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THE EFFECTS OF BIOFUELS POLICIES ON GLOBAL COMMODITY TRADE FLOWS

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1.0 INTRODUCTION

Within the past decade, biofuel has become a buzz-word with the potential to mitigate a range of the world's problems, spanning the gamut from reducing environmentally damaging transportation emissions to boosting economic development, be it in jatropha-growing countries in south-east Asia or the Corn Belt in the United States. Biofuels have undoubtedly become a policy tool, surrounded by political rhetoric and clouded in a haze of conflicting social objectives and scientific discord about their purported benefits. Yet, despite the uncertainty surrounding the industry in terms of environmental effects, profitability and sustainability in the absence of government support, and undoubtedly, the long-term effects on crop production practices and food security, biofuel policies continue to encourage expansion across the globe, and increasingly, in developing countries where issues such as food security are prevalent and environmental standards are little to none.

Given the political involvement, what effects has the rapid biofuels expansion had on the prices of grains, both those that serve as inputs in the production process, as well as those that are affected indirectly through cropping decisions? In turn, what effects are triggered in the livestock industries? The sheer volume of grain being used for biofuels, particularly in the US, also begs the question of the trade impacts, given that several countries traditionally considered net exporters of grain are sourcing increasing amounts for domestic biofuel production. Accompanying massive quantities of grain being directed into biofuels are ambitious consumption mandates, suggesting the need for imports of biofuels or biofuel feedstocks. Trade in ethanol is increasing, and raises the need for the classification of various biofuels within frameworks such as the World Trade Organization (WTO). With that being said, how do biofuels policies and programs fit within the WTO's stated goals of liberalization?

2.0 BACKGROUND

Biofuels are "liquid, gaseous or solid hydro-carbon fuels derived from bio-mass" (IFATPC 2006). More simply, biofuels come from biological origins, which at this time, are primarily agricultural, and are used either to blend with or completely replace traditional petroleum-based transportation fuel. The two most prevalent biofuels in large-scale use are bioethanol, hereafter referred to as ethanol, and biodiesel.

2.1 *Ethanol*

Ethanol is produced from crops with a high starch content, and subsequently, high sugar content. The most common feedstocks used in ethanol production are corn and sugar cane, although wheat, sugar beets and cassava are also used. Currently, the US and Brazil are the largest producers of ethanol, with the US producing nearly 18.4 billion litres of primarily corn-based ethanol in 2006, and Brazil producing roughly 17 billion litres of ethanol from sugarcane (RFA 2008a).

In terms of physical procedures, large-scale ethanol production utilizes either the wet mill or dry mill process. The dry mill process, which is most common in the US, produces dried distillers grains (DDGs), solubles and carbon dioxide as by-products along with ethanol. Wet mills, although producing the same ethanol as an end-product, also produce corn gluten meal, corn gluten feed, corn oil and carbon dioxide. These DDGs from the dry mill process, as well as the corn gluten meal and feed are capable of partially substituting for coarse grains in livestock rations, while corn oil is used in several industrial products, including soap and textiles.

In terms of consumption, the most common blends of ethanol in North American transportation fuel are between five to ten percent, represented by E5 and E10 respectively. At these low-level blends, engine modifications are not required, although older vehicles may experience frequently clogged fuel filters, as the ethanol acts to loosen built-up deposits and residues in the fuel system (NRC 2004).

Gasoline/ethanol blends higher than ten percent require the vehicle to be built with “flex-fuel” technology, where the owner is capable of switching between high and low ethanol blends, depending on relative prices or preferences. High-level blends range from 60 to 85 percent ethanol, with the most common being E85 (85 percent ethanol and 15 percent gasoline). At the end of 2007 however, Canadian consumers could only purchase E85 at two stations across the country, despite nearly 20 locations being available for government fleet vehicles (Young 2007). In the US, over 1200 stations are currently available, most switching to E85 in response to government tax incentives. In Brazil, many consumers own vehicles that are capable of running on pure ethanol - E100.

2.2 Biodiesel

Biodiesel is produced from oil-based crops such as canola¹, soybeans, palm, mustard or corn oil, as well as from animal fats or previously used cooking oils and greases. The primary by-product from the process is glycerol, a combination of glycerine and some remaining impurities and production catalysts. Biodiesel is most established in the EU and is derived primarily from canola oil, with roughly 5.5 billion litres produced by member states in 2006 (Biofuels Platform 2007). Biodiesel is not as prevalent in Canada or the United States, where production is based on canola and soybeans, respectively.

Biodiesel consumers can use pure biodiesel (B100), as well as lower-level blends with petroleum diesel in existing engines under certain conditions. In the US, collaboration between vehicle and vehicular component companies, diesel and biodiesel producers, federal and state-level authorities has produced a standard for pure biodiesel when used in B20 blends. At biodiesel blends higher than 20 percent, issues regarding the degradation of engine components such as fuel hoses and seals become more prevalent. The relatively short six-month shelf life and cold weather coagulation issues also become concerns. The National Biodiesel Board in the US states that “it may be possible to run

¹ The terms *canola* and *rapeseed* will be used interchangeably, despite differences in erucic acid levels, and therefore, oil profiles and potential end-uses.

blends higher than B20 in existing diesel engines and have a successful experience”, but recommends caution (NBB 2007a).

2.3 Other Biofuels

Both ethanol and biodiesel are currently what analysts call first generation biofuels, in that they are produced from agricultural feedstocks that are either high starch or high oil content (IFATPC 2006). Some believe that the future of biofuels production lies in what are called second generation biofuels, produced from cellulose, hemi-cellulose or lignin. Woody input material will be sourced from grasses, brushes, or small trees. The US Department of Energy estimates that significant gains will be made in the area of second generation biofuels within the next decade, causing analysts to list their exclusion as a major caveat in most quantitative analyses of the agricultural market impacts of biofuels (von Lampe 2006; Elobeid and Tokgoz 2006).

While the impacts of second generation biofuels are uncertain, this paper will concentrate on the effects of first generation biofuels, acknowledging that projections could be inaccurate given the incorporation of alternative types of biomass into large-scale production.

3.0 MAJOR PRODUCERS

Countries around the world are incorporating different mixes of domestic policies and trade barriers to stimulate in-country biofuels production. Domestic production is encouraged by governments, often to treat a series of policy issues. This is counter-intuitive to the Tinbergen rule in policy analysis – that one policy instrument is needed for each policy objective. Whether looking to deal with energy security, appease the agricultural lobby, or combat environmental problems, governments are using their biofuels policies to tackle a series of policy objectives.

3.1 United States

In the early 1990s, biofuels increasingly became associated with environmental policy objectives. The Clean Air Act was amended in 1990, authorizing the Environmental Protection Agency (EPA) to set federal limits on the amount of toxic pollutants in the air and encouraging the sale and development of alternative fuels (EPA 2007). The incorporation of biofuels into environmental policy continued through the end of 1990s, when several states began banning MTBE.

The Bush administration brought forward the Renewable Fuels Standard (RFS) as part of the Energy Policy Act of 2005. RFS involves the elimination of liability protection for MTBE, but more significantly, mandates minimum amounts of renewable fuels consumption, most of which is likely to be from corn-based ethanol. Specifically, RFS stipulates that 2006 renewable fuels consumption must meet or exceed 15.2 billion litres in 2006 and 28.4 billion litres in 2012 (Elobeid and Tokgoz 2006). These required production numbers are expected to continually increase, extending to 136 billion litres

of renewable fuels by 2022. Such large mandates continue to guarantee minimum supply requirements, although by 2022, there is optimism that technological developments would increase the market share of other renewable fuels such as cellulosic biofuels and biogases. In fact, in mandating 2012 RFS, President Bush mandates that roughly 60 percent must be from second generation cellulosic biofuels (RFA 2008b).

3.1.1 Ethanol

Biofuels production in the US consists primarily of corn-based ethanol, and has been increasing at an astounding rate. From January 2006 to January 2008, production capacity has nearly doubled from 17.4 billion litres per year, to roughly 27.3 billion litres per year (RFA 2008a). Expansion and construction projects are expected to increase this capacity to roughly 50 billion litres in the short to medium-term. Over the past decade alone, production has increased roughly 430 percent.

The beginning of government-supported ethanol production began in the early 1980s as a way to boost support for agricultural producers (Agra CEAS Consulting 2006), as well as decrease reliance on imported fossil fuels. Currently, the ethanol market has several types of government involvement, involving both legislative and tax components to encourage production.

In terms of production incentives, ethanol-blended fuel is exempt from the federal motor fuel excise tax, which currently provides a benefit of 51 cents per gallon (13.5 cents per litre) until 2010 (Agra CEAS Consulting 2006). Blends lower than 10 percent receive a pro-rated exemption relative to their blend ratio.

