. To understand the
possible consequences of incorporating the actual value of water into production costs and the challenges that irrigated producers could face in the future, this subsection considers the economic value of water for Sinaloa, where nearly half of Mexico’s irrigated corn is grown.

Water pricing is a complicated topic that has not been adequately studied and developed in Mexico. Although a rigorous analysis of water pricing is beyond the scope of this policy note, because water is so critical to Mexican corn production this subsection uses a simple formula for calculating the economic value of water (EVW) to get an idea of how water pricing could change the cost structure of producers in irrigated areas:

$$EVW(\text{$/m}^3) = \frac{\text{Value Added($)}}{\text{Volume of Water(m}^3)}$$

Since this formula has been widely used for calculating the price of water, including in the 2006 World Bank study “Mexico Assessment of Policy Interventions in the Water Sector Volume I: Policy Report,” it is possible to compare some results for EVW between this report and other studies.

The first step in the calculation is to determine the total amount of surface and ground water used per hectare, which according to the National Water Commission (CNA) is approximately 11,100 cubic meters for irrigated corn during the autumn harvest season (which is about 1,150 cubic meters per ton of corn, assuming a yield of 9.6 tons of corn per hectare). To corroborate such figure we used CNA’s data on overall water allocation that estimates that 8.679 billion cubic meters of water are used for agricultural purposes in the North Pacific region (including both irrigated and rainfed), which includes Sinaloa.32 Although corn is not the only agricultural product produced in this region, assuming there are 811,000 hectares of irrigated land (the latest information, from 2001) and that water is distributed for all irrigated land, each hectare in this region would consume about 10,700 cubic meters per year. This represents about 1,100 cubic meters per ton if it was all corn, a similar figure to the 1,150 cubic meters given before by the same source.

We assume that around 1,100 cubic meters of water are needed to produce a ton of corn in this region and we assume that 80 percent of the water needed to grow a hectare of corn in Sinaloa, which is very dry, comes from irrigation. Then the real consumption of irrigated water (both from underground and reservoirs) is 925 cubic meters per ton. In other states, such as Tamaulipas, the rate of irrigated water is about 50 percent according to some agronomists. Using this information (assuming a yield of 9.6 tons of corn per irrigated hectare, a price of 2,500 pesos per ton of corn, and production costs of 700 pesos per ton) the EVW of water would be roughly 2 pesos per cubic meter.33

This is not the price producers would be willing to pay for water because the EVW does not consider transaction costs (pumping, maintaining irrigation infrastructure, etc.) and other expenses. However, transaction costs, especially for pumping water, are heavily subsidized in agriculture. The average price of electricity for farmers is 63 percent lower than the average cost of producing it. Therefore the EVW is close to the value of every cubic meter used for agriculture, without considering other production costs.34

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32 CNA, at http://www.cna.gob.mx/SINA/doctos/Compendio_Agua_2002/6(2)_Uso_Agricola.pdf
33 This is calculated by dividing the 1800 pesos profit of producers (given 2,500 pesos price per ton and a cost of close to 700 pesos cash costs per ton) by 925 m3 used per ton. (The 925 m3 per ton were calculated by assuming that 20% of water for corn is rainfed and the rest is irrigated, meaning 8,880 cubic meters are used per hectare and each hectare produced 9.6 tons)
If this formula were used to estimate the EVW for tourism or other sectors in Sinaloa, the EVW would probably be higher, meaning that other stakeholders would probably be willing to pay more for water and the reallocating water from agriculture to other sectors could increase its added value for the state’s economy.

The mean industrial tariff of Region III (where Sinaloa is located), is US$0.52 per cubic meter with an average water productivity (EVW) of US$52 per cubic meter as shown in the World Bank’s water study. If the EVW–tariff ratio in the agriculture sector were the same as in the industrial sector, the water tariff for agriculture would be about US$0.0018 per cubic meter, or about 18 pesos per ton of corn, an amount that producers in Sinaloa could easily pay (about 1 percent of their income). This is lower than the proportion that urban settlers are willing to pay for water supply in Mexico City (4 percent) or in most other countries. In other words the price of water for agricultural use in Sinaloa could be of 1.9 cents (peso) per cubic meter if it was to reflect the EVW in a similar proportion to the industrial sector.

Another way to calculate the price of water is to estimate the maximum price producers would be willing to pay if they had to buy it from a private source. For example assuming a 25 percent profit margin for corn producers, average variable costs of about 650 pesos per ton, and a price of 2,500 pesos per ton (and ignoring the opportunity cost of not producing something else that is less water intensive) then using the same EVW formula we find that farmers could be willing to pay up to 1.5 pesos per cubic meter to continue producing corn to obtain a 25 percent profit margin (considering only variable costs).

This means that the price per cubic meter of water in irrigated areas could theoretically vary from a low of 1.9 cents to a high of 1.5 pesos. Although this may not necessarily reflect the real water scarcity in the region, it does reflect the range in which prices could fluctuate. Therefore the production costs of a ton of corn in an irrigated area could dramatically change producer’s cost, as seen in Figure 22.

35 Mexico Assessment Of Policy Interventions In The Water Sector Volume et al, pg 65

36 To obtain this value, the 650 peso cost per ton is subtracted from the 2,500 pesos price per ton and the result is multiplied by 0.75 to subtract the 25 percent profit margin. This is the price producers would be willing to pay per ton. Finally this is divided by the 925 cubic meters needed to produce one ton of corn, which gives a price 1.5 pesos per cubic meter.
Although the scenario shown in Figure 22 is theoretical, it is useful to show the need to properly price water in irrigated areas because it could dramatically change the competitiveness of producers and consequently the economic activities carried out in different corn producing regions.

The correct pricing of water in each of the irrigated areas would also need to consider water quality, discharges, and scarcity in each basin. However this is beyond the scope of the policy note and the sole purpose of including it here is that it is an issue that must be urgently addressed both by water and agriculture authorities.

III.4.2. Average Variable Cost Curves for Main Consumption Centers

This subsection integrates the field cost analysis for each of the main corn producing areas with transport and storage costs to construct average variable cost curves that allow assessment of the current competitive situation of commercial corn producers at main consumption centers.

Determination of the most important consumption centers is based on consumption information at the state level from Aserca (see Appendix 3) combined with Aserca’s view of which city in each state is most relevant in terms of where corn is transported from producers to consumption markets (see Appendix 4).
Because the 10 states with highest corn consumption are the Distrito Federal, Durango, Estado de Mexico, Jalisco, Nuevo Leon, Puebla, Queretaro, Sonora, Veracruz, and Yucatan, the 10 cities chosen as main consumption centers are Mexico City, Guadalajara, Monterrey, Veracruz, Ciudad Obregón, Durango, Mérida, Queretaro, Puebla, and Toluca (Figure 23). Some of these cities have higher per capita consumption than others, suggesting that these are consumption centers of corn for feedstock as well as human consumption.

Figure 23. Ten Main Corn Consuming States in Mexico

Average cost curves are constructed for each of the cities shown in Figure 23 by combining the production costs of all corn producing municipalities and adding transportation (flete corto y flete largo) costs as well as storage and financial costs provided by Aserca (Appendix 4).

The curves consider not only the average variable costs of producing and transporting a ton of corn from main production areas but also the amount of corn transported to each consumption center. Since this information has not been provided by Aserca, the distribution of corn from production zones to markets is estimated using the information and assumptions found in Appendix 5. Anticipated corn purchases for 2007 were used to determine Sinaloa’s corn distribution and distribution of corn from other producing areas was estimated based on the demands in each state by minimizing transport costs (for details, see Appendix).

The results are 10 different cost curves for each consumption market (see Appendix 6). Analyzing these average cost curves of corn for each market helps determine:

- The most competitive producers for supplying major local markets, given the indifference price of bringing in U.S. corn.
Where most competitive producers are located.

Which producers in which locations would be most affected by future declines in the price of corn.

Although most of the corn produced in the United States is yellow and most corn produced in Mexico is white, both are almost perfect substitutes when used as feedstock and can be substituted to a lesser extent when used for human consumption. Since the costs of planting yellow and white corn are almost the same, according to FIRA, the same cost assumptions are used for both varieties.

As an example, Figure 24 shows the average variable cost in June 2007 of supplying corn in Guadalajara (the largest corn consuming market) compared to the indifference price at consumption centers of bringing that corn from the United States. The two curves on the graph show total and logistics costs.

![Figure 24. Average Cost Curve of Supplying Corn in Guadalajara (2007)](image)

Notes: See Appendix 5 for detailed assumptions. Storage costs include financial costs and vary according to the number of months corn is stored in each state (Appendix 4).

Source: IMCO, with information of Aserca and SAGARPA (Logistics and Financial costs obtained from Aserca).

From the graph in Figure 24 it is clear that producers in Sinaloa are the most competitive despite having among the highest transport costs and storing corn an average of five months compared to two or three months for corn from the other states. It is also clear that producers from all states supplying corn in Guadalajara are competitive at current international prices, except for those in Chiapas, whose costs are higher than for imported corn from the United States. A closer look at differences in production costs at the field level within the different municipalities in Chiapas (Figure 25) show that producers in the most cost-efficient municipalities (shaded in grey) are probably the ones supplying Guadalajara.

37 Frontera Comalapa, Venustiano Carranza, Villaflores, La Trinitaria, Villa Corzo, La Concordia, Mazatán, Nicolás Ruíz, Socoltenango, Tuxtla Chico, Tizimol, Angel Albino Corzo, Totolapa, Ocozocoautla De Espinosa.
Analysis of the average variable cost curves for the other nine main consumption centers (Appendix 6) shows that:

1. Logistical costs account for 27 percent of the total variable cost of supplying corn to main markets.38

2. Sinaloa, Jalisco, and Chihuahua are the most competitive states in all the markets they supply (except for Sonora in Ciudad Obregon).

3. About half the cost of supplying corn from Sinaloa is due to logistics.

4. Chiapas and Veracruz are the states most vulnerable to price changes in the near future.

38 Estimated by calculating the weighted logistic cost in each center and then calculating the mean weighted average of these costs by the total consumption of the 10 markets.
IV. POLICY OPTIONS TO IMPROVE MEXICO’S POSITION IN THE FULLY INTEGRATED NAFTA CORN MARKET

The three most important issues facing Mexico as a corn producer and consumer in NAFTA are:

- High transport costs.
- High costs and lack of competition in the storage and warehouse system.
- Excessive dependence on a single country as supplier of corn imports.

This chapter analyzes these three issues and offers policy options to improve the competitiveness of Mexican producers and protect the interests of consumers.

IV.1. Reducing Transport Costs

According to some experts (Barkema and Drabenstott 1996)\textsuperscript{39} the major infrastructure restriction to Mexico’s long-run competitiveness in international agricultural markets is its transportation system. On the other hand, lowering transport costs increases market integration and reduces price differentials between U.S. and Mexican markets.

The cost analysis in the previous chapter identified two main stages of transport in corn distribution: from production areas to main hub centers (flete corto) and from main hubs to markets (flete largo). The cost of moving corn from hubs to markets is basically a function of distance. Aserca estimates these costs by

\textsuperscript{39} Williams Gary and Málaga Jaime E, Mexico Competitiveness: Reaching Its Potential, Input Paper, Mexico Agriculture Export Competitiveness, World Bank, 2006 pg 22
multiplying the current average price of $0.25 per kilometer per ton by the distance between hubs and markets. Aserca’s estimate of transport costs from production areas to hubs is the same for all states except Sinaloa, where they are 12 percent higher mainly because the distances between producers and hubs are greater (see Appendix 4). Although the 70 pesos per ton for flete corto in Sinaloa may not sound significant, it is more than 10 percent of the variable cost of producing a ton of corn in that state. This, combined with the long distances between Sinaloa’s production zones and main consumption centers, explains the state’s high overall transport costs (80 percent higher than variable production field costs). Distance plus expensive truck freight costs and limited entry points to main railways also contribute to raising these costs.

Truck traffic accounts for about 80 percent of Mexico’s food and agricultural shipments and although 3,400 miles of four-lane highways between major cities have been built since 1990, much more is needed, particularly to handle the growing truck traffic. Because many of the new highways are toll roads, trucks usually resort to public roads to avoid paying the toll, which leads to further deterioration of already poor public highways.

A number of important actions should be considered to reduce freight costs in Mexico. IMCO’s website (www.IMCO.org.mx) includes a more detailed explanation of the following recommendations:

- Increase investment in roads (access to roads and rail lines, improved highways, etc.).
- Optimize trucks’ cargo capacity.
- Allow private fleets to transport cargo on their return trips.
- Create incentives for renovating cargo fleets.
- Increase competition in the sector.
- Modernize customs, bridges, ports, and infrastructure for export.
- Create better market information on demand, bottlenecks, location, and prices of freight transport.

Another way of understanding areas of opportunity for reducing transport costs is by estimating consumers’ price differentials between consumption centers in local wholesale markets. When price differentials are higher than the cost of transporting corn from one market to the other there is room for arbitrage.

