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An Economic Analysis of a Major Bio-fuel Program Undertaken by OECD Countries

Canada

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Publication 2105/B
ISBN 0-662-66254-7
Catalogue A22-240/2001
Project 01-133-r

Aussi disponible en français sous le titre de :
ANALYSE ÉCONOMIQUE D'UN IMPORTANT PROGRAMME DE PRODUCTION DE BIOCARBURANTS MIS EN OEUVRE DANS LES PAYS DE L'OCDE

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Executive Summary

Prices of agricultural commodities expressed in real terms have been declining for decades. One factor contributing to the decline has been the replacement of agricultural commodities by non-agricultural commodities in many non-food uses. If through life science initiatives, economic uses of agricultural resources can be expanded, the decline in real prices could, in principle, be stemmed. At this point in time, bio-fuels (ethanol and bio-diesel) offer the best possibilities of creating a sufficiently large new demand for agricultural output and/or agricultural land to have an impact on world prices. But Canada is only one country in the world commodity markets. This analysis shows that for bio-fuels to have a significant impact on price of grains and oilseeds, the participation of other large countries with large populations and large demand potential is necessary.

The objective of the analysis is therefore to quantify the potential impact on grain and oilseed prices of a major bio-fuel program initiated by OECD countries over the 1999 through 2006 period. By incrementally raising bio-fuel production each year by one percent of the level of fossil fuel used by the transportation sector, we create a new demand for grains and vegetable oils. By the final year (2006), total bio-fuel production corresponds to eight percent of the fossil fuel used.

The increase in world and domestic prices for grains and vegetable oils is strong, especially toward 2006. On the contrary, protein meal prices decrease because of the increased supply of animal feed and meal as by-products of the ethanol and vegetable oil production. For livestock producers, the decline in meal prices compensates, to a certain extent, the increase in grain prices. Also, the large impact that increased bio-diesel production has on vegetable oil demand increases the need for oilseeds with a high vegetable oil content and has a very positive impact on the Canadian canola processing industry.

The analysis shows that a bio-fuel program of the magnitude described for all OECD countries would be beneficial to Canadian agriculture and would eliminate most of the problems related to farm income. In the sixth year (2004), net cash income would be two billion (Canadian) dollars greater.

Introduction

Given the relatively low grain and oilseed prices faced by Canadian producers, there is considerable interest in stimulating prices by either reducing supplies or increasing demand. This analysis provides some insight into the potential impact on grain and oilseed prices of a significant increase in demand.

At the same time, there is interest in and increased use of bio-fuels. They are helping OECD governments to achieve some of their environmental goals and obligations because they are renewable and they produce fewer greenhouse gas emissions than petroleum products.[1] The analysis attempts to estimate the price impact of increasing the demand for bio-fuels (ethanol and bio-diesel) in OECD countries. Ultimately an increase in OECD bio-fuel usage has a direct impact on the demand for grains and oilseeds which are important feed-stocks in bio-fuel production. Although bio-fuels can be produced from various feed-stocks, this analysis considers only ethanol from corn or wheat and bio-diesel from vegetable oils.

The focus of this analysis is to study the impact of the increased use of bio-fuels in the OECD transportation sector.[2] In particular, the analysis attempts to quantify the impact on grain and oilseed commodity prices. Over the period (1999 through 2006), we incrementally increased the bio-fuel share of fuel used by one percent each year.

The analysis presumes the increase in renewable fuel use and estimates the impacts of such use on agricultural commodity markets and farm income. The analysis does not consider factors which will or could bring about this increase. Such factors might include financial incentives, regulatory requirements as a result of government policy, or changes in market conditions which might lead fuel producers to use more renewable fuels.

The document has seven sections: introduction, background, scenario development, results, conclusions, bibliography and appendix.

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1. Seecharan et al. 2001.
2. Further references regarding the fuel use will always be for the OECD countries' transportation sectors.

Background

Average consumption of gasoline and diesel by OECD countries from 1996 to 1999 was 900 million tonnes. The United States accounted for the largest share (51 percent) followed by the European Union (26 percent) (Figure 1). However, there are considerable differences between the countries in their use of gasoline versus diesel. In the United States and Canada, gasoline accounted for 77 percent and 72 percent of the total fuel used, respectively. In the European Union and Japan, gasoline accounted for only 48 percent and 57 percent, respectively.