Accompanying domestic production incentives are significant trade barriers, involving a 54 cents per gallon (14.2 cents per litre) specific import tariff, as well as a 2.5 percent ad valorem tariff². The US has imported minor amounts of ethanol (nearly 2500 million litres in 2006, two thirds of which were from Brazil (RFA 2008a)) to meet domestic demand, but for the most part, import barriers have served to keep relatively cheaper Brazilian exports from gaining benefits targeted at domestic producers. However, through the Caribbean Basin Initiative (CBI), the greater of 227 million litres or 7 percent of the US domestic ethanol production is allowed into the country, duty-free, provided that at least 50 percent of the agricultural feedstock is grown in an approved Caribbean country.

State-level incentives include direct payments to ethanol producers, low-interest loans to assist in capital construction and expansion, income tax credits based on specific production levels, tax exemptions from petroleum fuel excise taxes, market mandates, and government vehicle fleet requirements, among others.

² There have been indications that the Bush administration, and the U.S. government in general, have been aiming to suspend ethanol import tariffs in order to decrease the price of renewable fuels. Both the National Corn Growers' Association and the American Corn Growers' Association, as well as the Renewable Fuels Association have opposed the removal of these tariffs, citing negative impacts on the domestic ethanol industry and reduced corn prices as incentives to keep the tariffs in place (Delta Farm Press 2006).

3.1.2 Biodiesel

The National Biodiesel Board estimates 2006 production at roughly 950 million litres per year, significantly smaller than ethanol numbers (NBB 2007b). In terms of agricultural feedstocks, production is mainly soybean-based.

The American biodiesel industry also receives significant government incentives. The current federal excise tax credit differs depending on both the type and amount of renewable material. For “agri-biodiesel”, this tax credit amounts to one cent for every percentage point of agricultural feedstock (primarily soybeans) used per gallon, and roughly half that amount for biodiesel made from other sources such as waste oil. The Small Agri-Biodiesel Producer Tax Credit is available to biodiesel producers with capacity of less than 60 million gallons and this is equal to ten cents per gallon of “qualified” agri-biodiesel, up to 15 million gallons per year (NBB 2007c).

3.2 European Union

The EU has set two biofuel directives, Directive 2003/30/EC (which sets consumption targets) and Directive 2003/96/EC (which gives the Member states jurisdiction to either partially or fully exempt fuels containing renewable substances from petroleum fuel taxes). The first Directive includes consumption targets for renewable fuels in share terms related to overall fuel consumption. Progress thus far has been slow compared to the frenzied growth in the US. Member states strived to reach a two percent share in 2005; however, it has been recognized that only 1.4 percent of transportation fuel has been successfully replaced with renewable alternatives (CEC 2007). An interim progress report released by the Commission in 2006 showed that of the 13 member countries indicating that they would meet this target in 2005, only Germany and Sweden were successful, with several member states not reporting production numbers. By 2010, the target share was aimed at 5.75 percent.

The success of Germany and Sweden in meeting their goals has been linked to common factors including their promotion of high-level biofuel blends, as well as low-level blends that are compatible with the current fuel distribution system. Both encourage domestic production with the use of tax incentives, but also use imported biofuels to help with supply. Although many member nations have since passed biofuel tax exemptions, the European Commission has stated that it is unlikely that the 2010 goals will be met (CEC 2007).

3.2.1 Ethanol

Data available from 2006 show ethanol production in the EU25 is estimated at 1,592 million litres, with Germany, Spain and France being the top three producers, respectively (eBio 2007). Sugar beets, as well as grain such as wheat, are used as feedstocks. Reports from 2006 show that French and Italian wine producers, with the support of the EU Wine Management Committee, were given subsidies to turn up to 4

million hectoliters of table wine and 1.6 million hl of quality wine into ethanol (Agra Europe 2006).

Ethanol production is less significant in the bloc than biodiesel, and member countries determine tax incentives and consumption mandates on an individual basis. For example, legislation out of Germany, the Biofuel Quota Act of 2007, replaces the previous biofuels tax exemption to firms with regulations for a minimum percentage blend for biofuels, which increases through 2010 (EC 2008a).

3.2.2 Biodiesel

Biodiesel is currently the most significant biofuel in the EU, with the top three producers, Germany, Italy and France maintaining roughly 63 percent of total EU biodiesel production capacity (EBB 2007). Canola oil is the predominant feedstock in Northern Europe, while sunflower oil and waste oil are more common in Southern Europe (Agra CAES 2006).

As an example of policy measures in the EU, diesel and petroleum producers in Italy are required by law to include predetermined quantities of biofuel, based on sales from the previous year. As of 2006, one percent of total sales must include biofuel (EC 2008b). Germany has passed the Energy Tax Act of 2006, which placed a partial tax of nine cents per litre for pure biodiesel and 15 cents per litre for biodiesel added to petroleum diesel (EC 2008a).

3.3 Canada

Towards the end of 2006, the Government of Canada released a biofuels strategy report, which mandated a minimum of five percent inclusion of renewable content in the national gasoline supply by 2010, as well as two percent in diesel fuel and heating oil by 2012 (Forge 2007).

The federal government's Renewable Fuels Strategy aims at increasing biofuels consumption and production in Canada. By helping the technology commercialization process, the government also helps to increase the availability of biofuels. The strategy also aims to help farmers capitalize on new opportunities accompanied by increased production (Government of Canada 2008a).

Through the federal government, the ecoACTION framework provides several funding opportunities for biofuels producers. The ecoENERGY for Biofuels Initiative, through Natural Resources Canada, will invest \$1.5 billion over nine years. The ecoAGRICULTURE Biofuels Capital Initiative, through Agriculture and Agri-food Canada (AAFC), provides \$200 million in repayable loans for the construction or expansion of biofuels production facilities. The use of an agricultural feedstock and the investment of agricultural producers are requirements of the program. The Biofuels Opportunities for Producers Initiative is designed to help farmers and rural communities hire the expertise needed to conduct feasibility studies or create business plans for biofuel

production facilities with greater than one-third farmer ownership (Government of Canada 2008b).

The federal government is also investing in second generation biofuels through the NextGen Biofuels Fund, which is designed to foster the development of “first-of-kind large demonstration-scale facilities” using feedstocks that are representative of Canada’s available biomass and have been tested in pre-commercial facilities (SDTC 2007). It was recently announced that \$500 million will be allocated to the Iogen Corp. for the construction of a cellulosic ethanol plant north of Saskatoon (SDTC 2008).

3.3.1 Ethanol

Relative to its southern neighbors, Canada produces small amounts of ethanol; yet, absolute numbers are significant. Production in 2007 was estimated at 580 million litres (RFA 2008a), with 2008 production expected to meet or exceed one billion litres following the completion of several ethanol plants (CRFA 2008a). To meet Canada’s target of five percent however, roughly two billion litres are required (CRFA 2008b). Canadian ethanol production has an east-west flavour, with ethanol production west of and including Manitoba being primarily wheat-based, while production in and east of Ontario being primarily corn-based.

Canada is similar to the US in that there are both federal and provincial incentives to encourage production. Federally, fuels blended with renewable material are subject to an exemption on the \$0.10 per litre excise tax applicable to petroleum fuels. The federal government, through Natural Resources Canada (NRC), has also funded two rounds of the Ethanol Expansion Program (EEP), designed to provide long-term capital loans to biofuel producers. Roughly \$118 million was allocated through EEP to construct new facilities or expand existing facilities at 11 locations across the country (Agra CEAS 2006).

In terms of provincial incentives, four provinces have well-defined objectives with respect to in-province biofuels consumption and production: Alberta, Saskatchewan, Manitoba and Ontario. Manitoba, for example, has a mandate that requires gasoline suppliers to replace at least 8.5 percent of petroleum gasoline sales with ethanol by the end of 2008. The tax incentives for producers amount to a declining production grant, beginning with 20 cents per litre of ethanol sold to fuel suppliers for 2008 and 2009, and dropping to 10 cents per litre from 2013 to 2015 (STEM 2008).

3.3.2 Biodiesel

Large-scale Canadian biodiesel is primarily canola-based, given its domestic supply; however, animal fats are also used. Current large-scale production is estimated at roughly 100 million litres per year; however construction and expansion is expected to bring production capacity to roughly 325 million litres per year in the foreseeable future (CRFA 2008a). Under the country’s Climate Change Action Plan, biodiesel production is

expected to reach 500 million litres per year by 2010 and currently exempt from the federal excise tax of four cents per litre.

Canadian biodiesel production capacity is maintained through three plants, with a fourth currently under construction. Provincial feasibility studies in several provinces suggest a relatively local focus with respect to the operation and sourcing of future biodiesel plants. Pilot projects across the country are being conducted to test the viability of biodiesel. Montreal and Saskatoon are testing low-level blends in city buses to determine the feasibility of incorporating biofuels into mass transit. Manitoba Hydro is also working with biodiesel in its refueling stations, using B5 blends in the winter and B20 blends in the summer months (Manitoba Hydro 2007).