One possible explanation for this is that trucks are not transporting cargo on their return trips so that the one-way transport of corn bears the full roundtrip cost of the truck. This might be the case for Ciudad Obregon, where corn wholesale prices were 22 percent higher than the mean wholesale price of the 10 markets at the beginning of 2006. These price differentials should gradually become lower as transport becomes more efficient. In Ciudad Obregon the price differential decreased to 2 percent as corn prices increased dramatically toward the end of 2006.

Therefore, in the case of consumption centers with higher transports costs, such as Ciudad Obregon and Merida, policy options that improve railroad systems and competition within the market should be considered, including:

- Helping last mile services become available to consolidate cargo in the railroad system as soon as possible.

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40 Williams Gary, Op cit pg 22

41 Creating a national index of consumer freight transport prices published each month based on actual tariffs charged, which could be disaggregated by freight, geographic zone, season, kind of transport, etc.

42 SNIM Secretaria de Economia 2006
Finding reciprocal mechanisms to avoid loss of cargo due to disagreements.

Establishing tariffs for different cargos and volumes.

Creating intermodal facilities throughout Mexico.

Enabling tracks to handle the weight of standard U.S. railcars to reduce the cost of having to use smaller cars.

Finally, actions can be taken at ports and borders to facilitate trade, such as:

- Reducing paperwork.
- Providing adequate facilities and staff.
- Implementing more efficient inspection procedures.
- Improving coordination between different government authorities.
- Better planning for traffic peaks.

Building more infrastructure, such as bridges, access roads, and rail lines at border crossings and additional commercial inspection facilities as well as overland routes from Mexican ports to inland distribution points.

It should be recognized that while reducing transport costs improves overall competitiveness, it could lead to price reductions in grain-deficit areas, with potential adverse effects on producers in these areas. The information on regional production costs in these notes may help to identify those areas that are both high-cost and deficit areas, which may be targeted for attention. Potential losses would of course need to be quantified to see if they are sufficient to justify intervention.

IV.2. Minimizing Storage Costs and Facilitating Access to Credit

Storage costs also represent a significant share of the cost of corn at consumption markets in Mexico. With unrestricted trade between Mexico and the United States, the option of buying corn from the main U.S. storage facilities with deferred payments and other favorable financial condition could contract the market for Mexican corn by as much as 40 percent over the next four years, according to the Association of State-Level Ministers of Agriculture (AMSDA). As noted by AMSDA, in the United States, buyers can defer up to 30 percent of the purchase price of corn using a letter of credit at a LIBOR rate, while in Mexico payment is required in cash. Therefore it is important to improve storage facilities, promote competition, and find better instruments for financing inventories in Mexican warehouses to improve the competitiveness of Mexican corn.

The main problems of warehouses currently are that there is no clear deposit system, no confidence in the credibility of warehouses receipts, no clear standards for quality and warehouse certification, and inadequate competition. The raids to supervise corn stocks throughout the country during the 2007 tortilla crisis, which clearly illustrated the lack of competition and transparency among those controlling inventories, sent a clear signal that change is needed. The warehouse problem has been discussed by various actors in recent years. As a result, SAGARPA in 2004 proposed a comprehensive reform of the system for licensing and regulating warehouses, and the proposed options need to be explored with the objectives of removing barriers to market entry and efficient operation, while preserving

44 This was affirmed in two interviews with Octavio Jurado president of AMSDA, who said he has talked about this with the Mexican chamber of industrialized corn flour.
supervision that ensures the integrity of financial instruments issued by warehouses.

In the absence of a comprehensive reform, to foster the creation of better financing schemes for selling inventories, the Mexican Treasury (Secretaría de Hacienda)—which currently issues licenses for warehouses—could consider how to lower market entry requirements for storage facilities in Mexico in order to increase competition. The current system of government-issued permits limits the number storage facilities (almacenes generales de depósito) in operation. This leads to unnecessarily high transaction costs and limits incentives and capacity to minimize the cost of inventories or to offer more attractive mechanisms for financing corn purchases over time.

For any reforms to work to full advantage, the current Ley General de Títulos y Operaciones de Crédito needs to be modified to allow rural warehouses to issue endorsable warehouse receipts. Such receipts give property rights to the depositor of the goods, who can ask for a bond (bono de prenda rural) if he needs a credit in favor of third parties financing part of the deposited goods. The law proposed by SAGARPA provides details of what provisions should be contained in the bonds and certificates. Licensing fees would provide the resources needed by SAGARPA to supervise the warehouses. The law also would allow supervision of the warehouses to be outsourced.

In considering reform options, one approach that could be used as a model is one that is working in the sugar sector—the reportos system (similar to the money and capital market derivative known as repos), which allows producers to repurchase the receipt of their inventory at a certain time, paying a premium to the buyer for holding the receipt. Commodity reportos work as a special contract of sale of a warehouse receipt (certificados de depósito). The buyer gives cash to the seller and the seller agrees to repurchase the receipt at a given date, paying a premium to the buyer for holding the receipt during the agreed term. The property of the warehouse receipt (and the commodity that goes with it) is transferred to the buyer, so there is no default risk. The physical commodity is held in the warehouse during the term. In some cases, the buyer may ask for additional (cash) collateral. Mexican law states that individual reporto contracts may not be longer than 45 days and may not be renewed more than two times. At the end of the first 45 day period the seller notifies the buyer whether it intends to renew the instrument for another 45 days (by paying the premium) or to repurchase the inventory (by paying the receipt price and the premium).

To control for price risk, reportos have margin call provisions. If during the term of the contract the price of the commodity falls below a specified threshold, the seller has to deposit a larger amount of the commodity in the warehouse. Likewise, if the price exceeds a specified threshold the buyer must return some of the stored commodity to the seller.

This system allows producers to store their crops and then sell them at a later time when prices are higher. Having these types of contracts requires certain conditions that currently are missing in the Mexican system of storage facilities, but that could be addressed in the short term, including:

- Adequate regulation of warehouses to avoid commodity deterioration and moral hazard.
- Negotiable warehouse receipts.
- Public, widely known, and correctly registered price information on the commodity deposited.
Other mechanisms that have proved successful in other countries could be considered, such as the Rural Production Certificates (Cédula de Producto Rural, CPR) in Brazil. The CPR is a bond issued by rural producers, farmers’ associations, and cooperatives in order to obtain financing for production. Although there are different types of CPR, all operate like a forward contract, with the exception that payment for the crops is made when the bond is issued, not at delivery. Producers receive cash (or inputs) upon the issuance and sale of the bond for their physical product and have the obligation of delivering either an agreed amount of cash or production at a determined location and future date. Premiums and discounts are expected in case the product delivered is of different quality.

In this way, the CPR provides financing for the production of the crop and manages the producer price risk by linking the debt to the product, transferring the price risk to the buyer. Traders and agroindustry also benefit from the guarantee and better planning of the crop supply. When the contract is set against cash, buyers leave the market price risk of the commodity with the supplier.

The most important feature of the CPR is by far the reduction of risks to the buyers. As stated in the law, the CPR is a bond that provides for the out-of-court settlement of disputes; in other words, the bond guarantees rapid execution in case of nonperformance or breach of contract on the part of the bond issuer, and therefore avoids endless discussions in the courts. This feature is definitely a major incentive for buyers of CPRs, because it reduces moral hazard risks and speeds loan recovery.

Two key elements that are needed for this to work are:

- The judicial sector must be prepared to guarantee the success of lawsuits; and
- Sustainable and accessible agricultural and credit insurance must be developed in order to mitigate risks.

IV.3. Opening the Mexican Corn Market to Non-NAFTA Imports

The growing world demand for corn, especially driven by rapidly expanding ethanol production in the United States, has increased corn prices and the international basis (Figure 26), thereby affecting corn prices in Mexico as well. This is the main cause for the sharp spike in tortilla prices in early 2007.

Corn prices are basically composed of the international price of corn plus the international basis and the internal costs of bringing the corn to market. The international basis refers to the difference in the current price of corn in specific areas (in the case of Mexico the most relevant is the Gulf of Mexico) and the price of corn futures for a specific time. Therefore the basis not only reflects the financial costs and transport costs of taking that corn from Chicago to New Orleans, for example, but also the value of corn through time. This is why the international basis is published by the CBOT and is used for speculative trading, since it is another futures price but constrained to a specific location.

In Figure 26 the composition of the price for imported corn in Mexico is explained by considering the international price, the international basis, and the national basis and storage costs. In this case the national basis refers basically to transporting the corn from a delivery point, such as the Gulf of Mexico, to a specific production or consumption center (in a strict sense it is the same basis since it is referenced in the future market in Chicago as well). The graph shows that the greatest price increase occurred in the international basis (160 percent), which caused corn prices to increase more than 64 percent overall, as explained below.
This graph shows that the 65 percent increase in corn prices in 2007 was driven by two main factors. The first is the 71 percent increase in the international price of corn, caused largely by the rising demand for corn in the ethanol market. The second and most important factor is the 160 percent increase in the international basis (price determined at Chicago Board of Trade for corn exports, includes logistics, transaction costs, and a premium), which was driven mainly by price speculation in the U.S. market for white corn because of the temporary shortage of white corn in the Mexican market.

Because of the sudden increase in tortilla prices in the beginning of 2007, the government signed an agreement with corn producers and traders to set a maximum convened price for tortillas. But this in turn has brought another concern to the public policy agenda: securing sufficient corn supply for Mexicans. A new plan announced by the federal government envisions how this will be achieved during the next 10 years. However, given productivity trends in Mexico, even if more land is allocated for corn production it would take time and a major change in the attitude of producers to achieve such a goal based mainly on domestic supply, nor is it clear that this is the most cost-effective strategy for achieving the objective.

While one would expect that the United States will generally be the most competitive source of supply for Mexico, there may be situations like that in early 2007, in which price volatility in U.S. markets cause spikes in Mexican import prices. To avoid this in the future, a prudent action for the government to consider would be to remove obstacles that currently discourage diversification of sources of import supplies. This supports the case for opening the Mexican market beyond NAFTA. This would allow importers to gain access to corn at better prices in unusual situations, and reduce possible price speculation in the Mexican and U.S. markets. To identify which countries are potential sources for competitively priced corn imports, the report analyzed major international corn trade flows, as illustrated in Figure 27.

As Figure 27 shows, the United States still supplies almost all of Mexico’s imported corn, but there are other major corn exporters from
which Mexico could buy on beneficial terms either on a quota basis or by simply eliminating corn tariffs altogether. It is worth noting that during the tortilla crisis the government opened a quota to import corn for tortilla production from anywhere in the world. Close to 10,000 tons were imported from South Africa,\textsuperscript{45} which was the only place where white corn was available at the time. The imported corn helped reduce speculation on the white corn basis in the U.S. market and also allowed corn inventories in Mexico to flow faster because there was more corn in the market.

\textsuperscript{45} According to ASERCA senior staff

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As seen in Figure 27, Japan is the largest importer of U.S. corn. This is not likely to change despite rising corn prices because the Japanese have a high per capita income (US$32,647)\textsuperscript{46} and a high dependence on U.S. corn.

Mexico is the second largest importer of U.S. corn and is also highly dependent on the United States as a source of supply. Although Mexico is expanding its plantings of corn and using technology and improved varieties to increase efficiency and yields, imports from the United States are expected to continue increasing in coming years. In addition, sorghum has become more expensive and has been losing market share to corn in the Mexican feedstock industry.

China, another important importer of U.S. corn, is currently expanding production, seeking new higher yield varieties, and increasingly using corn as feedstock. Something similar is taking place in Egypt and Colombia, which also are among the top importers of U.S. corn. Although China currently is the fourth leading exporter of corn (roughly 5 percent of total world exports), because domestic demand is outpacing production China's exports are

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\textsuperscript{46} IMF (Purchasing Power Parity 2005)
projected to decline as its imports rise, making it a net corn importer by 2012.47

For Mexico, Argentina would generally be the second best option for buying corn at competitive prices in the case of a price spike in the U.S. market. Argentina is one of the most efficient producers and is the second-largest corn exporter in the world. Its three main clients are Thailand, the Middle East, and Spain. Mexico could import corn at competitive prices from Argentina given that transport costs to Mexico are lower than to the Middle East, Asia, and Europe, and transportation costs from Argentina to Mexico would be lower than costs from other potential suppliers, e.g., South Africa. At about 3,200 pesos per ton the price of Argentine corn is competitive with the price of U.S. corn in Mexico, but currently Argentine corn is subject to a 194 percent tariff that would raise its price to more than 6,700 pesos per ton (Figure 28). Opening a low-tariff quota for Argentine corn (or significantly lowering or eliminating the tariff) could reduce speculation on both white and yellow corn prices in Mexico and the United States.