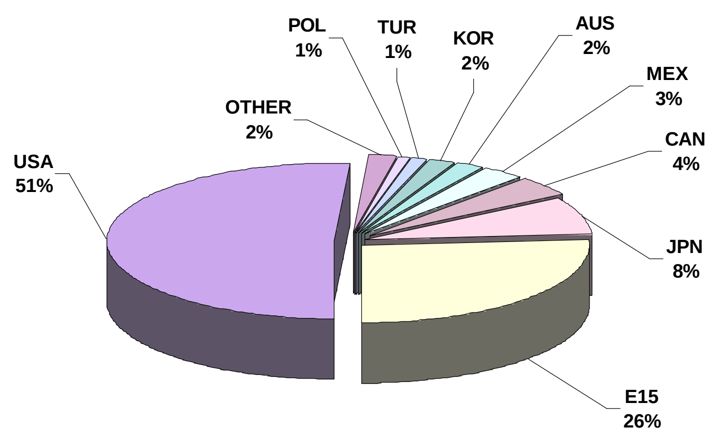

Figure 1: Shares of Gasoline and Diesel Use in the Transportation Sector, OECD Countries, Average, 1996-1999

While the development and introduction of bio-fuels is taking place in many OECD countries, the United States, the European Union and Canada are at the forefront. They have the highest levels of processing capacity using corn, wheat and rapeseed feed-stocks. In 1999, based on preliminary numbers, production of ethanol in the United States (using yellow corn) amounted to 5.8 billion litres or 4.5 million tonnes. In the European Union, 0.4 billion litres (0.3 million tonnes) of ethanol were produced from sugar beets and wheat and 0.7 billion litres (0.5 million tonnes) of bio-diesel were produced from rapeseed, sunflower and spent vegetable oils. In Canada, 0.2 billion litres of ethanol were produced (0.18 million tonnes) from wheat and corn. The production of bio-diesel in Canada and the United States is small and therefore not considered in this analysis.

In producing bio-fuels from corn, wheat and rapeseed or sunflower seed, the conversion process results in significant quantities of by-products which find their way into the feed ingredient market. In the United States, there are two types of corn milling processes to produce ethanol—wet and dry. The wet milling process accounts for 75 percent. Assuming a feed-stock of yellow corn at 9 percent protein, the wet milling process will produce 30 percent ethanol, 3 percent corn oil, 5 percent gluten meal (at 60 percent protein) and 21 percent gluten feed (at 21 percent protein). The dry milling process accounts for 25 percent and will produce 31 percent ethanol and 30 percent distiller dried grains (DDG) (at 27 percent protein) when feed-stock used is yellow corn at 9 percent protein.

In Canada, the dry milling process produces ethanol from either corn or wheat feed-stocks. When soft wheat at 11.5 percent protein is used, it produces 29 percent ethanol and 37 percent DDG (at 27 percent protein). In the European Union, bio-diesel production from rapeseed or sunflower seed is soft-seed crushing, yielding about 40 percent vegetable oil and 60 percent meal. The vegetable oil is transformed into bio-diesel and the meal goes into the protein meal market. For bio-diesel production, 90 percent can be produced from vegetable oil with the addition of 10 percent methanol.[3]

3. A by-product of petroleum production.

Scenario Development

In using AGLINK[4] to undertake the analysis, there are two important limitations—the partial nature of AGLINK and its limited coverage of the energy sector. We needed to project the gasoline and diesel use. Projections of GDP growth through 2006 for each of the OECD countries in the AGKINK model were used to extrapolate fuel consumption level for gasoline and diesel (Figure 2)[5]. Since the scenario implies an increase of the bio-fuel share annually by one percent of combined OECD gasoline and diesel fuel use, it was necessary to determine the starting point of the respective share for each country in 1999 because this level of use was already accounted for in the baseline. For all

