Chapter 12
The Food Versus Feed/Fuel Debate

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Chapter Highlights

- Over a short period of time beginning in 2007 and stretching into 2008, there was a dramatic rise in commodity prices.
- As a result of the increased commodity price of corn, rice, and wheat, food products based on these commodities also began to rise in price.
- Many nongovernmental organizations were quick to accuse the increased production of biofuels as the reason for the increased food prices – since more corn was being used to produce ethanol, there was less corn going into food production, hence the increase in prices.
- The debate is ongoing as to how policies that encouraged increased biofuel production and the events of the food price crisis are related and whether the cause was as simple as critics have claimed.

12.1 Introduction

Scientific principles such as "nothing happens in a vacuum" or "that for every action, there is an equal and opposite reaction" can also be extended into the realm of government policy, meaning that the implementation of government policy can and will impact other sectors of the economy and not necessarily in ways that were intended or even envisioned. In the decade of the 2000s, numerous industrial country governments began to implement domestic policies that supported development and production of biofuels, particularly ethanol. The rationale for this was twofold: first, it was part of many domestic governments' commitment to addressing climate

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change and, second, to reduce domestic dependence on fossil fuels. One event that occurred in a period that stretched from early 2007 to the fall of 2008 was a sharp increase in food prices. Many, especially within the media, were quick to accuse the expansion of corn-based ethanol production as being the cause for the increase in food products. Others, such as the biofuel industry and government departments that supported increased biofuel production, were quick to respond with opposing viewpoints. The objective of this chapter is to provide a detailed analysis of the literature from both sides of the spectrum.

Biofuels are frequently championed as an alternative to petroleum-based fuels and a potential climate change mitigation strategy. The expansion of biofuel production, however, has raised considerable debate among the media and in academic literature about whether biofuels actually lower greenhouse gas (GHG) emissions, their impact on food security, and the extent of environmental impacts (Pimentel and Patzek 2005; Farrell et al. 2006; Runge and Senauer 2007; Bailey 2008; Nuffield 2011). In spite of these criticisms, governments in many countries have implemented both biofuel mandates and policies, supporting the development of biofuels. Industry statistics show that the United States (USA), Brazil, and the European Union (EU) are the leading biofuel producers (Renewable Fuels Association [RFA] 2017a). In the USA, biofuel production consists mainly of ethanol from corn, in Brazil of ethanol from sugar cane, and in the EU of biodiesel from rapeseed oil.

Canada currently has 17 operating ethanol plants with a total capacity of 1.85 billion liters per year (Ethanol Producer Magazine 2017) and 9 operating biodiesel plants with a total capacity of 586 million liters per year (Biodiesel Magazine 2017). As of 2017, three ethanol plants and two biodiesel plants were planned to be built or were under construction. The main feedstocks used for domestic ethanol production are corn and wheat. There are operational facilities that can produce commercial-scale levels of ethanol from wood waste and municipal waste but because of economic reasons produce methanol instead (Dessureault 2016). Based on previous production data, Dessureault (2016) estimated that in 2016, 75% of Canadian ethanol was derived from corn, 23% from wheat, and 2% from other feedstocks. Most biodiesel is produced from canola, animal fats, and cooking oils (Canadian Renewable Fuels Association[1] [CRFA] 2010). The main ethanol feedstocks are corn in Ontario and wheat in Western Canada.

The 2007–2008 spike in food prices had impacts around the world. Protests, and even riots, against the higher price of staple commodities were commonplace in numerous nations, predominantly developing nations. In many instances the rise in the price of basic staples, such as rice and corn-based food products, adversely affected low-income segments of society. Many of the vocal opponents to this rise in food prices were quick to blame biofuel policies of industrial countries, particularly the USA, as being the reason for the price rise. In-depth analysis and assessment of this issue required considerable amounts of data to begin to make any kind

[1] Established in 1984 as a nonprofit Canadian organization that promotes the role of renewable fuels and value-added products made from renewable resources, the Canadian Renewable Fuels Association was relaunched in 2016 under the name Renewable Industries Canada – RICanada.

of observation, and in reality identifying a single driver responsible for the price increases was extremely difficult.

This chapter provides the background to biofuel policies in the leading biofuel-producing nations, of the USA, the EU, Brazil, as well as Canada. This is followed by a contextual overview of what occurred regarding commodity prices in the 2007–2008 period. Subsequently, a discourse of the price spike assessments is offered, providing insights into just how complicated an issue this turned out to be.

12.2 Background

The global production of biofuel has known periods of both fast and slow growth, depending on the applied policy support and feedstock availability. Total world biofuel production has increased almost 5 times between 2002 and 2012, from 23 billion liters to 110 billion liters (United Nations Conference on Trade and Development [UNCTAD] 2016). Among the developed countries, the major producers are, and are expected to remain, the USA, Brazil, and the EU. In 2011, the USA and Brazil produced approximately 87% of biofuel production, while Canada contributed 2% (Campbell et al. 2016). The most recent data from 2015 shows the USA and Brazil producing 70% of the world biofuel production (Araújo et al. 2017). According to the Organisation for Economic Co-operation and Development [OECD]-Food and Agricultural Organization [FAO] (2017), global ethanol production was 120 billion liters in 2016, and it is projected to increase to 137 billion liters by 2026. This increase is mainly due to Brazil, with a projected ethanol contribution of 60%, followed by the USA, China, and Thailand. World biodiesel production is projected to increase from 37 billion liters in 2016 to 40.5 billion liters by 2026. At a global level, the main feedstocks used in ethanol production are corn and sugar crops, while vegetable oil and municipal waste are mainly used in biodiesel production. OECD-FAO (2017) estimates that ethanol production will use 15% and 20% of world corn and sugar cane production, respectively, in 2026; ethanol obtained from biomass is expected to account for 0.5% of world ethanol production.

In the USA and EU, production and consumption are driven by the policies in place, the renewed Renewable Fuel Standard (RFS2) in the USA and the Renewable Energy Directive (RED II) in the EU. In Brazil, at present, production and use are driven by the development of flex-fuel vehicles and the differential taxation system which favors hydrous ethanol (OECD-FAO 2017).

12.2.1 Canada

The Canadian biofuel industry expanded following the turn of the millennium, largely due to federal policies targeting solutions for climate change, energy supply diversification, and rural development (CRFA 2010). Federal renewable fuels initiatives such as policy redesign, excise tax exemptions, and research grants were implemented to facilitate this growth. The Canadian government's Renewable Fuels Strategy has four components (Government of Canada 2017a). The first, "Increasing the retail availability of renewable fuels through regulations," is led by Environment and Climate Change Canada and refers to the 5% ethanol and 2% biodiesel **blending mandates**, implemented in December 2010 and June 2011, respectively. The second, "Supporting the expansion of Canadian production of renewable fuels" (named ecoENERGY for Biofuels), is comprised of investment initiatives (C$1.5 billion) to boost biofuel production, as well as eliminating excise tax exemptions for biofuels. In 2013, the Canadian government ceased subsidies for building new ethanol and biodiesel plants as biodiesel producers failed to meet production targets (McCarthy 2013). Only existing commitments were met until the program's expiration in 2017. Currently, the program is geared toward operating incentives for biofuel producers, based on production and sales volumes. Also, since 2008, the program implemented incentive rates for renewable alternatives to gasoline (starting at C$0.10/L) and for renewable alternatives for diesel (starting at C$0.26/L) (Natural Resources Canada 2016a). This program is being gradually phased out as the rates have declined to C$0.03 for ethanol and C$0.04 for biodiesel (OECD-FAO 2017).