In reality, of course the best option would be to open a quota or eliminate tariffs on a “most favored nation” basis for all countries, as was done in early 2007 in response to the tortilla crisis, so that corn could be imported from whatever source offered the best price for the type of corn needed. This could also reduce pressure on fundamental prices (as distinct from speculation) since U.S. yields for white corn are 5-10 percent lower than for yellow corn, which accounted for part of the higher price paid for white corn. During 2006 that overprice represented between 20 and 30 U.S. cents above the futures contract at the Chicago Board of Trade on a contract price of US$5–6 per bushel.48

The following actions would be ways in which the government could remove barriers to diversification of supplies, listed in decreasing order of potential benefits:

- Permanently remove non-tariff barriers and eliminate tariffs on an MFN basis for imports from all countries.
- Permanently remove non-tariff barriers and eliminate tariffs for imports from select countries (e.g., only Argentina and/or South Africa)
- Permanently open a low- or no-tariff quota for imports from select countries
- Put in place a contingency plan to quickly take one of the above actions in case of price spikes or disruptions in the U.S. market.

The permanent actions would introduce more certainty and allow better planning by private sector importers and users of corn, and the more comprehensive options would allow more diversification opportunities.

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48 Sagarapa in Estudio Maiz Blanco, op cit
V. POLICY OPTIONS TO IMPROVE COMPETITIVENESS OF MEXICAN PRODUCERS

The most important policy options to help improve the competitiveness of Mexican corn producers are:

- Using better technology, especially hybrids and new high-yield corn varieties that have already been used successfully in other countries, including genetically modified (GMO) crops.
- Increasing the size of mean landholdings to improve efficiency through economies of scale.
- Reconversioning land to crops with higher value-added where possible.
- Marketing to enhance access to U.S. and Canadian markets.
- Implementing better financial mechanisms

V.1. Improving Production Technology

Technology is definitely one of the best ways to improve the competitiveness of Mexican corn producers. The many areas in which use of technology can be enhanced include improved seeds, better water resources management, biological fertilizers (which cut costs considerably), crop rotation (labranza de conservación), mechanization of production processes, and cutting edge technologies such as genetically modified crops or biotechnology to improve yields and corn production in difficult areas.

Although most of these technologies have been explored to some extent in the most productive corn growing areas, genetically modified seeds have not yet been introduced in
Mexico, mainly because regulations do not allow it. However, hybrid corn has been used for many years in Mexico, resulting in higher yields as shown in Figure 29.

**Figure 29. Yields for Hybrid and Non-Hybrid Corn, 2002**

![Yields for Hybrid and Non-Hybrid Corn, 2002](image)

Despite the benefits of planting hybrid corn, its adoption has not been widespread, mainly because of:

- Lack of legal protection for creators of seed varieties.
- Differences in criteria for certifying seeds.
- Informal markets.
- Lack of a successful mechanism for distributing improved seeds.
- Expense of buying hybrid seeds.
- Lack of an adequate technological package to help achieve the potential productivity of hybrids.
- Seeds not adapted to local conditions.
- Most producers use their own seeds.

Most of these problems are being addressed by the new Law for Production, Certification, and Commercialization of Seeds that was approved in April 2007. In this law, aspects of labeling, standardized certification, and commercialization criteria have been adopted and more protection included for seed producers. Therefore, in this section we will focus more on the importance of permitting biotechnology and GMOs for the corn market, even if their use will be limited to certain parts of the country.

### V.1.1. The Importance of Biotechnology

Evidence in recent years on the use of Bt corn in other countries suggests that there is plenty of room for improvement in corn yields in Mexico through the use of biotechnology. Also, the evidence on the use of biotechnology in cotton plantations in Mexico proves that the use of such technology can be beneficial for all. The positive effects of biotechnology in cotton in the La Comarca Lagunera region have been estimated to be more than $6 million in the
In addition, the use of biotechnology in cotton met little consumer resistance and was quickly accepted by farmers. Although cotton is not a food crop, because of the successful economic impact it has had in northern Mexico and the widespread benefits it has provided for producers, the two largest agricultural producer organizations, CNC and CAN, are interested in exploring the use of genetically modified corn in Mexico.

49  Productivity and Innovation in the Latin America Agricultural Sector, Flagship Study Background Paper Albert K. A. Acquaye, Derek Byerlee, Matthew A. McMahon, Han Roseboom, Gustavo E. Sain, Greg Traxler, Johannes Woelcke June 24, 2004

The difference in yields between U.S. and Mexican corn producers and the slower rate of improvement in Mexican yields, suggest that improved corn varieties are needed to increase competitiveness in local markets. Figure 30 compares yields for municipalities in Mexico and counties in the United States (the width of each bar is the production per county or municipality and the height is their yield). The graph shows that only a small percentage of Mexican municipalities have yields comparable to those in the United States and that outside of these areas the curve for yields falls precipitously. The graph also shows how a relatively small number of high-yield counties in the United States (fewer than 350) produces the equivalent of Mexico’s total production.

Figure 30. U.S. and Mexican Yields by Municipality or County, 2002

The use of new and improved corn varieties not only increases production and yields by about 13 percent, but also decreases costs by 14 percent (even though the improved seeds is 20 percent more expensive), which allows some producers to compete in the U.S. market. For example, the use of technology in irrigated areas of Sinaloa and some municipalities of Chihuahua, Sonora, and Tamaulipas—high-yield, efficient producers close to the U.S. border—could enable Mexican corn to compete for the business of ethanol plants in the southern United States if transport costs are not too high. This could definitely be a project to consider in the future for each of these areas (Figure 31).
Another possibility, which the Inter-American Development Bank is already planning to study, is producing ethanol in these areas for export to the United States. This is already occurring in Sinaloa and Tamaulipas and could be economically feasible in other areas as well.

On the other hand, when analyzing the effect of GMOs in main consumption centers it can be seen that the implications are twofold: production costs fall and production increases. For example, in the case of the Guadalajara consumption market, all corn producers could become 14 percent more cost efficient in the short run and increase the supply of cheaper corn 13 percent (Figure 32), assuming biotechnology can reach all producers in all states. This cost relationship holds for white corn as well as yellow corn as there are several single- and double-trait varieties of pest resistant GMO white corn being grown in Honduras among other countries such as the Philippines.

Estimates at both the municipal and state level use the assumptions of improving yields for Mexico’s different areas provided by Monsanto, which can be seen in Appendix 7. The following exercise assumed a 20 percent increase in seed cost and used the high scenario.

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50 Some of the most common varieties are DR 353 and DK 234 among other different white corn seeds.
As the graph shows, production increases by 13 percent while costs are reduced by 14 percent over a two-year period, according to the present technology studied for Mexican climates in different regions. Costs fall mainly because of an increase in productivity and savings in pesticides costs and time. Although the 20 percent increase in seed costs is included, the overall benefits are greater than the costs and therefore producers become more competitive.

Using a different scenario, replicating what has occurred in the Philippines shows that results could even be better, with production increasing by as much as 25 percent and costs falling by as much as 26 percent in two years, making corn suppliers even more cost efficient and enabling some producers to compete in international markets.

Perhaps the most urgent recommendation to move in this direction is:

- Speed the regulatory process to deliver commercial permits.

Mexico is lagging behind the rest of the world in such technology adoption by at least 10 years. The problem is of utmost importance given that three years are needed to complete the steps required to harvest the first commercial crop of genetically modified corn:

1. First, varieties need to be tested in an experimental phase in small plots at research centers.
2. Second, the new varieties are allowed to be planted outside research centers in a pilot program, under strict surveillance, for one year.
3. Third, a commercial permit for planting such varieties is granted.

Therefore, to harvest the first genetically modified corn in 2011, Mexico would need to grant the first permit for the experimental phase before the cultivation season of 2008 (Figure 33).

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51 Leonardo A. Gonzales, Harnessing the benefits of biotechnology, The case of Bt corn in the Philippines, Society Towards Reinforcing Inherent Viability for Enrichment (SIKAP/STRIVE), Inc. 2005
Figure 33. Steps for Harvesting Genetically Modified Corn in Mexico

Reglamento | Permits | Trials on INIFAP experimental grounds | Pilot program on the field | Commercial approval
---|---|---|---|---
2008 | harvest | 2009 | harvest | 2010 | harvest | 2011

Source: IMCO

Given that the law for genetically modified organisms was approved by Congress more than a year ago, it is of utmost importance to have the rules (reglamento) needed to implement the law and the permits for the experimental phase published as soon as possible, so that by the end of 2011 higher yield corn can be harvested in Mexico.

Another way of evaluating the effect of biotechnology in corn is through the general equilibrium model where we estimate the effects technology has on the overall economy by releasing factors of production and inputs as fertilizers, pesticides, transport, etc., given the greater efficiency of production. The model also shows changes in relative prices among crops competing for the same land use. Increasing overall mean corn yields from 3 tons per hectare to 6 tons by using genetically modified corn results in an increase of almost 9 percent in agricultural production and 9.2 percent in general welfare. These results are explained by:

- Increase of 9 percent in the production of corn, 10 percent for sugar, 12 percent for beans, and 6 percent for wheat (which together account for more than 80 percent of cultivated land).
- Relative price decrease of 1.5 percent for sugar and 6 percent for beans relative to corn.
- Increase of 7.2 percent in the price of wheat relative to corn.
- Decrease in the use of all inputs except transport, with pesticide use falling by about 26.4 percent.
- Decrease in all relative prices for factors of production except transport, which increases by 140 percent because of bottlenecks caused by lack of infrastructure in most municipalities.

The results shown above as well as other changes in relative price and production can be seen in figures 34 through 38.
Figures 34 to 37. Long-Term Improvements from Biotechnology as Modeled through the GEM (Changing Mean Yield from 3.34 to 5.64 Tons per Hectare)

Figure 34

Changes in quantities produced

<table>
<thead>
<tr>
<th>Com</th>
<th>Sugar</th>
<th>Dry beans</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5%</td>
<td>7.6%</td>
<td>12.5%</td>
<td>6.6%</td>
</tr>
</tbody>
</table>

Figure 35

Change in relative prices

<table>
<thead>
<tr>
<th>Com</th>
<th>Sugar</th>
<th>Dry beans</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6.1%</td>
<td>7.2%</td>
<td>-6.1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Figure 36

Change in the use of inputs for corn production

<table>
<thead>
<tr>
<th>Capital</th>
<th>Labor</th>
<th>Transport</th>
<th>Water</th>
<th>Seeds</th>
<th>Fertilizers</th>
<th>Pesticides</th>
<th>Land</th>
<th>Logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10.7%</td>
<td>-9.4%</td>
<td>-9.0%</td>
<td>-9.0%</td>
<td>-9.5%</td>
<td>-26.4%</td>
<td>-9.3%</td>
<td>-6.1%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 37

Change in the use of factors of production in economy

<table>
<thead>
<tr>
<th>Capital</th>
<th>Labor</th>
<th>Transport</th>
<th>Water</th>
<th>Seeds</th>
<th>Fertilizers</th>
<th>Pesticides</th>
<th>Land</th>
<th>Logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4.8%</td>
<td>-6.2%</td>
<td>-7.4%</td>
<td>-9.4%</td>
<td>-8.3%</td>
<td>2.3%</td>
<td></td>
<td>-1.1%</td>
<td></td>
</tr>
</tbody>
</table>
In short, what these graphs show is that use of biotechnology in corn production increases output of both corn and other crops. As expected, this changes relative prices in the economy as well as prices for factors of production and inputs. Although the price of most inputs and factors of production fall, transport cost increase dramatically because moving the increased production of multiple commodities creates bottlenecks and strains the capacity of infrastructure that is already inadequate. This is why it is of utmost importance to address transport issues as one of the main concerns to take advantage of the implementation of technology so that the positive effects of greater efficiency will not be eroded.

Although there is ample evidence that implementing technology and especially biotechnology can be useful for corn producing areas as well as consumers, there is still some opposition to its adoption. The main reasons behind such opposition are explained in the following section.

Arguments against Biotechnology and Genetically Modified Corn

One of the traditional arguments against the use of biotechnology has been health risks. However, this argument has lost momentum and credibility in recent years as it is not supported by the mounting empirical evidence gathering throughout the world and as health organizations such as the British Medical Association (2004) publicly declare that genetically modified foods present no risk to human health.

Such declarations are based on the simple fact that there is no evidence proving health risks from GMOs, which are the most studied foods in the history of humankind. In addition to the continuous observations and testing such products have been subjected to in laboratories and both experimental and commercial fields, people have been consuming transgenic corn for almost 10 years with no demonstrated adverse effects. This is true even in Mexico, where it is estimated that about 60 percent of imported corn is genetically modified.52

The second argument against biotechnology and GMOs that they harm the environment by outcompeting other species or altering their genetic makeup through cross-fertilization. This argument has also lost strength lately as evidence in countries that have already been planting GMOs, including some of the most biodiverse countries in the world such as Brazil, Colombia, Philippines, and Mexico, have proven that this does not occur when GMO crops are planted correctly.

This a particularly sensitive issue in Mexico because it is the country with the richest diversity in corn species. However, this problem can addressed by having a clear plan that designates some areas for introduction of GMOs and other areas for planting other kinds of maize to foster diversification. In addition, species can be protected by keeping their genetic information in gene banks, as has already been done by Mexican authorities and research centers.