4.0 RESEARCH METHODS

4.1 *Introduction*

Given the political involvement in the biofuels industry and the rapid rise of biofuels production and consumption, it seems a logical and necessary task to examine the effects of these policies on agricultural markets, particularly with respect to the prices of the commodities that serve as inputs in the biofuels production process. The effects on these input commodities, mainly corn, vegetable oil and wheat could have significant effects on their corresponding trade flows. The following section provides an overview of the model used in this analysis and describes the methodology behind the study.

4.2 *Partial Equilibrium Models and AGLINK*

Partial equilibrium models are economic tools that are used to examine changes in one or more parts of the economy, without looking at the repercussions in others. Supply and demand for the various goods in these markets determine the respective equilibrium prices and quantities, independent of the excluded markets. Partial equilibrium models can be used to examine markets on a national level, or on an international basis, given the incorporation of trade equations to link the flow of goods across countries and to account for the trade effects on the goods in the model at equilibrium.

Given the increasingly multi-national nature of biofuels, and the wide variety of commodities both employed and affected by biofuels policies, any model used in this analysis would need to incorporate many commodities and many countries, and be able to incorporate changes over time. Based on similar work by von Lampe from the OECD³, as well as the availability of AGLINK, it was decided that this model not only provided the mechanism for determining world commodity prices, but also cross-commodity and trade effects for different agricultural commodities.

AGLINK is a multi-country, dynamic partial equilibrium model employed by the OECD and its member countries to aid in evaluating agricultural policy decisions. Supply and

³ See Appendix A for overview of work by von Lampe (2006), as well as work by Stillman et al. (2007) and AAFC (2002).

demand for various agricultural commodities are linked together in order to provide policy-makers with a mechanism to analyze the medium-term effects of members' agricultural policy decisions. Markets are assumed to be competitive, and imports into a country are treated in the same manner as domestic production. Products are homogenous across countries. The functional forms are mostly linear in logarithms (OECD 2007). An endogenous biofuels component is not contained in the model; however crude oil is contained as an exogenous variable. For a more detailed description of AGLINK, see OECD 2007.

For this analysis, ethanol production is simulated in Canada and the US, while biodiesel production is modeled for Canada, the US and the EU. The commodities affected by the increase in ethanol production are corn (which is aggregated into coarse grain use) due to the increase in American and Canadian production, and wheat, due to ethanol production in Western Canada. Soybeans will be affected based on American biodiesel production, and canola will be adjusted to account for European and Canadian production.

4.3 Data Sources

Data for the projections come from various sources. For US corn ethanol production, the ERS Feed Grains Database Yearbook tables for various years show the amount of corn going towards fuel alcohol production. From there, an estimated growth rate brings the annual corn requirements to roughly the amount mandated under the RFS. American biodiesel projections were based on a report prepared by John Urbanchuk for the National Biodiesel Board. Canadian ethanol projections were based on production capacity estimates from Agriculture and Agri-Food Canada. Canadian biodiesel projections were based on current and projected production capacity numbers from the Canadian Renewable Fuels Association and the goals set by the Federal government in their renewable fuels strategy. Biodiesel projections for the EU are based on estimates from the European Biodiesel Board and the Foreign Agricultural Service of the USDA.

4.4 Adjustments to AGLINK

To determine the price and trade effects of biofuels over the period 2005 to 2015, projections of national production for each biofuel are used. For each of the relevant commodities for the specific countries described above, the biofuels-induced demand is modeled as an exogenous shift to the corresponding behavioral equation in AGLINK.⁴ Described in more detail below, the quantity and subsequent feed-value of the corresponding by-products are calculated externally from AGLINK and accounted for in the analysis. The following subsections provide an example of how the exogenous ethanol and biodiesel shocks were performed.

4.4.1 Ethanol

⁴ The complete AGLINK model involves over 10,000 endogenous equations and several dozen countries. It should be noted that the equations adjusted for this analysis are only those specifically related to biofuel production in the stated countries.

In AGLINK, coarse grain use is separated into feed, food and other use. The use of feedstock in biofuel production is captured in the “other/alternative use” variable within a commodity grouping. The equation below represents this relationship for coarse grains within the US:

[1] *Coarse Grains Identity*

$$QC_i^{CG} = CG_i^{FE} + CG_i^{FO} + CG_i^{OU}$$

- QC_i^{CG} : total quantity of coarse grains consumed
- CG_i^{FE} : quantity of coarse grains used for livestock feed
- CG_i^{FO} : quantity of coarse grains used for human consumption
- CG_i^{OU} : quantity of coarse grains used for other purposes
- i : regions US and Canada

Coarse grains for feed and food have their own endogenous equations. The feed equation is based on own prices and oilseed meal prices, as well as both ruminant and non-ruminant production. The food equation is based on population, national economic activity, and the price of coarse grains. The third variable, CG_{OU}^{US} , is exogenous, and is used to capture the extra demand for coarse grains due to biofuels. Based on the projections for ethanol production in the US, the annual corn requirements are calculated. Conversion factors common to the literature and industry show that for every bushel of corn, there are 2.8 gallons (roughly 10.5 litres) of ethanol produced, along with 0.0087 tons (roughly 8 kgs) of DDGs (Elobeid and Tokgoz 2006; Davis 2001).

With the increase of the biofuel-induced corn demand, the total quantity of coarse grains consumed by the US is linked back to world markets and is aggregated with consumption from other countries. A world price for each commodity is determined with a market-clearing condition that takes into account the imports, exports and stocks of each country by reaching an equilibrium of aggregated supply and aggregated demand.

However, this shift in the demand for corn due to biofuels must also be adjusted to reflect the ability of the by-products to be absorbed by the livestock industry in the form of feed rations. Work from Westcott (2007) accounts for the DDGs from corn ethanol production to be fed back into the feed system as partial substitutes for the corn itself, as well as the soy component of rations. Based on different concentrations for each type of livestock, the following formula is applied:

[2] *Substitutability of Distillers' Grains for Corn (by species)*
 $CORN : 0.75 * [(0.8_{BF} * 1) + (0.1_{DY} * 0.45) + (0.05_{PK} * 0.85) + (0.05_{PLT} * 0.55)]$

[3] *Substitutability of Distillers' Grains for Soymeal (by species)*
 $SOYMEAL : 0.75 * [(0.1_{DY} * 0.55) + (0.05_{PK} * 0.15) + (0.05_{PLT} * 0.45)]$

BF : beef
DY : dairy
PK : pork
PLT : poultry

Westcott assumes that 75 percent of DDGs produced would be fed back into the domestic livestock sector rather than be used for export or other industrial purposes. From there, it is assumed that for beef, dairy, pork and poultry, there are differing splits between the energy and protein components in the rations, and therefore, between the amount of corn or soy that can be replaced with DDGs. Beef cattle, for example, are assumed to consume 80 percent of the DDGs allocated to total livestock rations, of which, 100 percent will replace corn. For dairy cattle, it is expected that 10 percent of DDGs allocated to livestock will be consumed, 45 percent of which will replace corn and 55 of which will replace soy. Pork and poultry are minor consumers of DDGs, both expected to consume 5 percent of total livestock DDGs. In pork rations, corn and soy substitution are expected to occur at 85 percent and 15 percent respectively, while poultry is assumed to absorb 55 percent in lieu of corn and 45 percent for soy.

The above methodology was used in this analysis for the DDGs from US ethanol production under the simplistic notion that all American ethanol is produced from corn; the treatment of DDGs is one of the major assumptions carried forward in the analysis. The DDGs from Canadian ethanol production were dealt with slightly differently, according to a paper from NRC (2003).

It was assumed that the relative distribution between corn and wheat-based ethanol in Canada would remain the same over the projection period, meaning that 70 percent of Canadian ethanol would come from corn, with the remaining 30 percent derived from wheat. Therefore, the DDGs from Canadian ethanol production were calculated as the sum of 70 percent corn-based ethanol and 30 percent wheat-based ethanol. It was assumed that for wheat-based ethanol, one bushel of the feedstock yielded 2.6 gallons (10 litres) of ethanol and 9.5 kg of DDGs (Bonardeaux 2007; NRC 2003).

According to the NRC (2003), DDGs from wheat-based ethanol production can be used in the same markets as DDGs from corn at a displacement ratio of 1:1 for corn and 1:1.04 for soymeal. This relationship is modeled based on the lower energy content and higher protein levels of wheat DDGs over corn DDGs. Similar to Westcott's assumption for the US, 75 percent of DDGs from Canadian ethanol production were fed back into the livestock sector, at the same beef-dairy-pork-poultry ratios as the American sector.