Third, "Assisting farmers to seize new opportunities" comprised of two parts: ecoAgriculture Biofuels Capital Initiatives – ecoABC – and Agri-Opportunities Program. The ecoABC program involved making capital available (C$200 million in repayable capital) to farmers for building or expanding production facilities and for developing business proposals and feasibility studies. This program ended in March 2013 at which point it had invested C$159 million. The Agri-Opportunity Program was a C$134 million program that provided funds to accelerate the commercialization of innovative value-added agricultural, agri-food and agri-based products, services, and processes not commercially produced or available in Canada. This program ended in March 2011.

The final part of the strategy, "Accelerating the commercialization of new technologies," the Next-Generation Biofuels Fund (NextGen Biofuels Fund), is available for producing **second-generation or advanced biofuels**. Sustainable Development Technology Canada (SDTC) is able to invest with the private sector in establishing large-scale demonstration facilities for the production of next-generation renewable biofuels and coproducts from nonfeed stocks (Natural Resources Canada 2016b). At a federal level, Canada's Renewable Fuels Strategy requires a blend of 5% renewable content in the Canadian gasoline pool and a blend of 2% renewable content in the distillate pool, excluding heating oil (CRFA 2014). Provincial government mandates and initiatives, however, preceded the federal ones which helped eliminate interprovincial trade distortions (Dessureault 2016).

For instance, provincial governments have supported biofuel development through reductions in provincial fuel taxes for gasoline containing ethanol (Manitoba), exemptions from excise taxes (Ontario), grants for ethanol blend distributors (Saskatchewan), refundable tax credits for ethanol production (Quebec), capital assistance for ethanol production facilities, operating grants, and numerous other forms of support. Federal and provincial blend mandates for ethanol and

Table 12.1 Provincial and federal biofuel blend mandates in Canada

Province	Ethanol	Date of adoption	Biodiesel	Date of adoption
Ontario	5%	January 1, 2007	2–4%[a]	April 1, 2014
Saskatchewan	7.5%	January 15, 2007	2%	July 1, 2012
Manitoba	8.5%	January 1, 2008	2%	November 1, 2009
British Columbia	5%	January 1, 2010	4%	January 1, 2012
Alberta	5%	April 2011	2%	April, 2011
Quebec	5%	2012[b]	n/a	n/a
Federal	5%	December 15, 2010	2%	July 1, 2011

[a]Depending on the amount of greenhouse gas emissions reductions
[b]This is not a mandate, it is a planned target to be implemented with second generation ethanol
Sources: Adapted from CRFA (2010), Biofleet (2011), Dessureault (2016), Sapp (2014)

biodiesel are shown in Table 12.1. Canadian subsidization for biodiesel has lagged behind ethanol, so the biodiesel industry has taken longer to develop and is smaller than the ethanol industry (Laan et al. 2009). At a provincial level, the ethanol mandates range between 5% and 8.5%, and the biodiesel mandates range between 2% and 4% in British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario. Quebec has a 5% aspirational mandate to be implemented with advanced ethanol. In addition to the mandates, British Columbia adopted a low-carbon fuel standard in 2008 based on a requirement to reduce the carbon intensity of fuels by 10% by 2020 from a 2010 baseline (Government of Canada 2017b). For both ethanol and biodiesel, Atlantic Canada and Quebec are exempt from the federal gasoline policy (CRFA 2014).

The Canadian ethanol blending mandates require over 2 billion liters of fuel-grade ethanol. As of 2016, Canadian biofuel production capacity was 1.775 billion liters, which means that Canada has to import the difference (Dessureault 2016).

The CRFA annual report (CRFA 2010) illustrated the challenges of building a biofuels industry from scratch, in the absence of, or certainly very limited, domestic market demand. Canadian biofuel subsidies have been provided through a mix of policy regulations and measures such as direct payments, tax exemptions, interest-free loans, grants, and consumption mandates (Table 12.2). Because information was scarce on subsidized production, sales, and payments which the Canadian biofuel industry had received, Laan et al. (2009) performed a comprehensive analysis of the subsidization process and range of payments.

Compared to investment and support in the USA and Brazil, biofuel subsidies in Canada are more recent and modest. Relatively low subsidies were targeted at ethanol research in the mid-1980s, followed by excise tax exemptions and investment incentives in the 1990s (Laan et al. 2009). A major federal policy strategy, the Ethanol Expansion Program was launched in 2003, offering loans for the construction of new ethanol plants. From 2006 to 2008, biofuel support was directed to virtually all stages of the supply chain, averaging C$300 million per year (Laan et al. 2009). Thus, the mandates implemented at a federal and provincial level, along with the subsidies and support for the domestic Canadian industry, have created

Table 12.2 Examples of government biofuel support in Canada

Stage of production	Subsidy types
Research, development, and demonstration	Grants and low-interest loans
Business planning	Grants for feasibility studies and market development
Plant construction	Grants and low-interest loans, accelerated depreciation
Production	Fuel tax exemption, producer payments
Price support	Mandated biofuel blending requirements and tariffs
Distribution	Grants for storage and distribution infrastructure
Operating incentives	Incentive payments paid on a per liter of biofuel basis
Consumption	Tax breaks for the purchase of biofuel-consuming vehicles, government procurement and dissemination of information to consumers

Source: Adapted from Laan et al. (2009) and Natural Resources Canada (2016a)

a policy-driven demand for ethanol in Canada (Campbell et al. 2016). Regarding advanced biofuels, the federal and provincial governments have initiated various research and development investments over time (Table 12.3). Advanced biofuels are produced from lignocellulosic plant materials such as agricultural residues, forestry by-products, and energy crops grown on marginal lands. Also municipal waste and algae are used for producing advanced biofuels. Canada has the advantage of a large stock of lignocellulosic biomass from agricultural waste and tree biomass, but competing with the Brazilian or American industry on this market raises serious challenges.

In Canada, the federal NextGen Biofuels Fund promotes the development of first-of-a-kind large demonstration scale facilities for the production of advanced biofuels (Sustainable Development Technology Canada [SDTC] 2018). The initial endowed budget was approximately $500 million. As of 2018, this fund stopped accepting applications, but will continue supporting existing projects until 2017 (SDTC 2018).

By comparison, in the USA, between 2007 and 2014, departments of Defense, Agriculture, and Energy provided more than US $1.7 billion in grants and loans for advanced biofuels along with tax incentives, government policies, and price incentives (UNCTAD 2016). In 2014, a public-private partnership between the European Community and the Bio-Based Industries Consortium, called the Bio-Based Industries Joint Undertaking, provided €3.7 billion to support converting biomass into common consumer products through innovative technologies by biorefineries (Flach et al. 2017).