The last important and most currently used argument is that GMO crops make producers dependent on powerful multinational companies. However, empirical evidence does not support such claims for two main reasons. First, although transgenic crops have been delivered through the private, rather than the public sector, the benefits in Latin America have been widely distributed among industry, farmers, and consumers, which suggests that protection of the intellectual property rights of private companies has not lead automatically to excessive industry profits.53 The World Bank

52 CEESP, et al pg 114
53 Productivity and innovation in the Latin America Agricultural Sector, Flagship Study Background Paper Albert K. A. Acquaye, Derek Byerlee,
study titled Productivity and Innovation in the Latin America Agricultural Sector suggests that evidence in Mexico and Argentina prove that small farmers have had no more difficulty than larger farmers in adopting new technologies. Therefore the benefits of biotechnology have been widespread and quite equitably distributed among producers, consumers, and seed providers. Second, technology adoption is also a way of enabling technological transfer and creating opportunities for private companies to work in projects for particular corn varieties in Mexico.

V.1.2. Policies to Improve Production Technology through GMOs

In general, governments can take three positions toward biotechnology:

- Favor technological change and promote it nationwide.
- Oppose the entry of technology through tough regulatory measures.
- Adopt an intermediate position that allows development of technology while emphasizing precautions and not promoting it openly.

Non-GMO technology may have higher potential for improving the productivity of a wider range of Mexican producers than GMOs. But as noted in section V.1 above, many of the policy issues that in the past have presented obstacles to development of this market have been resolved by the passage of the new seed law. Policy-making attention needs now to be focused on policy towards GMOs. While acknowledging that in the case of GMOs, it is necessary to first put in place a regulatory framework that includes appropriate safeguards against the well-known risks, we argue that the first option above is probably the most beneficial for Mexico since technology adoption is needed as soon as possible, even though GMO corn may not be necessary all across the country. In order to promote the use of biotechnology in Mexico it is necessary to:

- Promote public-private partnerships (for example with INIFAP) to develop technologies tailored for Mexican corn varieties and regions and tapping into niche markets for corn. This has multiple effects because it can spread to fruits, cactus, horticulture, and other crops were few advances have taken place.
- Promote producer associations to fund technology projects and distribute seeds. Motivating such groups requires full autonomy for public research institutions, including independent governing boards with representation by key stakeholders.
- Conduct a strong education campaign to inform and train producers of new corn varieties so that distribution of biotechnology continues in coming years. In this regard, it is crucial to train ejidatarios and agribusiness owners on the purpose and use of new technology and to retrain displaced agricultural labor.
- Make public research funds widely available through competitive and contractual mechanisms to encourage participation and accountability. This could foster more interaction among academia and both the private and the public sectors for technology diffusion and transfer.

The very long lead times required to take GMOs through biosafety protocols and develop and distribute adapted transgenic varieties to market makes it of utmost importance to quickly begin the process. It is likely that in the next decade a handful of new transgenic products will appear at the level of acceptance that Bt cotton or RR soybeans have achieved. It must be recognized that almost 10 years since
the first transgenic crops were introduced there are still only two novel traits—Bt insect resistance and herbicide tolerance—that have had important effects on world food production. Therefore, in order to have faster and more successful technology transfer, Mexican authorities should:

- Find a gene that adds market value.
- Permit access to adapted germ plasm.
- Create a centralized, transparent, science-based regulatory process.
- Improve their ability to protect intellectual property.
- Promote acceptance of GMOs by farmers, regulators, processors, and legislators.
- Develop the potential to finance biotechnology investments.
- Promote institutional arrangements for sharing intellectual property by public institutions.

Developing the potential to finance biotechnology investments in Mexico is a major constraint because there is little public investment and few public research facilities such as INIFAP that are inexperienced in negotiating and accessing protected intellectual property—an absolute necessity for any institution to play the role of developer or broker of useful biotechnology products.

Therefore one possibility is to create a large National Agricultural Research System in partnership with other Latin American countries such as Brazil and Argentina. This would be logical given the similarity of production constraints among countries, the scale and scope of economic advantages due to similar agricultural-climatic conditions, and the already existing research capacity in both basic and agricultural sciences in these countries. Although there is some spending on biotechnology research in these three countries, there is no indication that the public sector in any country will be able to deliver a transgenic crop to its farmers in the near future.54

In addition, since there is very little cross-border sharing of technology between public sector institutions (beside the sharing of germ plasm within the network of public research institutions), the private sector will probably continue to be the main promoter and distributor of new GMOs as they have increasingly shared more of their intellectual property (IP) amongst them. The lack of incentives for public of publics to negotiate technology transfer and the implicit competition among countries in international commodity markets probably explains this failing in the public sector.

This explains why private sector delivery has been and continues to be the most successful model for delivering GMOs. However, three major challenges must to be tackled to continue using this model:

- Reducing the huge transaction costs for market entry caused by the hurdle of obtaining biosafety clearances, which makes it uncertain and expensive for the private sector to consider market entry a good business risk.
- Protecting intellectual property rights.
- Making seed markets grow and become deeper, with farmer participation.

Also, some of the current programs within Alianza Contigo need to be changed to promote technology transfer, including:

- Improving incentives for private providers of technical services, who are the weakest link in

the implementation chain. They are recruited on short-term contracts, have no job security, and have few economic or moral incentives to do a good job.

- Changing the criteria for selecting projects so that funding is awarded on the basis of quality and cost efficiency rather than on a first-come, first-serve basis to proposals that have complete documentation.

- Promoting decentralization of rural policy. This could solve the lack of program coordination and harmonization of funding and would force state governments to internalize all costs and benefits, thus promoting greater efficiency and equity in resource use. For example, transferring most funding of production-oriented research and development (R&D) programs to the states in the form of block grants could facilitate the application of a territorial approach to rural development. The national government would still hold back funds to carry out strategic R&D for which national-level implementation is required. In addition state programs would be instruments to carry out state R&D strategies with verifiable objectives and outcomes.

In this section various topics related to technological transfer have been explored. The problem is much more complex than simply recommending technology transfer for corn producing areas, and several key points to keep in mind both in terms of the importance of new technologies (particularly transgenic crops) and addressing concerns over their implementation include:

- Transgenic crop varieties have delivered large economic benefits to farmers in some areas over the past eight years. However, it is important to recognize that they not a magic bullet, but rather a resource that can be useful when combined with competent adaptive research capacity.

- The environmental effects of Bt cotton and RR soybeans have been strongly positive. Negative environmental consequences, while meriting continued monitoring, have not been documented to date in any setting where transgenic crops have been deployed.

- Even though transgenic crops have been delivered through the private, rather than the public sector, the benefits have been widely distributed among industry, farmers, and consumers, suggesting that the monopoly that intellectual property rights creates in the case of a specific GMO does not automatically lead to excessive industry profits.

- Finally, evidence from China, Argentina, and Mexico suggests that small farmers have had no more difficulty than larger farmers in adopting the new technologies.55

Because of these effects, addressing the issues that are hindering introduction of genetically modified corn is an even higher priority than taking some of the other proposed measures that could reduce production costs, such as increasing the mean size of landholdings among some small-scale corn producers, which is explained in detail in the following section.

V.2. Improving Efficiency through Economies of Scale

One of the main characteristics of corn production in Mexico is the high degree of land fragmentation. According to the Ministry of Agriculture (Procampo data for 2005), more than 85 percent of the 1.6 million corn producers in Mexico had fewer than 5 hectares of land and almost 57 percent had fewer than 2 hectares. In
some states, such as Veracruz and Oaxaca, more than 75 percent of landholdings are smaller than 2 hectares. In contrast, in Sinaloa 57 percent of producers have landholdings larger than 5 hectares and in Jalisco 45 percent are larger than 5 hectares. However, by all standards corn production throughout the country is in the hands of small producers.

Although much has been said about increasing the mean landholding of producers to reduce costs through economies of scale, there is little analytical evidence in Mexico on the issue. One of the few cases is FIRA’s documentation of the results of a pilot program for wheat producers in Sonora in which mean landholding was increased from 2.4 to 7.0 hectares.56 Given the similarities of corn and wheat production, we use these results to demonstrate the gains that might be achieved by increasing the scale of production for some corn growing areas in Mexico.

The results of this program show that increasing the mean landholding in irrigated areas could result in overall cost savings of 17 percent and savings in specific inputs of between 6 and 34 percent, as seen in Figure 38.57 The greatest cost savings are in land preparation and control of invasives.

Figure 38. Savings in Production Costs Resulting from a 193% Increase in Size of Landholding

<table>
<thead>
<tr>
<th>Activity</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparing land</td>
<td>34%</td>
</tr>
<tr>
<td>Invading plants</td>
<td>33%</td>
</tr>
<tr>
<td>Peas</td>
<td>25%</td>
</tr>
<tr>
<td>Harvest</td>
<td>24%</td>
</tr>
<tr>
<td>Rent</td>
<td>19%</td>
</tr>
<tr>
<td>Planting</td>
<td>13%</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>13%</td>
</tr>
<tr>
<td>Others</td>
<td>13%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>9%</td>
</tr>
<tr>
<td>Financial</td>
<td>6%</td>
</tr>
</tbody>
</table>

Source: FIRA

However, for such programs to work, certain policies or instruments need to be put in place, including:

1. Agricultural contracts with buyers that guarantee producers a stable demand.
2. Price hedging and insurance mechanisms.
3. Financial guarantees for producers.
4. Government policies to foster the provision of technical assistance.
5. Input and service supplies for producers.

These are some of the main recommendations made in the pilot program carried out successfully in Sonora. The extent to which mean landholding can be increased is limited by a principal agent problem, where at some point there are diminishing returns. Therefore, case-by-case analysis is required. However, promoting producer associations that can help increase access to credit, information, and agricultural contracts is a good starting point in most commercially viable corn producing areas for gaining some of the benefits of economies of scale.

This approach is already working with more than 700 producers from the Confederacion Nacional Campesina (CNC), who as a group have gained access to better credit and insurance conditions, buy fertilizers and pesticides at discounted rates, and even sign some agricultural contracts in advance. One interesting aspect of this model, which includes about 5,000 hectares in Sonora and Sinaloa, is that producers who normally only rent land have incorporated the landowners into the project by sharing a small part of the profits with them. This gives the owners an incentive to maintain and improve the land they rent to others. This

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56 FIRA, Proyecto de compactación de Tierras para la producción de Trigo en el valle del yaqui, Tetabiabe empresa social, s.p.r. de r.l, 2005
57 FIRA, op cit.
model is based on the European experience known as “association with participation.”

Although technology, integration of land and markets, and other measures can certainly improve corn producers competitiveness, Mexico’s climate and geography make corn production economically and environmentally unsustainable in many of the areas where it is currently being grown. Therefore in many municipalities governments should be considering programs to reconvert land from corn to other uses, as explained below.

V.3. Reconveting Land to Other Uses

Reconveting land in the most inefficient corn growing areas (mainly subsistence agriculture) to crops or activities other than corn is a complicated issue that requires consideration of many factors. While a full discussion of this issue is beyond the scope of this policy note, two key points should be emphasized:

1. Reconveting many of the inefficient corn producing areas is of utmost importance.

2. Economic densities are a key criteria to consider, along with a range of other factors, when analyzing options for reconversion.

Economic density refers to the return that can be obtained from production of a specific crop at a given time. Although it is a useful tool, economic density does not address critical issues such as possible changes in demand or market access. Considering these factors along with future market growth and productivity trends for foreign and domestic producers could help better understand where opportunities for reconvension exist.

This rationale helps to illustrate that investing in crops whose productivity and rate of growth in yields is lower than foreign competitors is likely to be a poor choice, as is the case for corn in many parts of Mexico. This explains why in 2001-05 cereals on average represented about 48 percent of the area planted in Mexico’s main crops but generated only 24 percent of the total value of those crops (Figure 39). In the first table, crops for which economic densities have fallen, such as fruits, have either lost revenue due to price changes or lost production due to disasters, loss of market share, or other dynamics. The second table shows the comparative economic densities for different crops. For example the economic density for vegetables is 13.5 times higher than for cereals. It is important to stress that this is by no means the only criteria to consider in deciding whether to reconvert, but it is a useful analytical tool to help understand how resources should be allocated.