Rather than simply reduce the exogenous shock by the corresponding amount of DDGs being fed back into the feed system, it was deemed necessary to account for these by-products as direct inputs into the livestock sector through an exogenous shock to the feed component of (1), shown below:

[4] *Coarse Grains Feed Equation Adjusted for Distillers' Grains*

$$\ln(CG_{FE}^{US}) = \alpha + \beta_1 * \ln\left(\frac{PRICE_{CG}^{US}}{PRICE_{WT}^{US}}\right) + \beta_2 * \ln\left(\frac{PRICE_{OM}^{US}}{PRICE_{WT}^{US}}\right) + \beta_3 * \ln(QP_{NR}^{US}) + (1 - \beta_3) * \ln(QP_{RU}^{US}) + \beta_4 * \ln(TRND) + \ln(R.CG_{FE}^{US})$$

- CG_{FE}^{US} : total coarse grains used for feed in the US
- $PRICE_{CG}^{US}$: producer price of coarse grains in the US
- $PRICE_{WT}^{US}$: producer price of wheat in the US
- $PRICE_{OM}^{US}$: producer price of oilseed meal in the US
- QP_{NR}^{US} : total monogastric livestock production in the US
- QP_{RU}^{US} : total ruminant livestock production in the US
- $TRND$: trend incorporated into AGLINK
- $R.CG_{FE}^{US}$: intercept-shifter for American feed grain equation

By calculating the amount of by-products from annual ethanol production and applying the methodology of Westcott, the intercept-shifter in (4) is exogenously shocked to compensate for the increase in biofuel-induced coarse grain demand with the feed value of the by-products.

4.4.2 Biodiesel

For biodiesel, using Canadian biodiesel production as an example, the demand for oilseeds (the sum of canola, sunflower and soybean) is split into an endogenous crush demand and an exogenous feed demand. Because the biofuel-induced demand for oilseeds would increase due to its oil content, the demand for the oilseed crush was shocked over the simulation period. This demand is represented in the following equation:

[5] *Canadian Oilseed Crush to be Adjusted for Biodiesel Demand*

$$\ln(OS_{CR}^{CAN}) = \alpha + \beta_1 * \ln\left(\frac{PRICE_{OM}^{CAN} * YLD_{OM}^{CAN} + PRICE_{OL}^{CAN} * YLD_{OL}^{CAN}}{GDP_{CAN}}\right) -$$

$$0.9 * \beta_2 * \ln\left(\frac{PRICE_{OS}^{CAN}}{GDP_{CAN}}\right) + \beta_3 * \ln(OS_{CR(-1)}^{CAN}) + \ln(R.OS_{CR}^{CAN})$$

- OS_{CR}^{CAN} : quantity of oilseeds crushed in Canada
 $PRICE_{OM}^{CAN}$: producer price of oilseed meal in Canada
 YLD_{OM}^{CAN} : oilseed meal extraction rate from oilseed crush in Canada
 $PRICE_{OL}^{CAN}$: producer price of oil in Canada
 YLD_{OL}^{CAN} : oil extraction rate from oilseed crush in Canada
 GDP_{CAN} : gross domestic product of Canada
 $PRICE_{OS}^{CAN}$: implicit price deflator for GDP with base year 2000
 $OS_{CR(-1)}^{CAN}$: quantity of oilseeds crushed in Canada in the previous year
 $R.OS_{CR}^{CAN}$: intercept shifter for Canadian oilseed crush equation

While Canadian oilseed crush demand is a function of the prices and extraction rates of both the oil and the oilseed meal, the price of seed and the historical crush, the last variable in the equation allows the demand to be bumped equivalent to the new biofuel-induced crush.⁵ Both the crush and the aggregated vegetable oil, as well as the oilseeds and the oilseed meal are connected back to their respective world markets and allowed to clear based on global supply and demand. From there, world prices are transmitted back to the individual Canadian commodity markets, where export prices are determined.

To determine the amount of extra oil production needed, it was assumed that Canadian crush capacity would expand to meet the domestic demand created by the replacement of two percent of transportation diesel with biodiesel. Based on reports from the FAS (2003), it was assumed that one ton of biodiesel required an input of 2.672 tons of canola; similarly, the Canola Council of Canada (2008) reports that one metric ton of canola produces about 390 litres of biodiesel from 350 kg of canola oil. Doing the conversions, this translates to 7.4 lbs of canola oil for every gallon of biodiesel.

This conversion differs between soybeans and canola. For US biodiesel, it was assumed that 7.5 lbs of soybean oil was required for one gallon of biodiesel (Urbanchuk 2006). Based on these assumptions, it is calculated that one bushel of soybeans yields 1.49 gallons of biodiesel. Because the crush is endogenous, the extra by-products such as oilseed meal, are automatically adjusted according to the extraction rates in the model;

⁵ It is assumed that domestic oilseed crush capacity will expand to meet anticipated biodiesel needs over the projection period, due to the magnitude of government support for the development of domestic biofuels. This not only allows the crushing industry to expand due to the extra demand for vegetable oil, it also accounts for the extra oilseed meal that will be produced along with the vegetable oil.

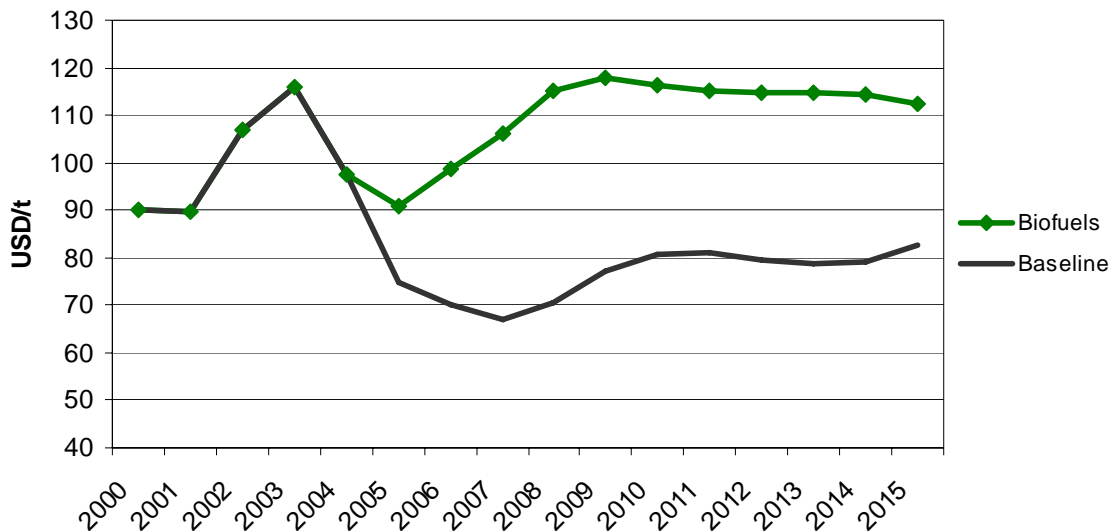
therefore, a second exogenous shock as applied to (4) in the case of U.S. ethanol production is not required in order to capture the increase in by-products entering the market from the increased Canadian crush demand.

5.0 RESULTS

5.1 Price Impacts

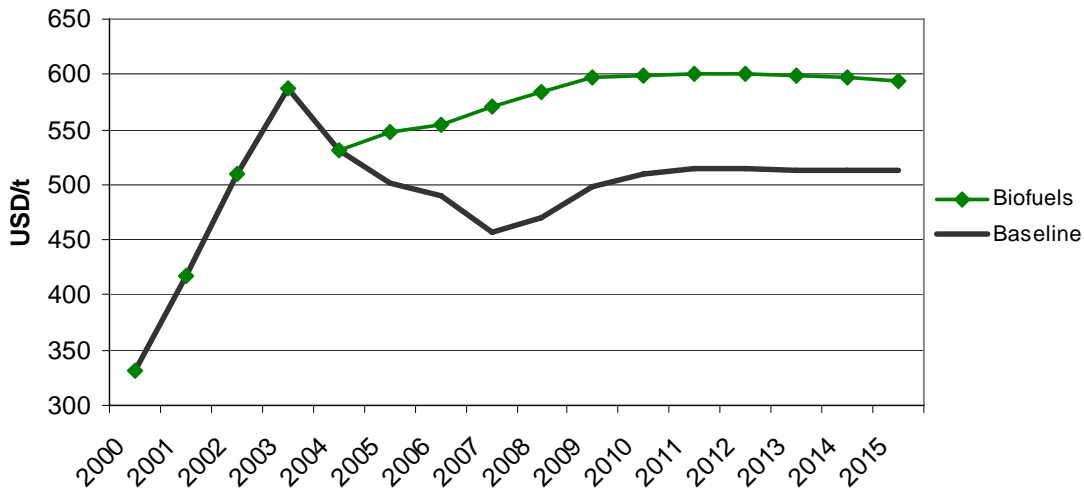
Figure 5.1 shows the price path that occurs in the world corn market after biofuels are introduced. The largest difference between the baseline projections and the projected increase due to biofuels is seen in 2008, with a 64 percent difference. Not to be considered a long-run equilibrium, the increase at the projection period was roughly 36 percent. The average price increase over the period was 45 percent.