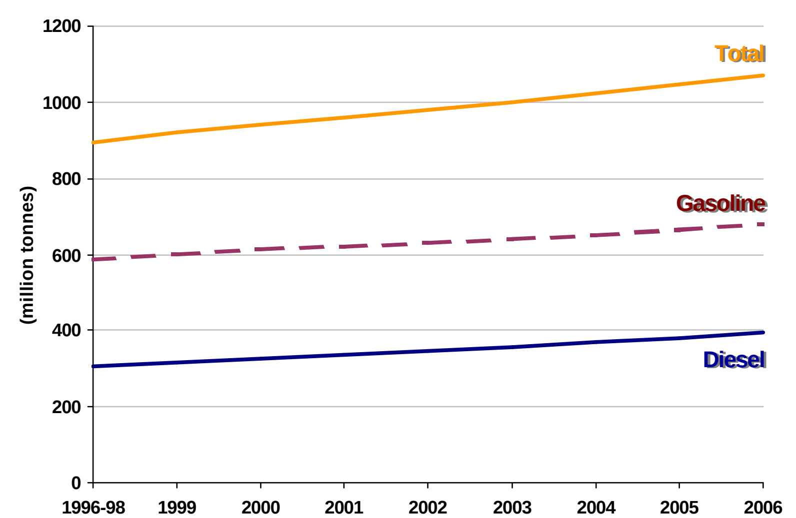

Figure 2: Projected OECD Diesel and Gasoline Fuel Use (for the transportation sector)

4. AGLINK is a multi-commodity multi-country policy-specific dynamic model of the international agricultural markets built by the OECD with member countries. Because of its partial nature, AGLINK cannot capture the decline in fossil oil prices and on cost of production that would emerge from a massive bio-fuel program. This would have a positive impact on world production of grains and oilseeds. However, because sugar is also not included, AGLINK cannot capture the decreasing use of land for grain production in the European Union resulting from the higher price of sugar (since sugar is the favourite feed-stocks to produce ethanol in the EU). This could have a negative impact on world production of grains and oilseeds. We do not know if these two factors will cancel out. For that reason, the results of this analysis should be used with these limitations in mind.
5. Growth in fuel consumption was adjusted down in the most advanced economies as growth in fuel consumption in recent years has been slower than growth in the overall economy.

the OECD countries, except the United States, Canada and the European Union, this percentage was effectively very close to zero.

For the United States and Canada, ethanol accounted for 1.00 percent and 0.44 percent, respectively, of the fuel used by the transportation sector. For the European Union, combined ethanol and bio-diesel production totalled 0.35 percent. In the first year of the analysis, it was assumed that all countries increased their bio-fuel production to a level equal to one percent of the level of gasoline and diesel used by their transportation sector. With the exception of the United States, Canada and the European Union, all the other OECD countries increased bio-fuel production from zero to one percent of the transportation sector's fuel requirement. Since the United States had already achieved the one percent level, no additional bio-fuel production was required in 1999. However for Canada and the European Union, bio-fuel production was increased to reach the one percent target. After all the countries reached the one percent level in 1999, bio-fuel production is assumed to account for an additional one percent of transportation fuel (gasoline and diesel) consumption each year.

Although AGLINK does not explicitly specify the demand for grains and vegetable oils from the bio-fuel sector, the impact of this scenario on the major grain and oilseed covered by AGLINK can be indirectly examined. There are two key increases at work in this scenario which had to be indirectly incorporated into AGLINK. The first is a positive direct increase in the demand for grains (wheat and corn) and vegetable oil (indirectly rapeseed, sunflower seed, soybeans) that is the result of increased ethanol and bio-diesel production. The second is the increased supply shift that occurs in the feed ingredient market where additional by-products from ethanol and bio-diesel production now have to be absorbed by the livestock sector.

To produce the scenario, a number of assumptions had to be made. The general rule followed for those countries with limited or no bio-fuel production (i.e. all OECD countries except the United States, Canada and the European Union) was to assume that ethanol and bio-diesel production would be expanded at rates that would account for incremental percentages of the individual country's gasoline and diesel requirements. Thus in 1999, each country would have bio-fuel production that accounted for one percent of the total amount of gasoline and diesel consumed by their respective transportation sectors. For the feed-stocks to produce ethanol, it was assumed that a country would use either wheat or coarse grain (likely corn) depending on the historic availability (through production or imports) of these crops.[6] To produce bio-diesel, it was assumed that the country did not differentiate and simply increased overall domestic vegetable oil usage.