**Figure 39. Economic Density of Main Crops**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Average 1996-2000</th>
<th>Average 2001-05</th>
<th>Economic Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a) Planted area</td>
<td>(b) Value of production</td>
<td>(b/a)</td>
</tr>
<tr>
<td></td>
<td>Avg. 96-00 %</td>
<td>Avg. 01-05 %</td>
<td>Avg. 96-00 %</td>
</tr>
<tr>
<td>Cereals</td>
<td>43.8</td>
<td>47.8</td>
<td>21.5</td>
</tr>
<tr>
<td>Forages</td>
<td>23.3</td>
<td>18.0</td>
<td>18.4</td>
</tr>
<tr>
<td>Fruits</td>
<td>5.7</td>
<td>5.6</td>
<td>18.1</td>
</tr>
<tr>
<td>Vegetables</td>
<td>2.5</td>
<td>3.0</td>
<td>16.8</td>
</tr>
<tr>
<td>Industrial</td>
<td>11.3</td>
<td>11.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Legumes</td>
<td>11.0</td>
<td>11.3</td>
<td>4.7</td>
</tr>
<tr>
<td>Oil crops</td>
<td>1.8</td>
<td>1.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Tubercles</td>
<td>0.3</td>
<td>0.4</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>0.3</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: IMCO, using SIAP database
Comparing crop economic density (x = times)

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Avg. 96-00</th>
<th>Avg. 01-05</th>
<th>Fruits</th>
<th>Avg. 96-00</th>
<th>Avg. 01-05</th>
<th>Tubercles</th>
<th>Avg. 96-00</th>
<th>Avg. 01-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>13.5 x</td>
<td>13.5 x</td>
<td>6.5 x</td>
<td>6.0 x</td>
<td>18.6 x</td>
<td>22.6 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forages</td>
<td>8.4 x</td>
<td>12.6 x</td>
<td>4.0 x</td>
<td>5.6 x</td>
<td>11.3 x</td>
<td>21.1 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>2.1 x</td>
<td>2.2 x</td>
<td>1.0 x</td>
<td>1.0 x</td>
<td>2.9 x</td>
<td>3.8 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>1.0 x</td>
<td>1.0 x</td>
<td>0.5 x</td>
<td>0.4 x</td>
<td>1.4 x</td>
<td>1.7 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>4.7 x</td>
<td>5.2 x</td>
<td>2.2 x</td>
<td>2.3 x</td>
<td>6.4 x</td>
<td>8.6 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legumes</td>
<td>15.8 x</td>
<td>14.1 x</td>
<td>7.5 x</td>
<td>6.3 x</td>
<td>21.7 x</td>
<td>23.6 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil crops</td>
<td>13.5 x</td>
<td>16.3 x</td>
<td>6.5 x</td>
<td>7.3 x</td>
<td>18.6 x</td>
<td>27.3 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubercles</td>
<td>0.7 x</td>
<td>0.6 x</td>
<td>0.3 x</td>
<td>0.3 x</td>
<td>1.0 x</td>
<td>1.0 x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>2.5 x</td>
<td>2.1 x</td>
<td>1.2 x</td>
<td>0.9 x</td>
<td>3.5 x</td>
<td>3.5 x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: IMCO, using SIAP database

Crop reconversion requires considerable investment and intense technical assistance, as well as market information that allows producers to identify alternative crops that have greater demand. Thus, a successful reconversion plan needs to be based on a cost-benefit analysis that includes a precise register of arable land, its current use, access to markets, and possible alternative land uses. All relevant information should be considered, including variables such as soil, rainfall, geography, technology, land tenure, demographics, and prices.

Technology, improved seeds, and more resistant crops have also played an important role in reconversion programs. In some cases greenhouses have been introduced to help reconvert land in both highly productive and less productive areas. Some experiences in Mexico show that using greenhouses can double the productivity of certain crops while also improving the quality of the crops, thereby allowing producers to get higher prices.58

Although greenhouses have been used in Mexico for more than 50 years, they have only been used in horticulture in the last 15 years. According to the Mexican Association of Greenhouse Builders (AMCI), currently there are only 6,500 hectares of greenhouses for vegetables and 1,750 hectares for flower production in Mexico, thus there is room for much more.

One interesting success story of reconversion through the use of greenhouses is in Los Reyes, Michoacan, where 7,000 hectares of sugar cane employing two workers per hectare with an average daily salary of US$3 was reconverted to berry production in 2000. The project started by covering 2,000 hectares under a lightweight, structured greenhouse called a “macro tunnel” that created 12 jobs per hectare at an average daily salary of US$17. The benefits for producers and workers have been revealing. It is true that such reconversion is costly and implies further costs in labor, water, and electricity, but the increase in productivity and profits of sets those costs.

V.4. Improving Financial, Marketing, and Entrepreneurial Skills

V.4.1. Financial Markets

In the wake of the financial sector crisis, rural credit largely collapsed and still has not recovered. The main problem is not lack of liquidity. The Fideicomisos Instituidos en Relación con la Agricultura (FIRA), one of the main funds

58 Invernaderos y Tecnología, Presentation by AMCI, Asociación Mexicana de Constructores de Invernaderos (SIAP Conference 2007)
created to provide credit in the agricultural market, still has not invested a large share of its resources, in part because producers are not perceived to have but feasible projects and have limited collateral due to the low value of land in the overall cost of production. The gradual migration of support programs from subsidies to guarantees may improve the creditworthiness of producers and should be continued. Development of a well-functioning storage and warehouse receipts market will also improve producers’ ability to offer collateral, as mentioned above.

One of the main goals in rural finance policy should be to reduce the transaction costs of processing credits for each production cycle. One way this can be achieved is by having multi-year credit programs that give producers in certain regions and for certain crops access to credit without having to register their guarantees with a notary public every year and go through the red tape of registering their assets. This would make the process faster and more efficient and would reduce financial costs because producers would have money when needed without having to borrow at higher rates from friends, family, or other sources while waiting for the credit to be approved.

Another way to improve creditworthiness is to improve the insurance instruments available to producers. A number of innovative products that improve upon the traditional crop insurance are being developed or piloted. Another option is to provide income insurance rather than just crop insurance, thereby insuring both quantity and price. However, this would require regulatory reform because income insurance currently is not permitted under the rules set by the National Insurance Commission. Forming a joint venture between Aserca and Agroasemex (the government’s agricultural insurance institution) could help create an insurance policy that incorporates a price hedging contract so that both quantity and price are covered. In this way, when the contract is signed Aserca could take an immediate position in the CBOT while Agroasemex would insure the crop. This could also occur with financial intermediaries if the government guaranteed such contracts.

Section IV.2 (Minimizing Storage Costs) discussed some financial instruments that are already being used in some markets in Mexico to increase liquidity. These could be expanded to make them available to corn producers. Mechanisms that have proved successful in other countries should also be considered, such as the Cédula de Productos Rurales (CPR) in Brazil. The CPR is a bond issued by rural producers, farmers associations, and cooperatives to obtain financing for production. Although there are different types of CPRs, all operate like a forward contract, with the exception that payment for the goods is made when the bond is issued rather than at delivery. The producer receives cash (or inputs) upon the issuance and sale of the bond for their physical product and in return has the obligation to deliver either an agreed amount of cash or product at a specific time and place. Premiums and discounts are established based on the quality of the crop actually delivered.


60 The traditional crop insurance model – which reimburses losses based on individual claims – has a number of shortcomings that limit its usefulness, especially in developing countries. For innovative alternatives, see World Bank, 2005 Managing Agricultural Production Risk: Innovations in Developing Countries, Agriculture and Rural Development Department, and World Bank, Rural Finance Innovations, Topics and Case Studies, Report No. 32726-GLB, The World Bank, April 2005.
In this way the CPR provides crop financing for the production of the crop and manages the producer's price risk by linking the debt to the actual product, thereby transferring price risk to the buyer. Traders and agroindustry also benefit through the guarantee and better planning of the commodity's supply. When the contract is set against cash, buyers leave market price risk of the underlying commodity with the supplier.

The CPR can also be indexed to future markets which have the advantage of leaving price risk to the buyer while at the same time allowing buyers to settle the contract financially, the key element of the Financial CPR.

Consolidation of the instrument has allowed for the generation of new, innovative, spin-off financial mechanisms, drawing new agents into the system and increasing liquidity. Online posting and trading of CPRs on the Brazilian Commodity Exchange (BBM) introduced agricultural transactions as an asset class even to private individuals, thanks to the Banco do Brazil's guarantees.

Through the end of October 2004, in less than one year of operation, nearly 70,000 contracts had been registered with BBM, with a total financial volume of approximately US$900 million. One of the major advances of the BBM system is that it permits potential investors to see the bonds that are guaranteeing their operations.61

By far the most important attribute of the CPR is that it reduces risk to the buyer. As stated in the law, the CPR is a bond that provides for out-of-court dispute settlements; in other words, the bond guarantees a rapid resolution in case of nonperformance or breach of contract on the part of the bond issuer, avoiding endless discussion in the courts. This characteristic is definitely a major incentive for the buyers of CPRs because it reduces risks of moral hazard and speeds the recovery of the loans.

Two key elements for this to work are:

- The judiciary must be prepared to guarantee the successful resolution of such suits.
- Development of sustainable and accessible agricultural and credit insurance to mitigate risks.

Instruments such as the CPR, of course, will be useful primarily to commercial producers. Other instruments, for example, micro-credit schemes, will be more suited for small-scale producers. Although there are many other recommendations to be made in agricultural financial markets, these in particular, could help bring about important fundamental changes.

V.4.2. Marketing and Entrepreneurial Skills (Market Intelligence System)

Integration of the North American corn market creates new opportunities for Mexican producers, especially in niche products. There are many types of native corn in Mexico that could be marketed to the Hispanic population in the United States. A U.S. niche market could also be explored for the Mexican delicacy cuílacoche (corn fungus), which has already been successfully marketed in France. In some cases penetrating or even creating specific segments in the market can depend on product packaging, production characteristics such as organic farming, and distribution strategies. However, to seize such opportunities, producers need more information on consumer preferences and habits, what to produce, and how to produce it (in terms of both cost efficiency and quality) to meet consumer demands.

In addition to information, certain marketing, entrepreneurial and managerial skills are needed to take advantage of such opportunities.

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and position products in the global market, including skills related to managing resources, minimizing costs, maximizing profits, and using new information technology to support efficient decisionmaking.

Mexico has not provided this kind of information or helped build such skills in the agricultural sector. Therefore, creating a “market intelligence system” to provide such information and skills to producers and agribusinesses is of the utmost importance. Neither the Ministry of Agriculture nor FIRA currently have data on niche markets for corn in Mexico or the United States despite the fact corn is Mexico’s main staple food and accounts for 40 percent of the land under cultivation. Having a market intelligence system similar to Fundación Chile could be very helpful for Mexico. Fundación Chile works with both the private and public sector to develop and expand foreign markets for small-scale producers in Chile. The key to its success has been a highly trained and appropriately compensated professional staff. By contrast, Mexico’s Ministry of Agriculture has insufficient staff capacity for such a task and has only a small, inefficient information system that lacks data on potential markets, consumption trends, marketing technology, and other key subjects that could help strengthen the competitiveness of the country’s agricultural producers.

Another good example of how information and managerial skills can help tap into competitive advantages in the agricultural sector is the Servicio de Información y Censo Agropecuario, an information and assistance service developed by Ecuador’s Ministry of Agriculture to support agricultural decisionmaking. It is time for Mexico to create the type of market intelligence system it needs to tap into its competitive advantages, strengthen the position of its producers in the white and yellow corn markets, and fully exploit the many market opportunities for products such as blue corn, red corn, cuitlacoche (corn fungus), and special foods such as dried tortillas and tostadas.

V.5. Planning for climate change

Long-term policy-making in all agricultural markets will have to cope with many uncertainties, foremost among them the specter of climate change. Mexico may suffer especially from reduction in water availability, with serious consequences for its agricultural production overall. The implications of this for competitiveness in the NAFTA market are not clear, however, since some of the most productive areas of the United States are also expected to suffer, and the impact on global markets is just beginning to be explored. Given the huge uncertainties involved in all of these forecasts, the most prudent path for the government is probably to establish an early consultative process with stakeholders to monitor and review the evidence on the impacts of climate change in order to stay abreast of the most recent developments and start to build early consensus on necessary policy actions and investments.

Impacts on the Latin America and the Caribbean region will be investigated in depth in the next flagship study of the Latin American and Caribbean Region of the World Bank,
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APPENDIX 1. GENERAL EQUILIBRIUM MODEL

A.1. Background

In order to understand if NAFTA tariff phase-out for maize, beans and sugar outweighs the costs of incurred by some producers a General Equilibrium Model (GEM) is a very useful tool as it measures the overall benefits in the economy. However in the detailed workings of the model one can learn how to:

- Measure the welfare impacts of market integration by maximizing a Samuelson-Bergson social utility function, subject to production and imports of select inputs and food staples,
- Understand the relationships between the various industries that will be affected by economic integration,
- Simulate the dynamics of exogenous shocks in agricultural industries,
- Evaluate the impact of increased consumption of grains (maize, in particular) for livestock, coming from additional domestic demand of poultry products and export demand of bovine meat.
- Assess the impact of ethanol production in the United States that will affect corn-consuming Mexican industries.

A.2. The Model

General equilibrium modeling is not a simple task. GE models usually have a costly learning curve. Estimating parameter has usually a weak econometrical basis. Furthermore, models
tend to be really complex, so results are rarely comparable because of different specifications between researchers.

Therefore, we developed an in-house model that very closely follows the classical Walrasian model of general equilibrium, using Mathematica.\textsuperscript{63} Mathematica is a flexible tool that requires less programming skills than most packages for GE modeling, as it relies heavily on pure mathematical expressions. The original model was created for a closed economy; however, with the appropriate assumptions, the model can simulate an open-economy.