However, despite the ongoing support for advanced biofuels, in the most recent OECD-FAO biofuels report (2017), one of the main world issues listed is that, due to the lack of policy signals and the low energy prices, investment in research and development for advanced biofuels produced from lignocellulosic biomass, waste, or nonfood feedstock is not supported. The main barriers for investment are the high research and development costs, production costs, and the regulatory uncertainty (Flach et al. 2017).

Table 12.3 Various Canadian federal government early support for second-generation biofuel research and development

Year	Total amount invested (million)	Program/initiative
Mid-1980s to Mid-1990s	$18	National Research Council Natural Resources Canada and Agriculture and Agri-Food Canada supported research by Iogen corporation to develop cellulosic ethanol production technologies
1999	$18	The federal government provided partial funding for Iogen's $40 million commercial-scale demonstration plant through loans repayable from future profits
2002	$2.7	Federal government awarded to Iogen a cost-shared research contract
2004	$550	SD tech fund managed by Sustainable Development Technology Canada (SDTC) provided $19 million between 2004 and 2008 for second-generation ethanol
2006	$145	Agricultural Bioproducts innovation program (ABIP) was a multiyear grant program to support new and existing research networks in the areas of bioproducts and bioprocesses, in addition to biofuels and other forms of bioenergy. ABIP funded the cellulosic biofuels network with $19.9 M in 2009 to develop a network to provide expertise, technology, and processes associated with cellulosic ethanol production
2007	$500	NextGen biofuels fund provided interest-free loans for large-scale demonstration facilities producing second-generation biofuels
2007	$134	Agri-opportunities Program provided funds for commercialization of new agricultural products, processes, or services

Source: Adapted from Laan et al. (2009)

For the most part, Canadian policies to support the development of the biofuels industry have been the implementation of biofuel blend mandates and the use of fiscal stimulus packages to encourage the advancement of biofuel processing technology as well as infrastructure investment regarding the construction of biofuel plants. As noted above, Canada is not considered a large player in the global biofuel market and the blend mandates and policy decisions would have had, at best, a minimal impact on the increase in food prices.

12.2.2 USA

American biofuel mandates require renewable fuels that satisfy environmental sustainability criteria such as GHG emissions savings relative to fossil fuels and **indirect land use change** (ILUC) restrictions. In 2005, the USA created the Energy Policy Act which was driven by the need to increase US energy security. This Act implemented renewable fuel blend mandates as a means of reducing the existing dependence on foreign oil imports. Other main policy drivers were promoting rural development through job creation, mitigating climate change through GHG emissions reduction, and enhancing competitiveness through innovative technologies (Mondou and Skogstad 2012). As of 2016, the gasoline consumed in the USA contained more than 10% ethanol on average (Renewable Fuels Association [RFA] 2017b). This increase in gasoline average ethanol content is attributed to the growing consumption of E15 (gasoline blends containing 15% ethanol), mid-level blends (20–50% ethanol), and flex fuels (51–83% ethanol) (RFA 2017a). In the USA, the two major low-carbon fuel policies in place are the Renewable Fuels Standards (RFS)1 created under the EPA in 2005 and the revised RFS or RFS2 created in 2010. The renewable fuel categories under RFS1 and RFS2 are biomass-based diesel, cellulosic biofuel, advanced biofuel, and total renewable fuel. RFS1 was created under the Energy Policy Act, which amended the Clean Air Act. The Energy and Security Act (EISA) of 2007 further amended the Clean Air Act by expanding the RFS to what is known as the revised RFS (US-EPA 2017).

The original RFS1 required 28.3 billion liters of renewable fuel to be blended in gasoline by 2012. When RFS1 was expanded under the EISA, the volume of renewable fuel to be blended into transportation fuel increased from 34 billion liters in 2009 to 36 billion liters by 2022, with 57 billion liters of corn ethanol and 21 billion liters of advanced biofuel by 2015 and 79.5 billion liters of advanced biofuels by 2022. Another important regulation regarding biofuel sustainability was the introduction of life cycle GHG performance threshold standards, ensuring that each category of renewable fuels emits fewer GHG than the fuel it replaces.

In 2010, under the RFS2 program, many regulations were included, clarified, and expanded, as the RFS2 program covers all transportation fuels used in road, rail, and marine transportation. The RFS2 requires a combined use of 140.4 billion liters of biofuels by 2022, of which 58.5 billion liters are conventional first-generation (corn ethanol) biofuels and 81.9 billion liters from advanced (cellulosic, biomass-derived diesel, and others) biofuels. The RFS2 requires specific GHG emission reductions depending on the fuel category, 20% for **first-generation biofuels**, 50% for advanced (second-generation) biofuels, and 60% for cellulosic (third-generation) biofuels. The methodology used for calculating GHG emissions should include all life cycle GHG emissions of fuel, including ILUC emissions (Scarlat and Dalemand 2011). The US Renewable Fuel Standard requires the creation of credits, representing volumes of renewable fuels, and has a credit trading system (Government of Canada 2017b).

The Environmental Protection Agency (EPA) annually provides minimum quantities for each of the four classes of biofuels required. In 2013 and 2017, the EPA decided to reduce total, advanced, and cellulosic mandates as the production capacity for cellulosic ethanol has been lagging (OECD-FAO 2015, Prentice et al. 2017).

American policy was targeted at setting aggressive blend mandates for the inclusion of biofuels. Biofuel production was subsidized through these policies, many new biofuel plants were constructed, and considerably greater levels of corn production were witnessed. The reality of the RFS1 policy was that the blend requirements for second-generation biofuels were simply too aggressive and the industry was not able to meet these mandates due to the technology gap that exists in converting cellulosic materials and waste into biofuels in an economical and efficient manner.

12.2.3 EU

The EU strategy for biofuels industry development is driven by motivating policy incentives, with the three main policy drivers being energy security, the continuous effort to reduce GHG emissions, as well as rural development interests (Swinbank 2009).

The EU RED requires that 20% of overall EU energy consumption be sourced from renewables, and a mandatory 10% minimum target for all member states for the consumption share of renewable energy in transportation Paragraph 18 of RED defines the 10% target as that share of final energy consumed in transport, which is to be achieved from renewable sources as a whole, and not solely from biofuels. In addition, second-generation biofuels' contribution to the target is twice that made by other biofuels (Article 21(2)).

The EU sustainability criteria came into effect in December 2010 in Articles 17, 18, and 19 of the RED (European Commission 2009). The criteria are concentrated on GHG savings, high-biodiversity value land, high-carbon stock land, and agro-environmental practices. The European renewables framework focuses on promoting renewable energy, setting mandatory national renewable energy targets, such as achieving a 20% share of renewable energy in final energy consumption and a 10% share of energy from renewable sources in transport by 2020. These goals contribute to the European 2020 growth strategy as they "contribute to Europe's industrial innovation and technological leadership as well as reducing emissions, improving the security of our energy supply and reducing our energy import dependence" (European Commission 2013). The 2013 European Commission report on the progress of renewable energy, however, observes that, after a good start to the project, there has been a slower than expected removal of barriers to renewable energy development, while some member states need to take additional efforts to achieve the proposed goals. The progress analysis reveals that the European economic crisis along with the administrative and infrastructure barriers, coupled with policy and support schemes disruption, are responsible for the target achievement delays.