Figure 5.1: Impacts on the World Price of Corn



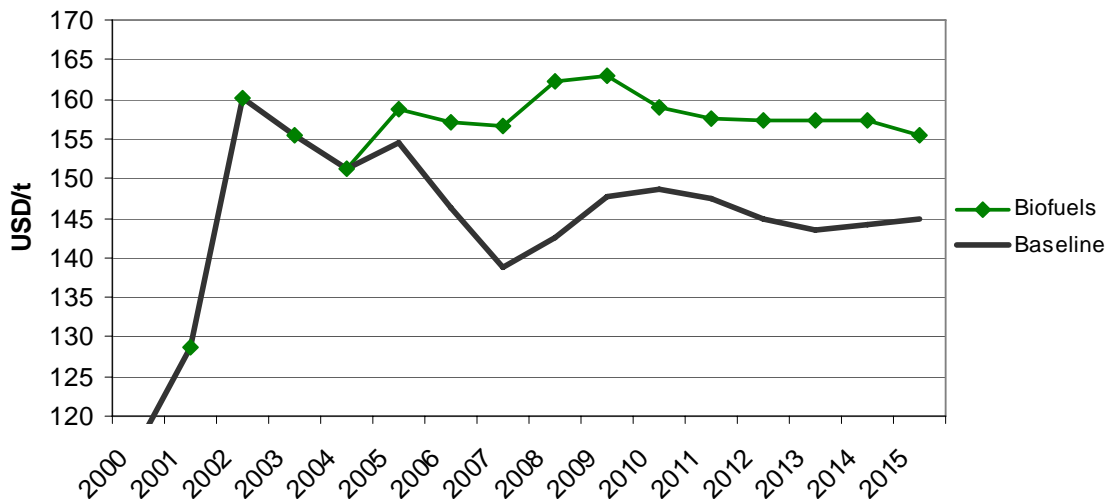
The vegetable oil market sees similar increases, with the largest relative change coming in 2007 and 2008 with a 24 percent increase. The price path in Figure 5.2 shows an increase in relative prices through to 2008, followed by a slight convergence of the baseline and projections at the end of the period. The average increase over the baseline period was 17 percent.

Figure 5.2: Impacts on the World Price of Vegetable Oil



The impact on the world wheat market is less significant than in the vegetable oil and the coarse grains markets. The highest relative increase is in 2008, at roughly 14 percent. The price path in Figure 5.3 again shows a relatively sharper increase in the first four years of the projection period, followed by a leveling of price as the market adjusts. The average price increase over the entire projection period was roughly 9 percent.

Figure 5.3: Impacts on the World Price of Wheat



5.2 Implications of Price Impacts

With increased ethanol production and therefore increased demand, come higher grain and oilseed prices. While higher grain prices provide grain and oilseeds producers with higher gross revenues, the implications for the ethanol plants are not so positive. Rising corn prices mean a declining profit margin for ethanol plants. According to economic theory, as margins become tighter, plants should be squeezed out of the market, and

reports out of the US confirm that some plants are closing their doors, and other planned construction is being put on hold (Neeley 2008).

Ethanol plants are not the only market players feeling the pressure from higher grain prices. Livestock producers also see margins shrink, with feed grain comprising a significant amount of their operating budget. Results from this analysis show that in general, Canadian livestock producers face an average 28 percent increase in feed expenditures for coarse grains, wheat and oilseed meal, reaching a high of 39 percent in the early stages of the projection period. Based on the assumptions related to the incorporation of the distillers grain by-products into the feed market, beef producers should be affected the least by these increases, unless these by-products are unavailable locally, or their cost with transportation factored in is greater than the feedstock itself.

However, despite higher feed costs, the quantity of beef produced in Canada increases by nearly ten percent over the baseline at the beginning of the projection period; following the peak, production continues to increase slightly, but by a declining rate, until the last years of the projection period, where beef production falls to roughly equal baseline numbers. The delays seen in the decreasing amount of beef production relate to the lagged effects of the declining herd size. Over the projection period, beef cow inventories fall at a relatively constant rate, reaching an eighteen percent difference from the baseline in the final year of the analysis.

The market price for beef steers in Canada reaches a peak of almost nine percent over the baseline midway through the projection period. It begins to decline, roughly around the same time as the quantity of beef production declines. However, despite declining supplies of beef, Canadian beef consumption remains more or less unchanged over the projection period.

With respect to pork, Canadian production decreases throughout the projection period, with the largest decline being calculated at roughly five percent below the baseline in the final year of the analysis. Pork slaughter production also decreases at a slightly lower rate than production, ending with a four percent decline over the period. These declines lead to an average increase in domestic pork prices of roughly 12 percent over the baseline. These price increases are accompanied by a fairly constant rate of domestic consumption.

The greater decline in the value of pork over beef is interesting in two aspects. The first relates to the changes in Canadian consumption when both beef and pork prices increase. The results from this analysis suggest that domestic beef consumption is relatively more price inelastic than pork production, and as such, less susceptible to price changes. The second relates to the relative ability of beef producers to absorb biofuels by-products over pork producers. Given the average 28 percent increase in the feed cost expenditure for a generalized livestock producer, the ability to absorb biofuels by-products would help to mitigate these costs, assuming that as biofuel production increased, the quantity of by-products would also increase and lead to a decline in their value. Based on values from the literature, it was assumed that 80 percent of distillers grains would be incorporated into the beef industry, compared to only 5 percent by the pork industry.

5.3 Trade Impacts

The increased use of grains and oilseeds in biofuels production, as well as the declines in livestock production suggest that there will be changes in the trade balance of the agricultural commodities being studied. Net trade impacts will be measured by the difference between exports and imports of a specific commodity.⁶

5.3.1 United States

Coarse grain exports in the US decline by nearly 62 percent on average, due to the sheer amount of corn going into domestic ethanol production. Beef and veal exports, as well as live animals also decrease by about 12 percent. Net trade in oilseeds also falls by about five percent, with a significant decrease of 17 percent in vegetable oil exports. This is a consequence of producer crop rotation decisions, as increasing amounts of land are switched into corn and away from soybeans. To a certain extent, the use of soybeans in biodiesel could also be a factor in declining vegetable oil exports. Wheat exports also drop by about 14 percent, likely for some of the same land constraints mentioned.

5.3.2 European Union

Coarse grain exports in the EU25 fall by roughly eight percent. This is accompanied by a decline in beef exports by about 16 percent. Declines in livestock are likely associated with the higher prices for corn and wheat on a global scale. Net trade in oilseeds remains fairly constant relative the baseline; however, a decrease of over 70 percent is seen in the net trade of vegetable oil. Given the amount of biodiesel production, these declines are not surprising.

5.3.3 Canada

In Canada, oilseed net trade decreases by seven percent, while wheat net trade falls by 14 percent. Declines in wheat exports are partially affected by the growth of wheat-based ethanol production in Western Canada, but also by producer cropping decisions. Results from the model show a consistent three to four percent decline in the area of wheat harvested in each year of the projection period. This coincides with large increases in the amount of barley being grown; increases of 13 percent were seen at the peak of the projection period, with an average increase of five percent over the baseline.⁷ Over the same period, the increase in the area of corn harvested peaks at roughly 6.8 percent. This is related to the high returns per hectare of corn that peak roughly 53 percent over the baseline and end the projection period around 30 percent higher.

The later-period decline in harvested corn area is still roughly five percent higher than the baseline until the end of the projection period; this decline is aligned with the slight

⁶ As a reminder, coarse grains include corn, barley, rye, oats and sorghum, while oilseeds include soybeans, sunflowers and canola. Vegetable oil refers to the oil from the oilseed crush, plus palm oil.

⁷ This suggests that barley is being at least partially substituted for feed corn in Western Canada.

decreases in global corn prices over peak numbers. These numbers show that land capable of growing corn is switched into production, both to capitalize on higher domestic biofuel-induced demand in the East, as well as a higher export price and increased demand in the US.

With respect to livestock, the beef sector sees exports of meat fall by an average of eight percent. Declines in beef exports were very small in the early years of the analysis, as beef production numbers were strong until relatively later in the projection period. Declines continued to increase in magnitude, as production begins to respond to adjustments to inventories of breeding animals. It all relates back to the increases in commodity prices and the consequent effects of the sharp increases in the feed expenditures discussed earlier.