The most common assumption in open-economy GE models is the immediate validity of the law of one price between integrating economies. This is an unrealistic assumption, because there are real constraints in the economy, such as logistics, physical infrastructure endowments, differing technologies and economies of scale that will result in different prices of similar commodities across economies.\textsuperscript{64} In such a context, the traditional Walrasian model can still be useful in explaining these price differentials, because every price in the model is endogenous. Although the initial model allows for the exogenous fixation of prices,\textsuperscript{65} we chose not to do so, and tried to find prices through initial calibration that made sense with reality.

The model maximizes a Bergson-Samuelson utility function that adds up the individual consumption of a basket of goods. It includes domestic consumers and export consumers of these products, which is a relevant aspect particularly in the livestock products sector.

![Figure A.1. Bergson-Samuelson Utility Curve and Production Possibilities Frontier](image)

The model allows for \( n \) commodities (sectors) and \( m \) factors of production. The standard production function used is a Constant Elasticity of Substitution (CES), although the formulation allows for other specifications to be used, even nesting of different types of production functions. It also allows for intermediate inputs and stocks, although we chose to model inventory separately in every period, assuming that the market clears in every period for the amount of the commodity that the supplier is willing to sell in order to maximize her profit.

### A.3. Full Specification

The Walrasian General Equilibrium Model has the underlying assumption of an auctioneer or clearing house that produces the equilibrium between supply and demand of the goods. Our Walrasian auctioneer needs to maximize the Samuelson-Bergson utility curve, which includes all the individuals in the society.

Different sectors compete for diverse inputs in order to produce the goods and services that the economy needs. However, primary agricultural producers and agro-industries

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\textsuperscript{64} In fact, a common criticism against free trade is that the law of one price does not necessarily hold. European Union integration is an example.

\textsuperscript{65} Noguchi, A (1991), pp. 102.
compete for different sets of inputs. Equilibria for these sectors are calculated separately, as shown below:

A.3.1. First Module: Primary Agricultural Producer’s Definition of Baseline Scenario

The first module encompasses primary agriculture. Four sectors (maize, sugarcane, wheat and beans) compete for nine inputs (capital, labor, transport, water, seed, fertilizer, pesticide, land, and storage-logistics).

In this module, the Walrasian auctioneer faces the problem of maximizing the following Samuelson-Bergson utility function

\[
\text{Escala} \prod \text{FactorE}[i] \text{ Sector}[i] \prod \text{Subs} \text{ Sector}[i] \prod \text{FactorE}[j] \text{ Sector}[j] \prod \text{Subs} \text{ Sector}[j] \prod \text{Subs} 
\]

(1)

FactorE[i] = the revealed preference factor for each of the products that the sectors produce; Subs is the elasticity of substitution in consumption; Sector[i] are the actual variables of quantities preferred. These factors were attained through a trial and error process in model calibration, evaluating whether the module generated a vector of quantities produced and a price vector similar to reality. The elasticity of substitution used is 0.4, which is entirely arbitrary, but commonly used in GE modeling.\(^6\)

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\(^6\) See Cool (2001), 129-135 and 144-155. In general, this implies a middle case between Leontief and Cobb-Douglas curves. The ad-hoc choice of parameter was made bearing in mind that the higher the substitution coefficient, the more instability in the model.
This maximization is constrained by the relative prices vector generated by production possibilities and consumer preferences. The functional form of the production function faced by these four sectors is

\[
A[i] = a1[i] \times x1[i]^{1-s[i]} + a2[i] \times x2[i]^{1-s[i]} + a3[i] \times x3[i]^{1-s[i]} + \\
a4[i] \times x4[i]^{1-s[i]} + a5[i] \times x5[i]^{1-s[i]} + a6[i] \times x6[i]^{1-s[i]} + \\
a7[i] \times x7[i]^{1-s[i]} + a8[i] \times x8[i]^{1-s[i]} + a9[i] \times x9[i]^{1-s[i]}^{1-s[i]},
\]

(2)

Where \( A[i] \) = the scale parameter in sector \([i]\)

\( a1 = \) the use of capital; \( a2 = \) the use of labor; 
\( a3 = \) the use of transport; \( a4 = \) the use of water;  
\( a5 = \) the use of seed; \( a6 = \) the use of fertilizer; \( a7 = \) the use of pesticide; \( a8 = \) the use of land; \( a9 = \) the use of logistics and storage.

\( S = \) the elasticity of substitution.

The production functions above were estimated by maximum entropy methods, using Monte-Carlo simulations. The Agricultural and livestock Information Service in SAGARPA (SIAP) produces yield data for the four agricultural products mentioned at the municipality level, which allows us to construct probability curves for yields. Similarly, INEGI published data from the 1991 Agricultural Census at municipality level, which provides us approximate information on dependent variables like number of cargo vehicles per municipality, fertilizer and pesticide use, and the other independent variables.

We produced probability curves for each of the independent variables, and introduced them into type (2) equations for each product, in municipalities where production of each of these products was present. We assumed normality of the nine coefficients, arbitrarily assigning them a 10 percent standard deviation.

The trickiest part of this estimation is obtaining the elasticity of substitution for each input in the production function. We used several elasticities of substitution in Monte-Carlo experiments that produced an estimated probability distribution for yields. We then compared the estimated probability distributions for yields with the actual probability distributions obtained from SIAP, and discarded functional forms that produced probability curves dissimilar to the original.

### Table A.1. Preference Parameter Estimated for Each of the Products

<table>
<thead>
<tr>
<th>Sector</th>
<th>Product</th>
<th>Weight in the Samuelson-Bergson Utility function (sum=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maize</td>
<td>0.34587419</td>
</tr>
<tr>
<td>2</td>
<td>Sugarcane</td>
<td>0.64861203</td>
</tr>
<tr>
<td>3</td>
<td>Beans</td>
<td>0.00105333</td>
</tr>
<tr>
<td>4</td>
<td>Wheat</td>
<td>0.00446045</td>
</tr>
</tbody>
</table>
The usefulness of using this method against using regressions is that a non-negativity constraint is automatically considered in the estimation of the production functions. The resulting estimated coefficient can be seen in Table A.2 below.

Table A.2. Estimated Coefficients for the Production Functions

<table>
<thead>
<tr>
<th>Capital</th>
<th>Labor</th>
<th>Transport</th>
<th>Water</th>
<th>Seed</th>
</tr>
</thead>
</table>

A.3.2. Calibration, Resources, Allocation and Model Solution

The model is solved by Mathematica utilizing successive approximations. Therefore, it is important to specify resources as a number in the same order of magnitude for every product, or else the resolution algorithm will encounter itself trying to divide a very large number by a near-zero number in its task of finding relative prices. In consequence, resources for each input are specified as 100, and once equilibrium is computed, everything can be put in the real units.

Also, it is important to take note that this is not a comprehensive model of Mexican agriculture, so the model may have some distortions regarding resource allocation. In Table A.3, the allocation of land for the sugarcane sector is roughly 10 times what it really is, while the allocation of land to the wheat sector is approximately double to reality. The interpretation that should be given to this odd result is that both cane and wheat are sectors that are comparatively more profitable than maize or beans and in absence of climatic or regulatory restrictions to the number of hectares allocated to each sector, the economy would probably allocate more land to these sectors. In reality, the extra land allocated to sugarcane and wheat is in sorghum or other products not considered by the model.

Table A.3. Allocation of Resources per Sector (% of total resource)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector[1] Maize</td>
<td>51.5727</td>
<td>56.3252</td>
<td>75.2755</td>
<td>58.5675</td>
<td>60.6499</td>
<td>58.1741</td>
<td>38.3357</td>
<td>47.2573</td>
</tr>
</tbody>
</table>
Table A.4. Land Allocation at Scale and Real Numbers

<table>
<thead>
<tr>
<th></th>
<th>% of land allocated by model</th>
<th>Hectares allocated by the model, assuming 7,978 thousand hectares in maize</th>
<th>% sowed in real 2005 Mexico (SIAP)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>47.2573</td>
<td>7,978</td>
<td>7,978</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>33.6251</td>
<td>5,676.61</td>
<td>630</td>
</tr>
<tr>
<td>Beans</td>
<td>10.3191</td>
<td>1,742.1</td>
<td>1,746</td>
</tr>
<tr>
<td>Wheat</td>
<td>8.79859</td>
<td>1,485.38</td>
<td>654.2</td>
</tr>
</tbody>
</table>

Some of these allocations could appear as meaningless, such as seed, because obviously the seed for each of these products is physically a different thing. However, the seed input could be interpreted as a whole sub-sector which makes allocation decisions for the production of determinate seeds for each productive sector. The market would send the signal to that seed sector that 60.64 percent of the resources should be devoted to producing seed for maize. In reality, the market for improved seeds and biotechnology seems to orbit around maize and secondarily produce anything else, so that result seems to be consistent with reality.

The model attempts to replicate reality by giving us a quantity and price vector. In fact, successive versions of the model are run and adjusted before arriving at a specification adequate for the baseline scenario. Due to the specification of resources in 1-100 numbers, the quantity and price vector needs conversion from model or “scale” units to real unit as seen in Table A.5 below.

Table A.5. Price Vector for Primary Products

<table>
<thead>
<tr>
<th></th>
<th>Maize</th>
<th>Sugarcane</th>
<th>Beans</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative price (model scale)</td>
<td>1</td>
<td>0.21</td>
<td>2.37</td>
<td>1.04</td>
</tr>
<tr>
<td>Real peso price per ton</td>
<td>1,900</td>
<td>399.92</td>
<td>4,516.28</td>
<td>1,978.95</td>
</tr>
<tr>
<td>assuming Maize Price = 1,900 $/ton</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table A.6. Quantity Vector for Secondary Products

<table>
<thead>
<tr>
<th></th>
<th>Maize</th>
<th>Sugarcane</th>
<th>Beans</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (model scale)</td>
<td>64.1376</td>
<td>153.8374</td>
<td>4.46</td>
<td>11.072</td>
</tr>
<tr>
<td>Production in real scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assuming national production</td>
<td>19x10^6</td>
<td>45.57x10^6</td>
<td>1.32x10^6</td>
<td>3.28x10^6</td>
</tr>
<tr>
<td>of maize =19x10^6 tons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Factor prices give merit to another explanation, because in general, we do not know exactly how much fertilizer or water, to name two examples, are actually used per hectare. Agricultural Census data gives us a proxy of the percentage of plots fertilized by municipality or the availability of water wells in ranches, but does not give us an amount of fertilizer actually utilized. Hence, factor prices should be interpreted as the unitary costs of fertilization, water or land that producers are willing to pay and owners of resources are willing to sell for in equilibrium, per ton of product.

A.4. Second Module: Agroindustries

We now turn to the agro-industries module, where we analyze industries that buy agricultural products and transform them into something else. In this module we chose the following industries:

- Ethanol
- Nixtamal Tortilla, wholesale
- Chicken meat
- Pork meat
- Bovine meat
- Wheat flour
- Corn flour
- Milk
- Cane Sugar
- Other consuming industries

These industries compete for five agricultural products: maize, sugarcane, beans, wheat and sorghum. Of course, some of these industries do not compete for some of the products, which entails a problem for a general model specification.

We chose to model the diverse agricultural inputs as a Cobb-Douglas production function of the form

\[ Ca[n][i]ca[i] Frijol[i][fr[i]] M[i] Maiz[i]ma[i] Sorgo[i]so[i] Trigo[i][tr[i]] (3), \]

Variable names are fairly straightforward, being the Spanish names for the agricultural products used. \( ca[i], fr[i], ma[i], so[i], tr[i] \) depict the Cobb-Douglas exponents for cane, beans, maize, sorghum and wheat, respectively. \( M[i] \) is a technical coefficient of input use. In some cases, we used numbers very close to zero\(^{67} \) for the cobb-douglas exponent, which are common especially in the case of beans (because very few of these industries actually consume beans). The table of coefficients used is shown below.