The European energy market is not open and competitive. The current policies strive to compensate for market failures through the use of support schemes, standards, and administrative rules designed to promote renewable energy development. The European Commission (EC) report (2013) observes that the planned trajectory for biofuels production for 2020 will also result in a deficit. Thus, considering that one of the amendments that the Commission proposed for biofuels was a greater use of nonfood feedstock, additional measures will be required to achieve the 2020 targets.

The 2009 RED initially required a 10% share of renewable energy use in the transportation sector by 2020. Related to this is the Fuel Quality Directive 2009/30/EC which set a 6% reduction in the GHG intensity of fuel used in transportation by 2020. Shortly following the implementation of this directive, numerous stakeholders expressed concerns that such a high mandatory usage of first-generation biofuels would lead to a massive cultivation of biofuel crops, either to the detriment of existing agricultural production or the expansion of cropland (Ernst and Young 2011). This is known as ILUC and relates to the unintended consequences of releasing a substantial amount of carbon emissions into the atmosphere as a result of changing the land use to the dedicated production of ethanol feedstocks or biodiesel crops. In October 2012, the EC amended the existing legislation on both the RED and the Fuel Quality Directive, capping the share of first-generation biofuels that can be used at 5%, down from the 10% renewable energy target by 2020 (European Commission 2012). One of the motivations of this amendment is to stimulate the development of advanced (second- and third-generation) biofuels that will further reduce GHG emissions. Additionally, ILUC factors will be considered when assessing the GHG performance of biofuels. Market incentives for biofuels with no, or low, ILUC emissions in particular for second- and **third-generation biofuels** were provided. The aim of the biofuel sustainability criteria is to prevent the direct conversion of forests, wetlands, and areas with a high biodiversity value to biofuel production.

RED was amended in 2015 by an EU Directive to a 7% cap on the share of conventional biofuels and a not-binding national target for advanced biofuels of 0.5%. In November 2016, the EC released the RED II for the period 2021–2030 to ensure that the EU will adhere to the target of producing at least 27% of its energy from renewable sources by 2030 (International Council on Clean Transportation [ICCT] 2017). To minimize the ILUC impacts, the RED II introduces a cap on conventional biofuels, toward the EU renewable energy target, starting at 7% in 2021 and going down gradually to 3.8% in 2030. In addition, the RED II encourages the use of advanced biofuels with a minimum share of 1.5% in 2021 to 6.8% by 2030. Furthermore, advanced biofuels should emit at least 70% fewer GHG emissions than fossil fuel (ICCT 2017).

The EU ethanol production rose from 5.1 billion liters in 2011 to an estimated 5.3 billion liters in 2015 (Flach et al. 2017). Cellulosic ethanol production began in 2014 with 50 million liters and is estimated to increase to 60 million liters in 2018. The most used feedstocks for producing ethanol are sugar beets, wheat, corn, and rye.

Biodiesel is the most important biofuel in the EU, and it has been commercially produced since 1992. The EU is the world's largest biodiesel producer followed by the USA, Argentina, Brazil, Indonesia, and Thailand (OECD-FAO 2017). Vegetable oil and municipal waste are the main feedstock sources for biodiesel production.

With the majority of the technology development in Europe focused on biodiesel as the preferred biofuel energy options, the EU imports considerable amounts of ethanol. The increased ethanol demands did put pressure on other markets to increase their ethanol production to serve the EU demands. As part of the EU's policy approach to the production and importing of ethanol, the EU has implemented some of the most rigorous land use regulations in existence. Not only can land use not change to increase ethanol production, that is, land that was not previously in cultivation cannot begin to be cultivated to produce biofuel crops, but the EU imposes many of its land use restriction on the nations that it imports ethanol from. The European policy approach to biofuels could be said to be largely driven by the environmental improvement criteria and climate change mitigation strategies (European Commission 2012).

12.2.4 Brazil

Until a few years ago, Brazil was the global leader in ethanol production and exports. Brazil is considered to be the worlds' most efficient ethanol producer (Sorda et al. 2010; Solomon 2010), even though it took a long time and supportive policies to achieve this. Brazil's advantages consist of its history of ethanol use, the well-established infrastructure, and its low-cost feedstock, sugarcane. Although the Brazilian biofuel industry was initially subsidized, particularly for building the infrastructure, the industry is viable without large government subsidies (Nass et al. 2007, Solomon 2010).

The expansion of the biofuel industry has also been driven by the development of the flex-fuel vehicle industry (OECD-FAO 2012), which began in 1970 and was launched through the Proalcohol Programme. The program implemented tax incentives and final consumer prices for both cars and ethanol (Kamimura and Sauer 2008). The Brazilian car manufacturing industry developed flexible-fuel vehicles over time that can run on increasingly higher percentages of ethanol. The growing Brazilian flex-fuel fleet can be powered by hydrous ethanol (E100), a mixture of ethanol and a small quantity of water, with no gasoline added. Another option for ethanol use in these vehicles is gasohol, a mixture of gasoline and 20% or 35% hydrous ethanol (Wisner 2012). The Brazilian ethanol mandates were initially increased from 18% to 25%, decreased in 2011 to 20% due to a low sugarcane production and a low ethanol supply, and then increased again at 27% in 2015 (OECD-FAO 2015). The 27% mandate and a differential taxation system in some Brazilian states, which favors hydrous gasoline in relation to gasohol, drive the ethanol production in Brazil (OECD-FAO 2015). Brazilian ethanol production is thus projected to increase from 29.2 billion liters in 2016 to 36.3 billion liters in 2026 (OECD-FAO 2017).

As of 2017, Brazil is the third biodiesel producer in the world, contributing 36% to global production, and it is projected that it will maintain its position (OECD-FAO 2017). The Brazilian biodiesel mandate gradually increased from 2% in 2006 to 8% in 2017 and a proposed 9% and 10% in 2018 and 2019, respectively. If technically feasible, it is intended to increase the mandate to 15% (Barros 2016). Brazilian biodiesel production was 4 billion liters in 2015 (Barros 2016), and it is projected to increase to 5.4 billion liters by 2026 (OECD-FAO 2017).

With the intent of reaching the GHG emissions targets set at the United Nations Framework Convention on Climate Change in Paris 2016, Brazil has announced the intention to implement the RenovaBio program which, as of November 2017, has not been approved yet by the Brazilian congress. Through RenovaBio, Brazil is supposed to reduce its GHG emissions by 43% of 2005 levels by 2030. Within this program, producers and importers will be issued decarbonization credits which will be traded on an exchange market. Fuel distributors will have to achieve their own individual decarbonization goals (Phillips 2017).