To emphasize, these results are based on a significant amount of DDGs from corn and wheat-based ethanol being fed back into the animal feed system. With that said, it is likely that both the price and trade results are conservative. One of the limitations of this study is the exclusion of Brazilian ethanol production; however, with sugar omitted from AGLINK, this task would be difficult. Similar work by von Lampe (2006) incorporates the World Sugar Model into AGLINK. Future work will be done to perform a sensitivity analysis based around varying the amount of DDGs absorbed by the feed market. These results make sense intuitively, as large amounts of a commodity being consumed domestically rather than entering the world market would lead to declines in trade flows and an increase in its world price.

6.0 WTO IMPLICATIONS

Trade in biofuels today is small relative to global production, although it is highly unlikely that this will always be the case. This raises issues regarding how biofuels will be classified by international trade-based associations such as the World Trade Organization (WTO) and the World Customs Organization (WCO), although for simplicity, the WTO traditionally follows the Harmonized System (HS) code set forth by the WCO. The classification of biofuels into agricultural, environmental or industrial goods would have an impact on the level of bound tariffs. Currently, the WCO classifies ethanol as an agricultural good; however, the end use of ethanol imports for fuel use and for other industrial purposes is indistinguishable. Biodiesel does have its own HS classification and is considered an industrial good (IFATPC 2006). Future biofuels, particularly those from non-agricultural sources, may be subject to different reductions in support and protection than either agricultural or industrial goods, due to environmental or other non-trade related “multifunctionality” arguments. The WTO has traditionally avoided negotiations in energy markets, for several reasons including arguments for national security reasons, as well as the fact that many key crude oil producers are not WTO members.

Current trade flows of ethanol are faced with significant trade barriers, particularly within the Americas. The US, in particular, currently hits imports with a 54 cents per gallon import tariff, as well as a 2.5 percent ad valorem tariff, although it should be noted again

that there are indications this may be temporary. Brazil currently exports the most ethanol globally and is continually strengthening trade connections with countries as diversified as Sweden and Japan. There are reports that within a year, Brazil will have the capacity to export somewhere in the range of 8 to 10 billion litres of ethanol (Ethanol Statistics 2008). Elobeid and Tokgoz (2006) speculate that the removal of US import tariffs on ethanol would increase world ethanol prices by 24 percent, decrease corn prices by 1.5 percent and essentially eliminate imports into the US under the CBI. Brazilian exports would also be expected to increase by 64 percent.

GATT Article 3 describes the principle of national treatment and requires that “imports be treated no less favourably than the same or similar domestically-produced goods once they have passed customs” (WTO 2008). This relates to potential restrictions placed on the feedstock used as inputs in the biofuel production process. If provinces, states or countries mandate the use of a minimum biofuel-blended product, and consequently act to encourage the use of local over imported feedstock, this would violate the definition of national treatment as put forth by the WTO. For reasons of national security, it could be argued however, that encouraging the discriminatory actions is necessary.

Of interest for the dynamics of the global biofuels industry are the competitive advantages recognized by the world’s tropical countries, many of which are developing countries. The cheaper labour, longer growing seasons, and in some cases, fewer environmental regulations and lower domestic demand, have the potential to create low-cost biofuel from a variety of sources, such as jatropha or palm oil. It would likely be in the interest of these countries to see classification issues clarified, as well as see the industry liberalized with respect to trade barriers.

Another issue is the effects of both production subsidies and consumption mandates for biofuels on other non-fuel markets, such as the oilseed meal market or the glycerol market in the case of biodiesel. It has been argued that in order for biofuels subsidies to affect producers in other markets by “cross-subsidizing”, the subsequent benefits or disadvantages must create a competitive advantage for some producers over others (IFATPC 2006).

7.0 CONCLUSION

The biofuels industry affects and is affected by government policies in countries around the globe. Government involvement takes on many forms, including petroleum fuel excise tax exemptions, production quotas, subsidized loans for capital projects, and consumption mandates, which effectively create a fixed demand for biofuels. These policies are designed to promote the domestic consumption, and perhaps in some cases, the eventual export of biofuels.

The motivations behind government promotion of biofuels are complex, involving issues ranging from the environment and climate change to agriculture and farm income. Regardless of motivation, this analysis shows that increased ethanol and biodiesel production has both price and trade effects, with respect to the commodities serving as

inputs in the biofuel production process, as well as to other sectors, such as livestock. It is important to note that the results in this analysis are based on optimistic assumptions regarding the ability of the livestock sector to absorb by-products. Further work is needed to perform a sensitivity analysis in this respect.

In terms of the global situation, trade in biofuels is small relative to world-wide production; however, given ambitious consumption mandates in many developed countries as well as increasing energy consumption, this will not likely remain the case in the long-run. Although biodiesel has been classified as an industrial good, ethanol is currently marketed as an agricultural product, though not specifically for fuel use. The removal of trade barriers, particularly in the developed countries, would not only ease pressure on the traditional feedstocks and lower world ethanol prices, but allow countries with a comparative advantage to capitalize on the opportunity to produce low-cost biofuel. Whether the removal of these trade barriers on biofuels would affect their efficacy as a political tool remains to be seen.

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APPENDIX A

Agricultural Market Impacts of Future Growth in the Production of Biofuels

Martin von Lampe, Organization for Economic Cooperation and Development

The Model

Von Lampe (2006) describes the biofuels production process as additional demand for agricultural commodities, namely wheat, corn and other grains; vegetable oils such as canola and soybean; sugar cane and sugar beets. Supplementing the Organization for Economic Cooperation and Development (OECD)'s model, AGLINK, Von Lampe's 14-equation model is not only able to incorporate biodiesel and ethanol, but is capable of being applied to other feedstocks that may increase in importance over time. Depending on the feedstock and the milling process used, the by-products can be used in varying proportions as substitutes for the energy and protein components of livestock rations. By distinguishing between the protein and the energy components, the by-products from various feedstocks are grouped and linked back to the feed market.

Von Lampe uses shares to differentiate between the different feedstocks for specific biofuels. For example, in calculating the amount of corn used in American ethanol production for a given year, von Lampe determines the supply requirements if the sole ethanol feedstock for that year was corn. This total corn requirement is multiplied by the percent of American ethanol that is produced from corn, as opposed to other feedstocks such as wheat or sugar cane. This equation would hold across all inputs for all biofuels.

In order to account for the partial substitutability of distillers' grains from ethanol for components in livestock feed rations, Von Lampe distinguishes between those that can act as a substitute for protein and those that are substitutable for energy. Again, using shares, the volume of ethanol produced from a particular feedstock is multiplied by either the amount of energy-rich feed or the amount of protein-rich feed yielded during the production of one tonne of ethanol. Von Lampe does not have similar equations for the by-products from biodiesel, and sticks exclusively to ethanol.

The quantity of a specific biofuel produced in a certain year is modeled as the result of utilizing a given proportion of the country's biofuel-specific production capacity. The production capacity for a certain biofuel in a given year is modeled as log-log function of the utilization capacity in the previous year, an annual growth rate, the elasticity of production capacity for that biofuel with respect to its cost ratio, a three year moving average of cost ratios, and an exogenous adjustment factor for production capacity.

The production capacity use share is modeled as a lower limit on production, in which von Lampe assumes that biofuel production is unlikely to fall below 50% of current capacity, in addition to a logistic function which not only brings the lower limit to the capacity utilization for that year, but also provides an upper limit to the capacity use.

The cost ratio for a specific biofuel is calculated as the ratio of net costs of production to a measure of the relative energy content between that biofuel and a petroleum-based fuel, multiplied by the inverse of the retail price of the fossil fuel.

Von Lampe defines net production costs as the aggregate of feedstock and energy expenses, as well as other lumped exogenous costs. These expenses are then adjusted downwards for the value of the byproducts that can be sold into the feed market and any subsidies that may have been collected and used to mitigate costs. These costs differ across feedstocks, as well as production processes; therefore, the net production costs variable is the sum of the net costs across feedstocks. The retail price of fossil fuel is modeled linearly as a function of the price of crude oil, accounting for exchange rates, and the taxes imposed by individual countries.

Von Lampe assumes constant substitution elasticities in instances where multiple feedstocks could be used, and adds an equation to re-scale the shares, due to violated unity assumption of the shares in the constant elasticity of substitution (CES) function. A table of technical parameters was borrowed from Smeets *et al.* (2005), while von Lampe obtained the parameters of the CES functions by calibrating the model to 2004 data.

To deal with the difficulties in modeling the relationship between energy and agricultural markets, von Lampe identifies three components: the use of agricultural commodities for biofuels, the link between energy inputs for the agricultural products, and finally, the effect of energy costs on the transportation of these commodities both domestically and internationally.

By using a two-part cost index to deal with production costs, Von Lampe is able to apply different indices to the tradable and non-tradable inputs. Those inputs affected by macroeconomic issues, such as global inflation and exchange rates, are deflated by the United States (US) Gross Domestic Product (GDP) deflator (as a proxy for global inflation), and those affected primarily by domestic policy are deflated using GDP deflators for the individual countries. Moving one step further, the tradable inputs are further categorized into energy and non-energy inputs, under the assumption that for OECD countries, energy comprises on average, 25% of production costs.