---

\(^{67}\) No actual zeros could be used, because the resolution algorithm breaks.
Table A.7. Coefficients Used for the Cobb-Douglas Input Function

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>ma[i]</th>
<th>ca[i]</th>
<th>fr[i]</th>
<th>tr[i]</th>
<th>so[i]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>1.231612</td>
<td>0.248</td>
<td>0.248</td>
<td>0.01</td>
<td>0.248</td>
<td>0.248</td>
</tr>
<tr>
<td>Tortillas Nixtamal</td>
<td>0.652315</td>
<td>0.957</td>
<td>0.011</td>
<td>0.011</td>
<td>0.248</td>
<td>0.248</td>
</tr>
<tr>
<td>Chicken Meat</td>
<td>68.28715</td>
<td>0.196</td>
<td>0.006</td>
<td>0.006</td>
<td>0.196</td>
<td>0.595</td>
</tr>
<tr>
<td>Pork meat</td>
<td>13.31295</td>
<td>0.248</td>
<td>0.01</td>
<td>0.248</td>
<td>0.248</td>
<td>0.248</td>
</tr>
<tr>
<td>Bovine meat</td>
<td>81.83752</td>
<td>0.247</td>
<td>0.012</td>
<td>0.247</td>
<td>0.247</td>
<td>0.247</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>1.782</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
<td>0.99</td>
<td>0.002</td>
</tr>
<tr>
<td>Maize flour</td>
<td>0.384955</td>
<td>0.957</td>
<td>0.011</td>
<td>0.011</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td>Milk</td>
<td>5.996954</td>
<td>0.499</td>
<td>0.001</td>
<td>0.001</td>
<td>0.01</td>
<td>0.49</td>
</tr>
<tr>
<td>Sugar</td>
<td>2.360817</td>
<td>0.002</td>
<td>0.99</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td>Other consuming industries</td>
<td>10.87812</td>
<td>0.017</td>
<td>0.018</td>
<td>0.92</td>
<td>0.01</td>
<td>0.012</td>
</tr>
</tbody>
</table>

The above equation (3) is embedded into a CES production function that combines the above inputs with the factors of production, as follows:

\[
b[i] = \left[ \frac{1}{B[i]} \right] \left( f[i] \right)^{b2[i]} \left( \text{Maize} \right)^{b1[i]} \left( \text{Sugar} \right)^{b1[i]} \left( \text{Wheat} \right)^{b1[i]} \left( \text{Other Consuming Industries} \right)^{b1[i]} \]

(4)

Where \( f[i] \) is the use of production factors; \( b2[i] \) its associated CES coefficient for sector \( i \); \( b1[i] \) is the CES coefficient for inputs, \( Sb[i] \) is the elasticity of substitution in sector \( i \), and \( B[i] \) is the scale parameter. The elasticity of substitution used in the production function (between factors and inputs) for every \( Sb[i] \) was 0.37.

In the same fashion as the agricultural producing industries, the Walrasian auctioneer maximizes a social Samuelson-Bergson utility curve which is CES in construction and includes the 10 agro-industrial products mentioned before. Elasticity of substitution used in the utility curve was 0.4.\(^{68}\) The weights of each product in the social utility curve are as follows:

\(^{68}\) These low elasticities of substitution, both in the Utility CES and the production CES, take the CES curves in both ambits closer to the Leontief case. Using higher elasticities of substitution, or even Cobb-Douglas functional forms or even linear (to represent perfect substitutes) makes the general equilibrium model very unstable and almost impossible to solve.
Table A.8. Weights of Each Product in the Social Utility Curve

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight in the Samuelson-Bergson utility curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>0.00000025</td>
</tr>
<tr>
<td>Tortillas Nixtamal</td>
<td>0.24253</td>
</tr>
<tr>
<td>Chicken Meat</td>
<td>0.000001162</td>
</tr>
<tr>
<td>Pork meat</td>
<td>0.00402</td>
</tr>
<tr>
<td>Bovine meat</td>
<td>0.0000004</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>0.00001</td>
</tr>
<tr>
<td>Maize flour</td>
<td>0.06703</td>
</tr>
<tr>
<td>Milk</td>
<td>0.01055</td>
</tr>
<tr>
<td>Sugar</td>
<td>0.18580</td>
</tr>
<tr>
<td>Other consuming industries</td>
<td>0.49028</td>
</tr>
</tbody>
</table>

Ideally, the estimation for agro-industries coefficients should have been done by using maximum entropy and Monte-Carlo experiments. However, the richness of geographically-disperse data available for the agricultural primary sectors was not available for the agro-industries. Therefore, estimation relied on point data of the INEGI 2004 Industrial Census and annual price information from Secretaría de Economía (SE), as well as technical coef cient information from SAGARPA. The recovery of parameters was done merely by a trial-and-error calibration: seven basic constructions of the model were tried, of which we made an average of 40 to 50 experiments in each. The 36th experiment in the seventh construction of the model gave us a price and quantity vector that could be similar to the Mexican equilibrium as seen in Table A.9 below.

Table A.9. Calibrated Prices and Quantities Versus Actually Produced Prices and Quantities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>985.101</td>
<td>1</td>
<td>40136</td>
<td>40136</td>
<td>1</td>
</tr>
<tr>
<td>Cane sugar</td>
<td>4812.44496</td>
<td>0.95657169</td>
<td>5246212.54</td>
<td>4842089</td>
<td>1.08346058</td>
</tr>
<tr>
<td>Tortillas nixtamal</td>
<td>6398.47727</td>
<td>1.1731069</td>
<td>34879.0118</td>
<td>36636</td>
<td>0.95204203</td>
</tr>
<tr>
<td>Chicken meat</td>
<td>12402.1261</td>
<td>0.99090165</td>
<td>697213.875</td>
<td>668750</td>
<td>1.0425628</td>
</tr>
<tr>
<td>Pork meat</td>
<td>16933.9847</td>
<td>0.99282402</td>
<td>15463.047</td>
<td>14934</td>
<td>1.03542567</td>
</tr>
<tr>
<td>Bovine meat</td>
<td>18911.1809</td>
<td>0.95721941</td>
<td>57370.024</td>
<td>55654</td>
<td>1.03083379</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>3267.03821</td>
<td>1.16551029</td>
<td>3662091.25</td>
<td>3576609</td>
<td>1.02390036</td>
</tr>
<tr>
<td>Maize flour</td>
<td>4325.06624</td>
<td>1.25119729</td>
<td>1562628.11</td>
<td>1887041</td>
<td>0.82808382</td>
</tr>
<tr>
<td>Milk</td>
<td>8108.5929</td>
<td>1.16008324</td>
<td>3827610.78</td>
<td>4233540</td>
<td>0.90411589</td>
</tr>
</tbody>
</table>
A.5. Understanding the Agroindustrial GDP in the GEM

The GEM model of IMCO does not consider the value of production for any specific grouping of GDP but does it in relation to the inputs for which they compete. Therefore the agro industrial GDP considers all the products used in the agro industry, thus a useful guide to understand the relevance of this number in relation to GDP is the following table:

Table A.10. Value of Production for Estimating the Agroindustrial GDP (information for 2003)

<table>
<thead>
<tr>
<th>Product</th>
<th>Good</th>
<th>Value of production compared to agricultural GDP</th>
<th>Value in the agricultural GDP</th>
<th>Value for the part of GDP that considers agroindustrial products; Rama I “Alimentos Bebidas y Tabaco”</th>
<th>Value of production (pesos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol ²</td>
<td>Intermediate good</td>
<td>0.0136%</td>
<td>0.0000%</td>
<td>0.0000%</td>
<td>$39,538,000</td>
</tr>
<tr>
<td>Sugar</td>
<td>Intermediate good</td>
<td>0.0050%</td>
<td>0.0000%</td>
<td>0.0041%</td>
<td>$14,427,205</td>
</tr>
<tr>
<td>Tortillas</td>
<td>Final consumption</td>
<td>0.0994%</td>
<td>0.0000%</td>
<td>0.0819%</td>
<td>$287,945,000</td>
</tr>
<tr>
<td>Chicken</td>
<td>Final consumption</td>
<td>2.8892%</td>
<td>0.0000%</td>
<td>2.3803%</td>
<td>$8,370,076,000</td>
</tr>
<tr>
<td>Pork</td>
<td>Final consumption</td>
<td>0.0879%</td>
<td>0.0000%</td>
<td>0.0724%</td>
<td>$254,720,000</td>
</tr>
<tr>
<td>Beef</td>
<td>Final consumption</td>
<td>0.3795%</td>
<td>0.0000%</td>
<td>0.3127%</td>
<td>$1,099,521,000</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>Final consumption</td>
<td>3.4606%</td>
<td>0.0000%</td>
<td>2.8511%</td>
<td>$10,025,582,000</td>
</tr>
<tr>
<td>Corn flour</td>
<td>Final consumption</td>
<td>2.2516%</td>
<td>0.0000%</td>
<td>1.8551%</td>
<td>$6,523,014,000</td>
</tr>
<tr>
<td>Milk ²</td>
<td>Final consumption</td>
<td>13.7188%</td>
<td>6.8594%</td>
<td>5.6513%</td>
<td>$39,744,000,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>22.9057%</td>
<td>6.8594%</td>
<td>13.2090%</td>
<td>$66,358,823,205</td>
</tr>
</tbody>
</table>

² The value of ethanol production is considered in another part of national GDP, “Sustancias químicas, derivados del petróleo, productos de caucho y plástico.”
³ Suponiendo que un 50% del valor de la producción se agrega en el sector primario y el 50% restante como parte del valor agregado bruto agroindustrial, por falta de más datos al respecto.
APPENDIX 2. ASSUMPTIONS FOR UPDATING PRODUCTION COSTS

In order to convert FIRA production costs from 2005 to 2006 the following price changes in this period were used:

Table A.3 Variables for updating FIRA 205 figures

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Price changes</th>
<th>Variable used as proxy</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection (transport)</td>
<td>13%</td>
<td>Diesel</td>
<td>EIA</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>9%</td>
<td>Fertilizer prices</td>
<td>USDA</td>
</tr>
<tr>
<td>Financial cost</td>
<td>-13%</td>
<td>Interest rates (Cete)</td>
<td>Banxico</td>
</tr>
<tr>
<td>Fuel</td>
<td>13%</td>
<td>Diesel</td>
<td>EIA</td>
</tr>
<tr>
<td>Insurance</td>
<td>-13%</td>
<td>Interest rates (Cete)</td>
<td>Banxico</td>
</tr>
<tr>
<td>Labour</td>
<td>4%</td>
<td>Inflation</td>
<td>Banxico</td>
</tr>
<tr>
<td>Pesticides &amp; herbiscides</td>
<td>5%</td>
<td>Pesticides prices</td>
<td>USDA</td>
</tr>
<tr>
<td>Seeds</td>
<td>4%</td>
<td>Inflation</td>
<td>Banxico</td>
</tr>
<tr>
<td>Water</td>
<td>4%</td>
<td>Inflation</td>
<td>Banxico</td>
</tr>
</tbody>
</table>

To update prices from the end of 2006 to mid 2007 a 2% increase in field cost was assumed. The rest of logistic costs are at 2007 prices.
### Table A.4 The 10 largest corn consumers

<table>
<thead>
<tr>
<th>State</th>
<th>Tons</th>
<th>Tons per capita</th>
<th>Flowering mills in the state or close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jalisco</td>
<td>4,614,556</td>
<td>0.67</td>
<td>Guadalajara</td>
</tr>
<tr>
<td>Estado de México</td>
<td>2,902,002</td>
<td>0.19</td>
<td>Tlantepe &amp; Tetihuacan</td>
</tr>
<tr>
<td>DF</td>
<td>2,208,768</td>
<td>0.25</td>
<td>Tlantepe &amp; Tetihuacan</td>
</tr>
<tr>
<td>Sonora</td>
<td>1,963,691</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Qeretaro</td>
<td>1,729,517</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>Veracruz</td>
<td>1,320,007</td>
<td>0.18</td>
<td>Veracruz</td>
</tr>
<tr>
<td>Puebla</td>
<td>1,162,233</td>
<td>0.21</td>
<td>Tlantepe &amp; Tetihuacan</td>
</tr>
<tr>
<td>Yucatan</td>
<td>1,151,537</td>
<td>0.31</td>
<td>Merida</td>
</tr>
<tr>
<td>Durango</td>
<td>1,078,990</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Nv Leon</td>
<td>1,028,830</td>
<td>0.24</td>
<td>Monterey</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19,160,131</strong></td>
<td></td>
<td><strong>64%</strong></td>
</tr>
</tbody>
</table>

Source: Grupo Consultor de Mercados Agrícolas GOMA with information from SAGARPA (SIAP)

Note. The consumption in Merida considers the population of Quintana Roo and Campeche States as there are no other major flour plants in the peninsula and calculating costs of supplying corn to Merida is probably already considering much of the corn that will be consumed in neighboring States.
## APPENDIX 4. TRANSPORT COSTS