Brazil's domination of biofuel production and export was surpassed by that of the USA. Brazil has a long history of biofuel use and has developed and promoted the growth of the industry through the use of government policy designed to support a domestic vehicle development program. The use of fiscal and economic incentives has created a strong domestic industry that is now witnessing a removal of the original subsidies to industry. Brazil's ethanol production advantage lies in its abundance of sugarcane, the most economical feedstock available for ethanol production.

12.3 Food Price Crisis of 2007–2008

Over the 24-month period from the start of 2007 to the end of 2008, global food prices witnessed a drastic increase, especially cereals. The rise in food prices is best reflected from the increase in the Food and Agriculture Organization's Food Price Index.[2] The **Food Price Index** (FPI) is a combined measurement of commodity prices for meat, dairy, cereals, oils and fats, and sugar. By collecting commodity prices over time, it is possible to compile a price index that reflects the average trading prices for commodities at any specific moment in time. The overall FPI rose from an average of 158.9 in 2007 to an average of 199.8 in 2008 (FAO 2013) – a rise of 26%. It was the **Cereals Price Index** (CPI) that rose the most sharply and accounted for most of the increase. The CPI, which is comprised of cereal and rice trading prices, rose from a 2007 average of 166.9 to a 2008 average of 237.8, an increase of 43%. In 2009, the FPI dropped by 21% with the CPI dropping by 27%.

A more detailed examination of what has been dubbed "the price crisis" reveals the rise in prices from the start of 2007 to the peak of prices in 2008, to be even sharper. The FPI rose from 134 at the start of 2007 to a peak at 224.4 in June 2008, an increase of 67%. The rise in the CPI was considerably more dramatic, rising from 144 at the start of 2007 and peaking in April 2008 at 274.1, a rise of 90%. Appeals for food aid were issued by 36 countries (US Department of State 2011). The rapid rise and decline in both indexes over the period of 2007–2008 are illustrated in Fig. 12.1. Ultimately, these events triggered the FAO's November 2009 World Summit on Food Security.

Delving down a step further by more closely examining the price increase of the three staple food commodities of corn, rice, and wheat, it is possible to gain further

[2] Online at: http://www.fao.org/worldfoodsituation/foodpricesindex/en/

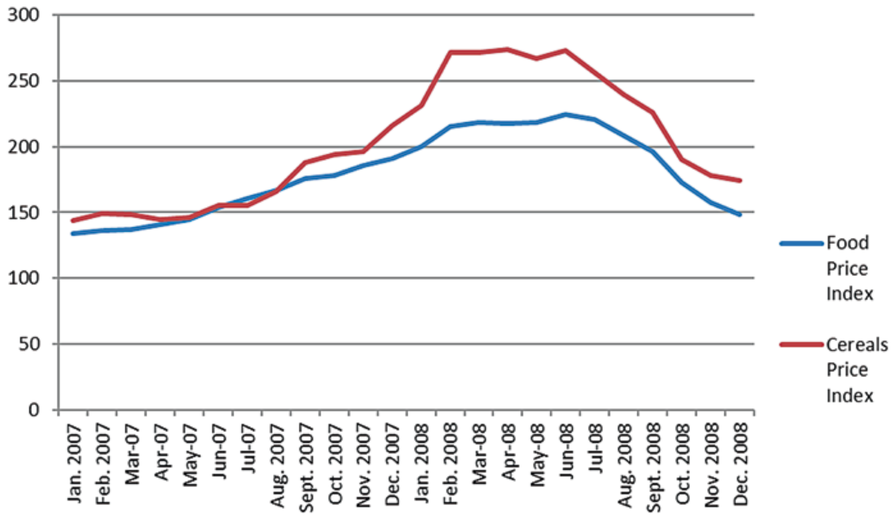

Fig. 12.1 Food and cereal price indexes, 2007–2008 (Source: FAO 2013)

insight into the hardships that resulted from the price increases. These three commodities account for the dominant intake for household nutrition on a daily basis. An in-depth assessment of the food crisis by the International Food Policy Research Institute found that in some nations, monthly year-over-year price increases were in excess of 100% in some instances (Headey and Fan 2010). A selection of examples of commodity price increases is provided in Table 12.4.

Rice prices rose rapidly throughout the fall of 2007 and the early months of 2008. A report by the Economic Research Services (ERS) of the US Department of Agriculture (USDA) indicates that the rice benchmark for global trading prices (Thailand's 100 Percent Grade B long-grain milled rice) was trading in excess of US$1,000 per ton in April of 2008 (USDA-ERS 2009). This price was double the trading price in February 2008 and triple that of November 2007. The percentage of rice price increases between the second quarter of 2007 and the second quarter of 2008 is documented in Fig. 12.2.

Increasing corn prices impacted most Latin American countries, particularly Mexico. Many of Mexico's poor rely on tortillas as their main dietary staple. While specific data is not easily discernible, one study estimates that between 2005 and 2011, the price of tortillas rose by 69% (Wise 2012). Wise goes on to estimate that the **Tortilla Price Index** rose from a level of 110 in the fall of 2006 to a level of 130 by the summer of 2008, an increase of 18% in less than 2 years.

The third staple commodity, wheat, also witnessed record price increases during this period. Using the commodity trade benchmark of US No. 1 hard red winter wheat, the price of wheat rose from US$195 per tonne in May 2007 to a high of US$440 per tonne in March 2008 (Index Mundi 2013). This represents an increase of 125% in less than 12 months.

Table 12.4 Staple commodity price changes, 2008

Country	Commodity	Average price increase, M-07 to M-08
Thailand	Rice	75%
Haiti	Rice	27%
Nicaragua	Corn	38%
Bolivia	Wheat	41%
Chile	Rice	46%
Bangladesh	Rice	31%
Ethiopia	Corn	115%
Uganda	Corn	109%
Malawi	Corn	116%
Tanzania	Corn	73%
Afghanistan	Wheat	71%
India	Rice	16%

Source: Adapted from Headey and Fan (2010) with permission from the International Food Policy Research Institute (www.ifpri.org)

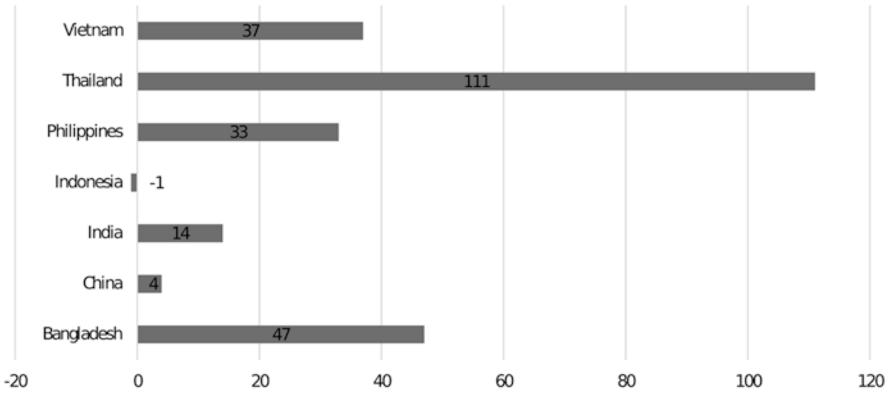

Fig. 12.2 Rice price increases, 2007–2008 (quarter two, year-over-year, % age) (Source: Dawe 2009)

Since commodity prices around the world rose drastically in such a short period of time, substantial price increases resulted for many staple food products based on rice, corn, and wheat. Civil unrest occurred in many nations due to the inability of the poorest in society to be able to afford to buy these food products at inflated prices. These rapid price increases were quite unexpected and triggered great consternation within many governments and international organizations and agencies.