The Scenarios & Results

Von Lampe uses the above model to examine three different biofuel scenarios for the European Union (EU), Canada, the US and Brazil.

Constant Biofuels: This scenario contains constant exogenous shifts in biofuel production, crop demand resulting from biofuels, and the by-products resulting from this production. In accordance with data calibration, these shifts are consistent with 2004 numbers. Although the results from this scenario are used in comparison with those from the other scenarios, the baseline only looks at biofuels growth in the US and Brazil. Von Lampe finds that over the projection period, the US would require additional 14 millions tons of coarse grains for biofuel production. World prices of coarse grains, wheat and vegetable oil would fall relative to the baseline by 2.5 percent, 1 percent and 1.5 percent respectively. With respect to livestock markets, minor effects were reported; price declines of under 1 percent were noted for dairy and most meats, with the exception of the pork price (1.2 percent relative to the baseline).

Brazil however, saw more significant effects in the sugar market, with exports increasing by 54 percent by the projection period. Von Lampe notes that at 8 percent of the global sugar market, these additional exports are enough to cause a 37 percent drop in the world sugar price, relative to the baseline.

Policy-Target Scenario: This scenario accounts for biofuels growth, given policy initiatives and official goals from the four countries/country blocs in focus. Results show that relative to the previous scenario, the EU and Canada would see more significant results than Brazil and the US, whose projections would be similar to those from the original baseline.

Overall, the EU saw ethanol production increase wheat and coarse grain usage by approximately 24 million tons, or a slightly more than 9% of projected grain use. Breaking down these figures to the commodity level, the highest growth for allotment to biofuels was seen in vegetable oil, with growth numbers of approximately 48%. Other high increases were seen the sugar beets, with 17% of projected production used for biofuels, and wheat, with about 10%.

For Canada, von Lampe projected that 15% of domestic cereal use in 2014 would be put towards biofuel production, an increase of more than 5 million tons. Biodiesel expansion showed modest gains, with an increase of vegetable oils in the neighborhood of 4%.

In terms of prices, von Lampe forecasts the world price of vegetable oil at USD697 per ton by 2014, an increase of 15% over the constant biofuels scenario. By the same token, the price of oilseed meal, affected by the increase in biodiesel by-products, falls below comparison scenario by 6%. Sugar markets, facing increased European demand, would see prices exceed the constant biofuels scenario by nearly 60%. Grain prices in general would also see increases, with wheat increasing to about USD 167 per ton, roughly 4% higher relative to the first scenario. Slight increases in meat prices, most noticeable in the pork market, were reported, as well as in butter prices, although von Lampe attributes the latter to increased vegetable oil prices, rather than the increased costs associated with dairy production.

With respect to trade flows, the European demand for vegetable oil is projected to increase imports by 300%, while Canadian exports of wheat and coarse grains would drop by 13% and 34% in 2014, respectively. Von Lampe notes that these results ignore the possibility of technological change, such as advancements in second-generation biofuel technology.

High Oil Price Scenario: In this scenario, crude oil prices are fixed at USD 60 per barrel from 2005 onwards, in order to capture the effects of high oil prices on net production costs, biofuel prices and the overall profitability of biofuels. In essence, it aims to capture the complex relationships between biofuels and petroleum-based fuels; higher fuel prices drive up production costs for commodities and therefore, the increase the price of the feedstocks used as inputs for biofuel production. In addition, a certain degree of

substitution occurs, as increasing petroleum fuel prices also increase the demand for alternatives, namely biofuels. Depending on the share of energy costs in the overall crop production expenses, assumed to be 25% for OECD countries and 43% for non-member countries, the impacts of high oil prices can vary.

Von Lampe begins by focusing on the production effects and ignoring the increased pressure to find alternatives to oil-based fuels. The direct implication from the high oil costs is decreased crop production, associated with higher expenses. Compared to the policy-target scenario, reductions in global wheat, coarse grains, vegetable oils and sugars were projected to be 1.5%, 1.7%, 2.8% and roughly 2%, respectively. It is noted that high protectionist measures in many of the OECD member countries serve to isolate domestic sugar production; therefore, it remains mainly unchanged in most countries. Because energy costs affect the production costs of all crops, the relative crop allocation remains fairly unchanged.

With respect to prices, von Lampe approximates a 10% increase in world wheat prices, and a 17% increase in oilseeds by the end of the projection period. Because this scenario holds biofuel prices constant, production of both ethanol and biodiesel falls by roughly 8% and 6%, respectively.

Even though production costs are increasing, von Lampe explains that higher petroleum-based fuel prices increase biofuel producers' incentives to expand their production through utilizing previously unused production capacity. It is at this point he brings in the effects associated with substitution. In comparison with the policy-target scenario, ethanol and biodiesel production increase globally by about 8% and 16% respectively. In this scenario, the impacts on wheat and coarse grains are minor, below 3% in addition to the increase. However, both world sugar prices and vegetable oil prices would be expected to increase by about 4% in addition to the increases from the direct impacts. Oil meal prices would also decrease.

Von Lampe notes that on the global market, most major impacts are seen in the sugar market, due to Brazilian dominance, and in the vegetable oil market, due to increased European biodiesel production. It is also noted that in this scenario, more countries outside of those in the study, would be likely to increase their biofuel production; neither China nor India were included, but produced 9% and 4% of the global biofuel supply in 2004. It is not unreasonable to expect further expansion into the projection period, as well as developments in second-generation biofuels and alternative inputs, such as jatropha or cassava.

An Economic Analysis of a Major Biofuel Program Undertaken by OECD Countries

Strategic Policy Branch, Agriculture and Agri-Food Canada

The Strategic Policy Branch (SPB) of Agriculture and Agri-Food Canada (AAFC) uses the OECD model, AGLINK, to determine the effects of increased biofuel demand in member countries (see OECD 2007 for a detailed description of AGLINK).

The SPB performs a two-part exogenous increase to model these effects. By positively shocking the demand for wheat, corn and vegetable oil, the effects on the crop input markets are accounted for. The second shock involves an increase in the by-products from biofuels production. In this step, the feed market sees an increase in DDGs, corn meal, etc, thereby expanding supply.

From GDP projections out to 2006, the SPB was able to determine and extrapolate national fuel consumption levels for the OECD countries. The scenario dictates an annual increase of 1 percent in the share of biofuels (using an aggregated measure of ethanol and biodiesel) in national fuel consumption, ending with all OECD countries having an 8 percent biofuel share in the transportation fuel sector. The first year of the scenario was 1999, in which all of the OECD countries had an effective biofuel share of zero, with the exception of the US, Canada, and the EU. Canada's biofuel share was roughly 0.44 percent, while the US and the EU had 1 percent and 0.35 percent, respectively. In the first year of the scenario, it was assumed that biofuel production would be expanded just enough to bring all countries to 1 percent, and in each of the following years, an additional one percent would be added to the biofuel share in total transportation fuel consumption.

A number of assumptions were made by the SPB in this exercise. It was assumed that all countries would use wheat or coarse grains (mainly corn) for ethanol production; this was analyzed on a per country basis, looking at historical domestic production and import numbers. Biodiesel was assumed to be produced from non-specific vegetable oil.

Due to the dominance of gasoline over diesel in the Canadian transportation sector, it was assumed that all of the expansion in the Canadian, as well as the American, biofuels sector would be completely ethanol-based. While the American ethanol supply is produced primarily by corn, the Canadian industry is assumed to be split by about 80 percent corn and 20 percent wheat. With that being said, the EU biofuels sector is dominated by biodiesel. Ethanol production does exist, with 70 percent being produced with sugar beets and the remainder produced from wheat. In all instances, it is assumed that the shares remain constant throughout the projection period, and that the increase is distributed accordingly.

As the type (and therefore, the effects) of the by-products varies depending on the feedstock and processing method, completely capturing the process in AGLINK is unlikely. Other than the US, it is assumed that the dry milling process for ethanol is used and will continue to be used. For those countries using corn as an input, it is assumed that the by-products would have a feed value equivalent to a ration of 56 percent soybean meal and 44 percent corn. For wheat, the feed value is 53 percent soybean meal and 47 percent soft wheat. Since the US uses a combination of wet and dry milling, it is assumed that for the wet milling process, the by-products are equal to 61 percent soybean meal and 39 percent corn. Throughout this analysis, it is also assumed that by-products stay at comparative prices relative to the main feed ingredients.

The Results

The SPB notes that because a 1 percent increase is added in every year of the projection period, the results in the final year are not to be interpreted as long-run equilibrium predictions.