**Estimated freight costs from corn to market by F.F.C.**

<table>
<thead>
<tr>
<th>Production area</th>
<th>Consumption market</th>
<th>Distance</th>
<th>Distance * .25 pesos</th>
<th>price + VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINHALA (CULIACÁN)</td>
<td>B. CALIFORNIA</td>
<td>1,297</td>
<td>324.25</td>
<td>372.88</td>
</tr>
<tr>
<td></td>
<td>DUERANGO</td>
<td>1,340</td>
<td>335.00</td>
<td>385.25</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>1,318</td>
<td>329.50</td>
<td>372.18</td>
</tr>
<tr>
<td></td>
<td>ESTADO DE MÉXICO</td>
<td>1,408</td>
<td>352.75</td>
<td>405.66</td>
</tr>
<tr>
<td></td>
<td>GUANAJUATO</td>
<td>1,127</td>
<td>281.75</td>
<td>324.01</td>
</tr>
<tr>
<td></td>
<td>JALISCO</td>
<td>807</td>
<td>201.75</td>
<td>232.01</td>
</tr>
<tr>
<td></td>
<td>MICHOACÁN</td>
<td>1,228</td>
<td>307.00</td>
<td>353.05</td>
</tr>
<tr>
<td></td>
<td>Nayarit</td>
<td>538</td>
<td>134.50</td>
<td>154.68</td>
</tr>
<tr>
<td></td>
<td>NUEVO LEÓN</td>
<td>1,676</td>
<td>419.00</td>
<td>481.85</td>
</tr>
<tr>
<td></td>
<td>PUEBLA</td>
<td>1,576</td>
<td>394.00</td>
<td>453.10</td>
</tr>
<tr>
<td></td>
<td>Sinaloa</td>
<td>62</td>
<td>15.50</td>
<td>17.83</td>
</tr>
<tr>
<td></td>
<td>Sonora</td>
<td>600</td>
<td>170.00</td>
<td>196.50</td>
</tr>
<tr>
<td></td>
<td>QUERÉTARO</td>
<td>1,188</td>
<td>297.00</td>
<td>341.55</td>
</tr>
<tr>
<td>TAMAUJIPAS (C.D. VICTORIA)</td>
<td>COAHUILA</td>
<td>401</td>
<td>100.25</td>
<td>115.29</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>994</td>
<td>248.50</td>
<td>285.78</td>
</tr>
<tr>
<td></td>
<td>Hidalgo</td>
<td>890</td>
<td>222.50</td>
<td>258.88</td>
</tr>
<tr>
<td></td>
<td>NUEVO LEÓN</td>
<td>290</td>
<td>72.50</td>
<td>83.38</td>
</tr>
<tr>
<td></td>
<td>SAN LUIS POTOSÍ</td>
<td>562</td>
<td>140.50</td>
<td>161.58</td>
</tr>
<tr>
<td></td>
<td>QUERÉTARO</td>
<td>917</td>
<td>229.25</td>
<td>263.64</td>
</tr>
<tr>
<td></td>
<td>ZACATECAS</td>
<td>1,097</td>
<td>274.25</td>
<td>315.39</td>
</tr>
<tr>
<td>JALISCO (GUADALAJARA)</td>
<td>AGUASCALIENTES</td>
<td>490</td>
<td>122.50</td>
<td>140.88</td>
</tr>
<tr>
<td></td>
<td>COAHUILA</td>
<td>924</td>
<td>231.00</td>
<td>266.65</td>
</tr>
<tr>
<td></td>
<td>COLIMA</td>
<td>299</td>
<td>64.75</td>
<td>74.46</td>
</tr>
<tr>
<td></td>
<td>DF</td>
<td>934</td>
<td>201.50</td>
<td>231.15</td>
</tr>
<tr>
<td></td>
<td>Hidalgo</td>
<td>966</td>
<td>246.50</td>
<td>263.48</td>
</tr>
<tr>
<td></td>
<td>GUANAJUATO</td>
<td>320</td>
<td>80.00</td>
<td>92.00</td>
</tr>
<tr>
<td></td>
<td>MICHOACÁN</td>
<td>421</td>
<td>105.25</td>
<td>121.04</td>
</tr>
<tr>
<td></td>
<td>Nayarit</td>
<td>272</td>
<td>68.00</td>
<td>76.20</td>
</tr>
<tr>
<td></td>
<td>NUEVO LEÓN</td>
<td>1,034</td>
<td>258.50</td>
<td>297.28</td>
</tr>
<tr>
<td></td>
<td>SAN LUIS POTOSÍ</td>
<td>534</td>
<td>133.50</td>
<td>153.53</td>
</tr>
<tr>
<td></td>
<td>QUERÉTARO</td>
<td>364</td>
<td>91.00</td>
<td>104.65</td>
</tr>
<tr>
<td>ESTADO DE MÉXICO</td>
<td>HIDALGO</td>
<td>218</td>
<td>54.50</td>
<td>62.68</td>
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<td>153.24</td>
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<td>43.25</td>
<td>49.74</td>
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</table>
## Tables A.6

Estimated freight costs for corn by F.F.C.C.

<table>
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<tr>
<th>Production area</th>
<th>Consumption market</th>
<th>Distance</th>
<th>Distance + 25 pesos</th>
<th>price + VAT</th>
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<td>389.75</td>
<td>448.225</td>
</tr>
<tr>
<td>DS MOCHIS</td>
<td>Celaya, GTO.</td>
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<td>396.46</td>
</tr>
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<td>94.52</td>
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</tr>
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<td>351.85</td>
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<td>393.47</td>
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<tr>
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<td>405.75</td>
<td>446.47</td>
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<tr>
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<td>181.99</td>
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<tr>
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<tr>
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<td>422.95</td>
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</tr>
<tr>
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<td>401.25</td>
<td>452.47</td>
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<tr>
<td>Toluca, MEX.</td>
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<td>350.00</td>
<td>401.25</td>
<td>452.47</td>
</tr>
<tr>
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<td>AGUSCALIENTES</td>
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<td>389.75</td>
<td>448.225</td>
</tr>
<tr>
<td>(ATLACOMULCO)</td>
<td>Celaya, GTO.</td>
<td>1,39</td>
<td>344.75</td>
<td>396.46</td>
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<td>CHIHUAHUA, CHIH.</td>
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<td>350.00</td>
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<tr>
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<td>312.00</td>
<td>352.75</td>
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<tr>
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<td>380.50</td>
<td>422.95</td>
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<tr>
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<td>350.00</td>
<td>401.25</td>
<td>452.47</td>
</tr>
<tr>
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<td>350.00</td>
<td>401.25</td>
<td>452.47</td>
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### Tables A.7 Freight costs from field to Hub + Storage costs + Financial costs of storing main production areas (information from Aserca)

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<tr>
<th>State</th>
<th>Freight Cost (field-hub) pesos / ton</th>
<th>Months stored</th>
<th>Storage cost pesos / ton/h</th>
<th>Financial Cost</th>
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<td>5</td>
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<tr>
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<td>62.5</td>
<td>3</td>
<td>80</td>
<td>CETES+4</td>
</tr>
<tr>
<td>JALISCO</td>
<td>62.5</td>
<td>3</td>
<td>80</td>
<td>CETES+4</td>
</tr>
<tr>
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</tr>
<tr>
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<td>60</td>
<td>CETES+4</td>
</tr>
<tr>
<td>CHIAPAS</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
</tr>
<tr>
<td>GUANAJUATO</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
</tr>
<tr>
<td>PUEBLA</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
</tr>
<tr>
<td>CHIHUAHUA</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
</tr>
<tr>
<td>GUERRERO</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
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<td>VERACRUZ</td>
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<td>2</td>
<td>60</td>
<td>CETES+4</td>
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<tr>
<td>OAXACA</td>
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<td>2</td>
<td>60</td>
<td>CETES+4</td>
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<td>HIDALGO</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
</tr>
<tr>
<td>CAMPECHE</td>
<td>62.5</td>
<td>2</td>
<td>60</td>
<td>CETES+4</td>
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</table>

1/ Includes all delivery expenses and transaction costs of delivering and retrieving corn from warehouses
APPENDIX 5. DETERMINING CORN SUPPLY AT MAIN CONSUMPTION CENTERS

Table A.8 Anticipated corn purchases from Sinaloa (2007)

<table>
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<th>Anticipated corn purchase for White corn in Sinaloa</th>
<th>Autum Winter 2006-07 (Tons)</th>
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<td>CHIAPAS</td>
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<tr>
<td>NUEVO LEÓN</td>
<td>182,902</td>
</tr>
<tr>
<td>JALISCO</td>
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<td>YUCATÁN</td>
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<td>SONORA</td>
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<td>BAJA CALIFORNIA</td>
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<tr>
<td>GUANajuato</td>
<td>134,963</td>
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<tr>
<td>DISTRITO FEDERAL</td>
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<td>COAHUILA</td>
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<td>77,804</td>
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<td>74,731</td>
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<td>GUERRERO</td>
<td>67,555</td>
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<td>TABASCO</td>
<td>65,488</td>
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<td>PUEBLA</td>
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<td>DURANGO</td>
<td>13,322</td>
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<td>ZACATECAS</td>
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<td><strong>TOTAL</strong></td>
<td><strong>3,493,952</strong></td>
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</tbody>
</table>

Source: ASERCA. DIRECCIÓN ESTATAL EN SINALCA.
Table A.9 shows the general assumptions considered for estimating the distribution of corn producing areas to main consumption markets.

**General assumption for the construction of Variable costs curves in 10 consumption markets**

1. Transport costs were minimized to sell as much corn in local markets. Except for Sinaloa’s corn whose allocation was given by Aserca.

2. All consumption for the State was to be fulfilled in the consumption market (excluding autoconsumption).

3. We only consider 70% of consumption of all States as 30% is assumed to be autoconsumption except for DF were we assume there is only a 5% of autoconsumption.

4. We consider only 70% of States production to be commercial except for Sinaloa, Jalisco, Tamaulipas and Chihuahua were we assume 90-95% is commercial.

5. Financial Cost given by Aserca are assumed to be proportional as we only had financial costs for 60 days, thus 80 and 160 days are just a multiple of the 60 day costs.

6. For those States were there was no transport cost estimate of Aserca, we assumed similar costs for freight costs within States (For example from Edo de México to Toluca similar to that of Puebla to Puebla City). The transport costs estimated in relation to other similar distances were Campeche to Yucatan, 100 pesos and Sinaloa to Yucatan, 650 pesos.

7. The field variable costs for 2006 were converted to 2007 costs to meet Aserca’s logistics cost, by increasing general variable production costs by 2%. Half of the 4% increase of 2006.

Table A.10 Consumption at each of the main consumption centers considering assumptions above

<table>
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<th>Center</th>
<th>tons</th>
</tr>
</thead>
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<tr>
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<td>Cd Obregon</td>
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</tr>
<tr>
<td>Qro</td>
<td>1,210,662</td>
</tr>
<tr>
<td>Veracruz</td>
<td>924,005</td>
</tr>
<tr>
<td>Puebla</td>
<td>813,563</td>
</tr>
<tr>
<td>Mérida</td>
<td>806,076</td>
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<tr>
<td>Durango</td>
<td>755,293</td>
</tr>
<tr>
<td>Monterrey</td>
<td>720,181</td>
</tr>
</tbody>
</table>

Source: Aserca
Table A.11 Final supply table assuming corn suppliers minimize transport costs and using Aserca's destinations (2007)

Destinations of corn from production zones using Aserca's transport table

### Production of Estado de México
- **Toluca**: 65%
- **Guadalajara**: 11%
- **DF**: 10%
- **Puebla**: 10%
- **Veracruz**: 2%
- **Monterey**: 2%

### Production of Chiapas
- **Gdlj**: 40%
- **Qro**: 28%
- **DF**: 16%
- **Mérida**: 12%
- **Puebla**: 4%

### Production of Puebla
- **Puebla**: 80%
- **DF**: 20%

### Production of Jalisco
- **Gdlj**: 55%
- **Qro**: 17%
- **Cd Obregon**: 13%
- **Toluca**: 10%
- **DF**: 3%
- **Durango**: 2%
- **Monterey**: 1%

### Production of Michoacan
- **Gdlj**: 45%
- **DF**: 30%
- **Toluca**: 25%

### Production of Veracruz
- **Toluca**: 10%
- **Veracruz**: 80%
- **DF**: 3%
- **Durango**: 2%
- **Monterey**: 1%

### Production of Chihuahua
- **Durango**: 70%
- **Monterey**: 30%

### Production of Hidalgo
- **DF**: 60%
- **Puebla**: 40%

### Production of Guerrero
- **DF**: 80%

### Production of Tamaulipas
- **Monterey**: 39%
- **Qro**: 30%
- **Gdlj**: 13%
- **Durango**: 9%
- **DF**: 8%
- **Veracruz**: 1%
APPENDIX 6. COST CURVES FOR MAIN CONSUMPTION CENTERS

Graph A.1 Average Variable cost curve for Mexico City (DF) 2007

Graph A.2 Average Variable cost curve for Guadalajara 2007
Graph A.3 Average Variable cost curve for Monterrey 2007

Graph A.6 Average Variable cost curve for Queretaro 2007

Graph A.4 Average Variable cost curve for Toluca 2007

Graph A.7 Average Variable cost curve for Merida 2007

Graph A.5 Average Variable cost curve for Puebla 2007

Graph A.8 Average Variable cost curve for Durango 2007
Graph A.9 Average Variable cost curve for Veracruz 2007

Graph A.10 Average Variable cost curve for Cd Obregón 2007
## APPENDIX 7. EFFECTS OF BIOTECHNOLOGY IN DIFFERENT PRODUCTION ZONES IN MEXICO

### Table A.12 Average Variable cost curve for Cd Obregon 2007

<table>
<thead>
<tr>
<th>Area</th>
<th>Other general cost reduction</th>
<th>Yield increase (Low scenario)</th>
<th>Yield increase (high scenario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacifico O-I Riego</td>
<td>3%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Bajio-P-V-Riego</td>
<td>3%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Noreste-O-I-Riego</td>
<td>4%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Occidente-PV-Temp</td>
<td>6%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Valles Altos-PV-Temp</td>
<td>5%</td>
<td>10%</td>
<td>13%</td>
</tr>
<tr>
<td>Sureste-PV-Temp</td>
<td>6%</td>
<td>10%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Source: Monsanto