The chapter now turns to discussing what reason(s) or causes were responsible for the food price crisis. The gist of the broad debate on the topic can be condensed into the following question: Did the increase in US biofuel production trigger the food price crisis? While many commentators were quick to come to this conclusion, time and factual-based research has shown that the correlation is not as evident as critics have assumed.

12.4 Analysis of the Food Price Crisis

Without a doubt, biofuel production around the globe dramatically increased during the first decade of this century. While the EU focuses much of its domestic technology development on biodiesel, it still imports vast quantities of biofuel. Canada is not a significant player in the international biofuel market, so increased biofuel demands in Canada had minimal impact at an international level. Brazil's production increased, as did production in the USA. The increase in the amount of corn production being utilized by the American biofuel industry is highlighted in Fig. 12.3. The percentage of US corn production increased from 5% at the turn of the millennium to almost 40% by the end of the decade. Correspondingly, the production of corn has also increased as is shown in Fig. 12.4.

Critics of industrial agriculture were quick to conclude that the food price crisis was directly triggered by the US increase in biofuel production, as increasing amounts of corn were being diverted away from food use to biofuel use. While there are numerous examples to draw upon of the arguments put forth by the critics of the biofuel industry, a report released by ActionAid International provides the essence of these arguments. ActionAid is an antipoverty nongovernmental organization (NGO) that is based in the UK. In a report that is typical of NGO criticism of many North American agricultural practices, ActionAid (2012: 3) states, "There is widespread agreement among experts that the recent surge in global biofuels production has been an important contributor to the rise in global food prices over the last six years.… The increase in corn ethanol production in the US has contributed to rising corn prices in several ways." Unfortunately, ActionAid provides no details as to who the experts are, or for that matter, what qualifies them to be experts. The fact that

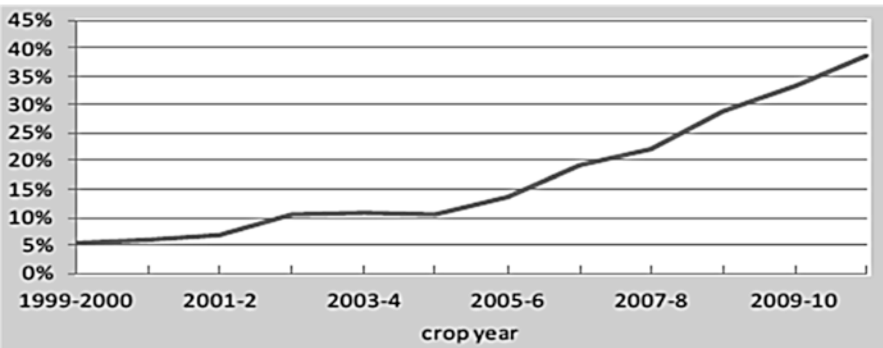

Fig. 12.3 Ethanol share of US corn production (Source: Wise 2012)

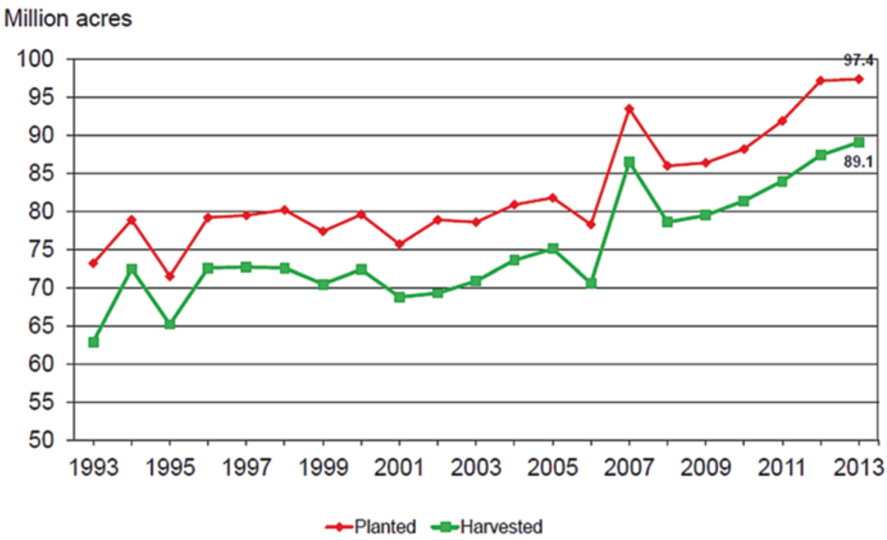

Fig. 12.4 US corn production (Source: USDA-NASS 2013)

this report came out 4 years after the food crisis and ignores other, more balanced, research is indicative of the biased research that is far too common within the NGO community.

A more balanced assessment of the food price crisis is offered by Hays (2008) who indicates that food prices increased due to a number of reasons: (1) the sale of foodstuffs, namely, corn and soybeans, to biofuel producers; (2) increased demand in places like China and India, where people were becoming richer and demanding more and better food like crop-consuming meat; (3) weather problems and droughts in bread baskets like Ukraine and Australia as well in sub-Saharan Africa; (4) the high cost of fertilizer due to high oil prices; (5) hoarding of grains by nations wanting to ensure their domestic supplies stayed put; and (6) panic buying, hoarding, and speculation.

While Hays includes increased biofuel production as the leading driver of the food price crisis, he does acknowledge other issues also drove food price increases. Non-peer-reviewed online studies, reports, and commentaries, however, offer minimal value in trying to understand what triggered the food price crisis of 2007–2008. Auld (2012) estimates that there are in excess of 1,000 reports, studies, book chapters, and journal articles pertaining to the topic of biofuel production and the price of commodities. Obviously a discussion on this volume of literature is beyond the scope of any publication. To gain insight into this issue, an examination of fact-based data analysis research is required. It is to this literature that we now turn our attention.

As was discussed previously in this chapter, governments have utilized a variety of policy measures to support and encourage the growth of the biofuel industry. One common policy measure that has been used is subsidies. The problem with using subsidies, whether they are targeted at farmers or ethanol plants, is that they distort the market and create inefficiencies. For example, if a production subsidy is available for corn, many farmers will plant corn to take advantage of the subsidy but would not have planted corn had the subsidy not been available. Another policy option used by most governments has been the implementation of fuel/biofuel blend mandates that require a certain percentage of fuel to contain biofuel. de Gorter and Just (2010) observe that the benefits resulting from blend mandates can easily be lost with the inclusion of biofuel subsidies into the policy fix.