Looking at the last three years of the projection period, the average price increases for wheat, corn and soybeans were 22 percent, 45 percent and 12 percent, respectively. Vegetable oils saw gains of 66 percent, while the price for protein meal dropped by 33 percent, due to the increase in by-products, such as the DDGs and oilseed meal on the market. The oilseeds market, particularly soybeans, faces both upward and downward pressures. The increase in oilseeds price mentioned above is partially mitigated by the declining demand for soybeans as a result of lower meal prices (major by-product of soybean production). On the other hand, increased prices in the grain sector increase the attractiveness of grain versus soybeans, resulting in fewer acres of soybeans being planted and higher prices for soybeans. The increased soybean price and lower meal price also negatively affect crushing margins. With respect to the livestock industry, benefits are seen from lower protein meal prices; however, with feed grain costs rising, the US saw a six percent increase in the feed cost index, and 12 percent in the final three years. The feed cost index in AGLINK is a non-specific feed index that relates the general feed costs in livestock production to overall costs. As ruminants comprise a larger share of the Canadian livestock market, it follows that Canadian producers would have a higher feed stock index than their American counterparts.

The effects on Western Canadian agriculture are slightly different. Given the high oil content in canola, the effects of the high oil price have a greater impact than the declining meal prices. Again, over the final three years of the scenario, increases of 31 percent, 38 percent and 44 percent were seen in wheat, corn and canola, respectively. Soybeans saw a 13 percent increase. Wheat exports were expected to decrease by roughly 6 percent, while coarse grain exports were expected to fall by 73 percent. The canola crush margin was actually predicted to increase by roughly 36 percent and net exports by an average of nearly 7 percent. However, the Canadian livestock sector sees an increase in the feed cost index of 12 percent on average, and 21 percent in the last three years, with combined beef, pork and poultry production declining by 1.3 percent on average.

Analyzing the Impacts of Biofuel Mandates on World-Wide Grain, Livestock, and Oilseed Sectors

Richard Stillman, Jim Hansen, Ralph Seeley, Dave Kelch, Agapi Somwaru, Edwin Young, Economic Research Service

The Model

Stillman et al. use the multi-commodity, multi-region Partial Equilibrium Agricultural Trade Simulator (PEATSim) developed by the Economic Research Service (ERS) to analyze scenarios with varying degrees of world-wide increases in biofuel production. PEATSim is a reduced-form model with the ability to account for the discontinuous nature of tariff-rate quotas (TRQs). While the model is capable of analyzing many policy

questions related to trade and domestic policy, this piece focuses on the effects of ethanol production in the US, the EU, Brazil and China.

For an individual commodity, the model balances supply and demand such that net trade in that commodity (the difference between exports and imports) is equal to the domestic production minus total demand and the difference in ending stocks, where total demand is equal to the sum of food demand (not relevant to oilseed meals), feed demand (related to the levels of livestock production in the model), other demand (primarily related to biofuels production), and crush demand in the case of oilseeds. The constraint placed on global markets restricts the sum of net trade over all of the regions in the model to zero.

Production of grains and oilseeds is a multiplicative function of yield and area harvested, both of which are endogenous and are specified as constant elasticities. The area harvested of a given commodity is specified as a function of its own producer price, as well as the producer prices of other crops, while yield is modeled as a function of the crop price and historical yields. For oilseeds, both vegetable oil and meal are a function of the crusher demand and the amount of each extracted from the crush. Crush demand is modeled based on the previous year's crush demand, as well as the crushing margin (yield multiplied by the dividend of the value of the crush and value of the seed). In terms of livestock, production is a function of production levels in the previous year, prices in the current year and a feed index to account for costs of feed.

Prices for the major commodities are based on world prices. Prices of a country's imports are based on world price of that commodity, ad valorem tariffs and transportation costs, as well as any commodity-specific duties.

The Scenarios

Stillman et al. incorporate several assumptions into their analysis, one the most important being that the EU is only capable of meeting two thirds of its biofuels mandate due to capacity limitations in domestic rapeseed production, as well as the reluctance to import less-environmentally friendly tropical oils. Another set of important assumptions involves the incorporation of distillers dried grains solubles (DDGS), a by-product of corn-ethanol production, back into the corn market as a substitute for feed corn. Stillman et al. assume that a pound of corn used in ethanol produces approximately one third of a pound of DDGS, and that one pound of these DDGS is equivalent to one pound of feed corn in beef rations. Corn DDGS are less suitable for other livestock, and subsequently, lower replacement ratios are used for hogs, poultry, dairy, etc. These feed assumptions are significant, in that they are likely to mitigate some of the price impacts of all three scenarios. Three scenarios are examined using the model and the assumptions described above.

Scenario 1: The first scenario examined by Stillman et al. examines the effects of a 10% percent underestimation of American corn-ethanol production in 2010. While holding the European, Brazilian and Chinese production constant, the price and trade effects on corn, as well as other grains and oilseeds are determined. The effects on livestock markets are also examined.

Scenario 2: The second scenario holds American ethanol production at its projected 2010 levels of increase, while assuming that European biodiesel production levels were understated by 10 percent. Again, Chinese and Brazilian biofuels production remains constant, with similar variables as in the first scenario being examined.

Scenario 3: The third scenario looks at the effects of the US, the EU, Brazil and China all exceeding projected biofuels production levels by 10 percent, again in year 2010.

The Results

The effects of the scenarios on six commodities: rice, wheat, corn, soybeans, cotton and sugar, were generated. The relative effects on the world prices of these commodities were also determined. The percentage changes in domestic production and consumption, as well as exports and imports were determined for the US, the EU, Brazil, China and Argentina.

Scenario 1: A 10 percent increase in American-based demand for ethanol results in an increase in the world producer price of corn of roughly 3.6 percent. This price increase leads to decreased production in rice, wheat, soybeans and cotton in the US, with a minor increase in sugar acreage. As American land is moved into corn production, slight increases in world prices are seen in all of the aforementioned commodities.

In terms of the international effects of American production increases, the EU reduces imports of corn by roughly 9 percent. Likely due to higher world prices, domestic production of wheat, rice, corn and soybeans increases slightly, as imports decline. Brazil increases production of corn by approximately 1.4 percent, while exports increase by nearly 28 percent. Argentina also increases production of all commodities, with domestic consumption remaining relatively unchanged, and imports increasing. China remained fairly constant in its production and consumption of the commodities, although corn exports increased by over 50 percent, while imports dropped roughly 3 percent.

Stillman et al. point out that higher world prices for corn and soybean have a negative effect on meat production. Beef, pork and poultry production and consumption fall in all of the countries in the analysis, with the exception of European and Argentinean pork. World prices of all livestock increase by roughly 1 percent, while processed dairy products also see slight price increases.

Scenario 2: The results of the second scenario are only presented for the EU. A 10 percent increase in EU biodiesel production leads to production increase in approximately 2.5 percent, while rape oil production expands by 5 percent. Domestic consumption of rapeseed and rape oil increase by 5 percent and 14 percent respectively, while exports of rape oil effectively drop to zero. According to the model, a 9 percent increase is seen in rapeseed, while the world price of rape oil increases by nearly 19 percent. Imports are actually shown to decrease, but the authors point out that this is not likely not the case. It is probable that imports would actually increase slightly; this discrepancy is due to the net trade structure of the model. Production and consumption of wheat and corn decrease, as land moves into rapeseed production. World prices in all

commodities increase slightly; however, increases are not as significant as in the first scenario.

Effects on livestock are fairly minimal, with EU production in beef, hogs and poultry increasing slightly, due to the increase in oil meal on the protein market.

Scenario 3: Under the 10 percent underestimation of European, American, Brazilian and Chinese biofuels production, the world price of corn rises by approximately 4.25 percent, the largest increase of the three scenarios. Prices of rice, wheat and soybeans also increased in the neighborhood of 1.5 percent, while the world price of sugar increased by 3 percent. The world prices of rapeseed and rape oil were similar to those in the second scenario, only slightly higher. Corn production increased in all of the countries in the analysis, ranging from less than a tenth of a percent in the EU to 2.3 percent in Argentina. US exports of corn decreased by nearly 12 percent, while exports in Brazil and China increased by 29 percent and 37 percent respectively. Argentina and the EU showed minor growth in exports as well. Corn imports decreased in all of the countries, most notably, the EU, with a decrease of nearly 10 percent. Rapeseed production in the EU increases by 2.7 percent. For the most part, production of other grains and oilseeds declines, as more land switches into corn and rapeseed.

In terms of livestock, the world prices of beef, pork and poultry increased approximately 1.3 percent, 0.79 percent and 1.1 percent respectively. These price responses are likely in response to decreased production in all of the countries in the analysis, with the exception of the EU, where pork and poultry production expands in response to a 5 percent decrease in protein-rich oil meal. The decline in US livestock production is slightly greater in this scenario than in the first. The prices of processed dairy products also increased, varying from 0.39 percent for butter to 0.91 percent for cheese.