One economic relationship that is crucial to understanding this issue is the relationship between gasoline prices, ethanol prices, and the price of corn. Economies the world over are growing; hence there are greater energy demands in these economies. Simply put, as economic growth occurs within a country, the demands for fuel increase in parallel. These increased energy demands can be to power a new manufacturing plant and transport products from one location to another or for planting more cropland. When a government has implemented blend mandates into its energy policy, as the demand for fuel increases, so too will the demand for ethanol and biofuels to be blended. What then, is the impact on corn prices? de Gorter and Just (2010) indicate that prior to 2004, there does not appear to be any correlation between ethanol prices and corn prices, but following 2004, the authors indicate that the price of corn is directly linked to the price of ethanol. Thus, when the demand for ethanol to be blended into gasoline increases, so does the price of corn used to produce that ethanol.

Increases in the price of oil also contribute to inflating food prices. Farmers face higher input costs through higher fertilizer prices and higher fuel costs. Rail companies and grain handlers face higher fuel costs to move commodities from rural collection points to either commodity processing plants or export facilities. Additionally, food products are widely transported, both nationally and internationally, and higher oil prices result in higher fuel costs, contributing to increased food costs. Fuel costs account for a large portion of transportation costs pertaining to food prices, whether it is for bulk commodities or process foods.

As presented, energy policies and economic growth have an impact on commodity prices and hence food prices. In an effort to distinguish the impact of these two factors on food price inflation, Hochman et al. (2011) model the effects of economic growth, increased energy demands, biofuel expansion, fluctuations in the rates of currency exchange, and levels of crop inventories. Hochman et al. (2011) posit that when these factors are taken into consideration, they "explain 70 percent of the price increase for corn, 55 percent for soybean, 54 percent for wheat, and 47 percent for rice during the 2001–2007 period." The authors speculate that factors such as commodity trading, trade policy, and adverse weather may account for the balance of the price increase.

Beginning in 2002, the US dollar began to experience a significant decline relative to other major currencies. Charlebois and Hamann (2010) analyzed the consequences of US dollar depreciation and highlight that this was a contributing factor to the 2008 agricultural price increases. The world price for major crops, and the international trading of these crops, is typically denominated in US dollars; thus a declining value of the American dollar will eventually lead to increased prices (Flammini 2008). This rationale is reinforced in a World Bank Report (Mitchell 2008), which shows that another factor that contributed to the rapid increase in the world market prices for major food commodities, along with biofuels, rising energy prices (and implicit price increase in fertilizers and chemicals), increased costs of production, or protectionist exporting policies, was the declining US dollar. Mitchell (2008) calculates that the dollar depreciation against the Euro in the 2002–2008 interval was of approximately 35%. Hence, the depreciation of the American dollar during this period led to increasing commodity prices (Gilbert 1989; Baffes 1997).

A policy choice that further inflated food prices was the decision by some governments to ban the export of certain staple commodities, which resulted in a contraction of the global supply available for purchase by other countries, hence further inflating the price of that commodity. Hochman et al. (2011) identify that this policy option was implemented by both China and India in the 2007–2008 period. As a means of ensuring consistent domestic supplies, governments of both countries banned the export of raw commodities. In the case of China, their government banned the export of rice and corn, while the Indian government also banned the export of rice. An additional 14 countries followed suit and banned the export of basic commodities to ensure that domestic supplies could be maintained, but the cost of this policy was substantial as the panic that resulted from this drove the price of those commodities even higher, resulting in higher costs to these governments when faced with importing food products.

Swinnen et al. (2011) make an interesting observation in the discussion of the food price crisis. They observe that numerous NGOs and international agencies have long suggested that poverty and food insecurity in developing countries were due in part to low commodity prices. Following the food price crisis of 2007–2008, these same organizations completely reversed their position and argued, however, that rising commodity and food prices threatened food security. The authors posit that many of the NGOs operating in the agriculture, food security, and sustainable development field are guilty of biased communication policies and simply champion whatever message gets them the greatest degree of media attention. Many large, international NGOs are predominantly fixated on raising money and will frequently bias their communications with whatever message will generate the greatest level of donations; hence they lack any real commitment to the actual issue they are communicating about.

In their International Food Policy Research Institute report, Headey and Fan (2010) examined evidence that would link certain food price increase factors to the rise in food prices. They determined that, based on the evidence they reviewed, three factors drove the increase in food prices. First, rising oil prices due to economic growth; second, increased demand for biofuels due to high blend mandates from numerous governments; and third, trade shocks on commodity prices. Agriculture is an energy-intensive industry, and as discussed above, rising oil and fuel prices contributed to increased food prices. Trade shocks include export bans on staple commodities by some governments and the panic buying behavior that resulted with many government purchasing agencies. The report observes that the rice export bans enacted by both the Indian and Vietnamese governments strongly contributed to the price volatility that was witnessed in the international rice market. The hoarding of staple commodities created considerable consternation within importing nations, resulting in the bidding up of commodity prices in an attempt to secure enough supply to satisfy domestic demands. One contributing factor to the increase in wheat prices was the severe drought that was experienced by Australia during the 2005 and 2006 crop years, which reduced international wheat stocks. Headey and Fan determine that speculation by commodity brokers, which was suggested as one of the major reasons for increased food prices, did not have sufficient evidence to be a determining factor in the food price crisis.

Piesse and Thirtle (2009) observe that the when taken in context, the price increases from 2007 to 2008 were considerably below those of the 1970s. When inflation is factored into food prices, the increase in food prices during the 2007–2008 crises was actually 50% lower than the food shortage of 1973. Piesse and Thirtle believe that yet a further factor was responsible for the rapid increase in food prices, which is that of low international commodity stocks heading into this period. They show that in periods of low stocks, commodity markets face increasing volatility. As is shown in Fig. 12.5, the stock-to-utilization ratio was at a lower point than it had been during the 1973 food shortage and, coupled with the Australian droughts of 2005 and 2006, created the right environment for commodity price volatility to expand, hence the rapid increase in food prices. Timmer (2010) observed that the Philippines' government policy to purchase import supplies at any price was one of the main triggers for the panic that ensued in the commodity markets, with prices rising rapidly.

One aspect of the discussion of the various factors and aspects affecting and relating to the food price crises that remains to be discussed is: what was the impact in terms of increased poverty and reduced food security in developing countries? Headey (2011) identified that the World Bank estimated that in the 2007–2008 period, over 130 million people worldwide were driven into poverty. In addition to that, a further 75 million people became malnourished, meaning that due to their

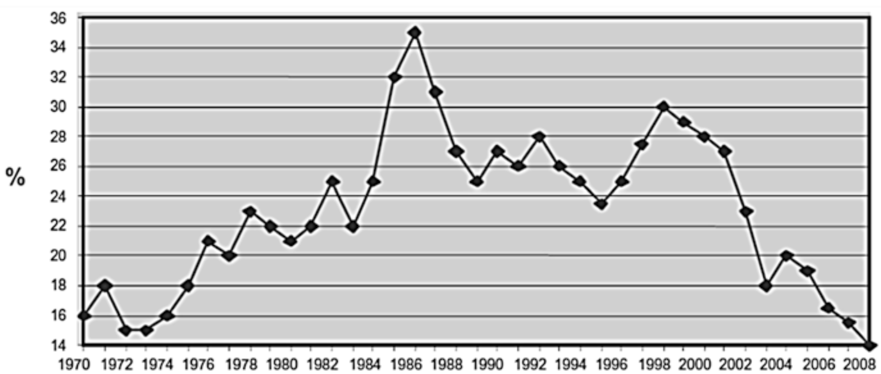

Fig. 12.5 Stock-to-utilization ratio, 1970–2008 (Source: Piesse and Thirtle 2009)

limited revenue, the higher food prices meant that these people could no longer purchase enough food on a daily basis to sustain their nutritional requirements. The costs of this in terms of pain and suffering can never be calculated.

Clearly a multitude of factors came into effect and all contributed to some degree to the increase in food prices. Some of these factors had a substantially higher effect than did others. As is demonstrated above, even those that can be called experts in the area cannot agree as to whether or not the same factors carried the same degree of impact. Some of the literature presented above argues that some factors did not have an impact on increasing food prices, while other experts suggest that the same factor had a considerable impact. This illustrates just how complicated an issue this is and how, depending on the data used to derive the results, the impacts of one factor may vary considerably.

12.5 Closing Comments

The focus of this chapter has been to determine whether the increased production of ethanol from corn in the USA triggered a dramatic rise in food prices in 2007–2008. The answer according to many nongovernmental organizations was obviously a positive one and that increased US ethanol production was the leading reason for increased food prices. Less passionate and more reasoned analysis, however, suggests that, yes, the increased production of corn-based ethanol did play a role in increasing food prices, but it was one of several factors that occurred simultaneously that ultimately was responsible for the increase in food prices.

On its own, increased ethanol production from corn may have resulted in a modest increase in food prices at this timeframe, possibly a few percentage points, but the increased use of corn to produce ethanol was not responsible for price increases in the magnitude that has been described above. The rise in food prices were due to the combined effects of the following market circumstances and events: rising oil prices; declining value of the American dollar; government policies that implemented aggressive biofuel blend mandates; increased demand for and production of biofuels; low commodity stocks; trade barriers, such as preventing the sale and export of staple commodities; and panic buying of staple commodities by some governments.

More often than not, any single event or crisis is never triggered due to the results of a single action or policy. As is evident from this discussion, the increase in food prices was due to a combination of at a minimum, eight different major factors. Initially, the entire process was the result of the American and EU implementation of blend mandates that exceeded existing domestic capacities, and as a result of the mandates, industry responded by increasing biofuel production, which, when taken in combination with other market factors, resulted in the food price crisis. Of course, no individual or theoretical model could have predicted the impacts that ultimately resulted from the implementation of government policies that required blend mandates.

As part of their recognition that the implemented blend mandates were overly aggressive given the existing technology and the inability of industry to overcome the transition to second-generation biofuels as quickly as government policy makers had hoped, both the EU and USA have extended the deadlines for blend mandates as well as reduced the level of blending that is mandated. Both of these policy revisions have assisted in reducing the pressure on the biofuels industry to meet the blend mandates, especially the mandates for the inclusion of second-generation biofuels, which has resulted in food prices experiencing reduced volatility.

What lessons have been learned from this experience? There would appear to be three key take-away messages that are crucial for the biofuels and bioproducts industries and their relationship with agriculture and food production. First, food price spikes are not one-time events; they occur periodically, and unfortunately, there will be another one. As was commented on above, there was a food price crisis in the early 1970s, when oil prices spiked. While economists and statisticians are getting better at modeling trends in the price of oil, there will always be events that are unpredictable and that will ultimately have tragic consequences. Therefore, future food price spikes are not preventable, any more than an earthquake is preventable, but what is possible is to plan and prepare for the next one, such that the effects of the price spike are not as drastic or as widespread as was experienced in 2007–2008. International development agencies like the FAO and the World Bank have held several planning sessions and events to share experiences and knowledge about what transpired as a means of ensuring that this knowledge is widely disseminated such that when the next price spike is triggered, governments the world over will have a better understanding of what policies should, and what policies should not, be implemented as a means of managing the crisis.

Second, domestic energy policy is an extremely complicated field, requiring reams of data and considerable thought and reflection prior to implementing a new policy or revising existing policies. As is evident, a socially desirable policy such as implementing a biofuel blend mandate as a means of reducing GHG emissions can have unintended effects. No policy analyst has a crystal ball in which to gaze and determine the future course of events and is therefore able to plan perfectly. Hence, those responsible for developing government energy policies have to be extremely diligent to ensure that they are utilizing the most complete datasets possible to assess the impacts of future policies and consult with leading experts in industry and academia to ensure that gaps in the development of the policy are recognized early in the policy development process and can be accordingly corrected or mitigated and the monitoring of the circumstances pertaining to existing policies not be ignored. To a large degree, it is this last pertinent part of the policy process that created the market circumstances for the food price increases as governments in the EU and USA were unable to respond quickly enough to the market results from the aggressive blend mandates that had been enacted.

Third, trade barriers against the exporting of commodities in times of low commodity stocks only exacerbate the problems. While many governments and political parties struggle to trust the free market, it is better able to respond to critical events than when governments attempt to intervene in the economy in their attempts to offset or minimize the crisis. The hoarding of commodities by some governments disrupted the international trading of those commodities, resulting in dramatic price distortions. While many remain unconvinced that markets are efficient at allocating resources in times of scarcity, it is evident from the government policies that banned the export of staple commodities that government intervention in the market during times of crisis does not produce results that improve the situation. Obviously, no one is capable of forcing governments not to intervene in the market during critical events; all that can be done is to ensure that information about the social cost of such intervention is widely available.

The food price crisis of 2007–2008 had tragic consequences in many developing nations, the cost of which in terms of human suffering will never be accurately, or adequately, measured. The best that can be hoped for is that government policy makers have gained new insight into the unintentional impacts of changing energy policies and that they will be more cognizant in the future about monitoring newly implemented policies to ensure that unintended consequences are not brewing in the background. As has been said many times, those who do not remember history are doomed to repeat it.

Where could policy-efforts be best directed to ensure that when food prices begin to rapidly increase the next time, that buffers have been developed and implemented that are designed to mitigate the worst of the impacts? One important policy area would be the further investment in lignocellulosic biofuel technology development. An increase in research and development funding would allow for the use of nonfood crops to offset the demand for corn as the main feedstock for biofuel production. Technology improvements, so that wood waste, post-harvest waste, and urban waste are capable of becoming efficient feedstocks, would alleviate some of the pressure by shifting land from the production of corn for biofuel to the production of other food crop alternatives. Research into increasing the yield ability of biomass crops (e.g., *Panicum virgatum*, *Mithcanthus* spp.) that would be better suited for production on marginal lands could contribute to shifting biofuel feedstock production away from food-producing land. Regardless of what policy option is pursued, one key policy is the investment in innovation. In the absence of innovation investment, the next food price crisis could be expected to be of equivalent scale and scope.

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