In this analysis, we assume that the United States and Canada meet their bio-fuel commitments solely by producing ethanol, due to the limited development of bio-diesel and the more heavily weighted share that gasoline represents as a proportion of fuel usage. In the European Union, we assume that the more heavily weighted bio-diesel share is maintained which results in larger bio-diesel production than ethanol. For the particular feed-stocks used, based on recent historical trends, we assume that the United States continues to use corn predominantly in ethanol production while Canada uses 80 percent corn and 20 percent wheat. In the European Union, ethanol production comes from sugar beets and wheat (about 70 percent and 30 percent, respectively). We assume that this share is maintained and

6. Based on historical crop availability we assume that ethanol production from wheat occurs in Australia, Czechoslovakia, Poland, Switzerland and Turkey and from corn in Hungary, Japan, Korea, Mexico, New Zealand and Norway.

consequently only 30 percent of the increased ethanol production translates into increased grain demand. If we had assumed that all new ethanol production came from wheat, the impact on prices would have been greater. With regard to bio-diesel, we assumed the larger production in the European Union translates directly into an increase in vegetable oil demand.

As mentioned in Section 2, the impact that increased bio-fuel production has on the livestock feed ingredient market is somewhat varied depending on the method of processing and the feed-stock. Although AGLINK does not capture all the ingredients that result from ethanol production, the increased supply of these feed ingredients can be implicitly captured by reducing the demand for corn, wheat and protein meal.[7] We assume that all countries use or will use the dry milling process, with the exception of the United States which uses both the wet and the dry milling process. We assume that the dry milling process, to produce ethanol from either corn or wheat, will result in feed ingredients that would be effectively equivalent on a weight basis to a feed ration composed of 56 percent soybean meal (41% protein) and 44 percent corn (9% protein) or 53 percent soybean meal and 47 percent soft wheat (11% protein) when corn or wheat feed-stocks are used respectively.[8]

Using the methodology described above, the appropriate adjustments were made to AGLINK to simulate the impact of the bio-fuel scenario on average grain and oilseed prices.

7. The analysis implicitly assumes that the price of the ethanol feed by-product will always remain competitive with other feed ingredients and relates to the initial assumption that bio-fuel production remains economically viable or is imposed by governments through regulation.
8. United States' production of ethanol from the wet milling process yields a higher protein feed ingredient. As such, we assume that it could be replaced by a feed ration composed of 61 percent soybean meal and 39 percent corn. An additional output of the process is corn oil which has been subtracted from the total United States vegetable oil consumption.

Results

Prior to discussing the results from the bio-fuel scenario, it is important to reiterate the key assumption underlying this analysis. On an annual basis, we incrementally increase bio-fuel production in each OECD country such that it represents one, two, . . . , eight percent of total gasoline and diesel fuel requirements by the transportation sector in 1999, 2000, . . . , 2006. This methodology is used over eight years for both ethanol and bio-diesel production. Thus, by the end, all OECD countries have expanded their bio-fuel production to a level that represents eight percent of the total gasoline and diesel requirements of their respective transportation sectors. Since shocks are introduced every year of the analysis, the results observed in the final year (2006) cannot be thought of as a sustainable long-term market equilibrium. In fact, considerable adjustments are taking place in the simulation scenario[9] and would continue after the final shock in 2006 until markets arrive at a more stable long-term equilibrium.

The impact of the scenario on major commodity prices is illustrated in Figure 3.[10] It is apparent that the general effect on world price of the scenario is more favourable for major grains (wheat and corn) than for soybeans. The average price impact observed in the final three years of the scenario are 22 percent for wheat, 45 percent for corn, 12 percent for soybeans, -33 percent for protein meal and 66 percent for vegetable oils. The additional ethanol production creates a significant expansion in wheat and corn demand and ultimately results in much higher average prices. Although this is partially off-set by the additional by-product feed ingredients that now enter the livestock market, the net impact on prices is positive.

9. For example, in the final year (2006), the world production levels of wheat and coarse grains are respectively 2.3 and 10.8 percent higher than in the baseline.
10. The percentages on the Y-axis represent the percentage impact relative to the baseline.

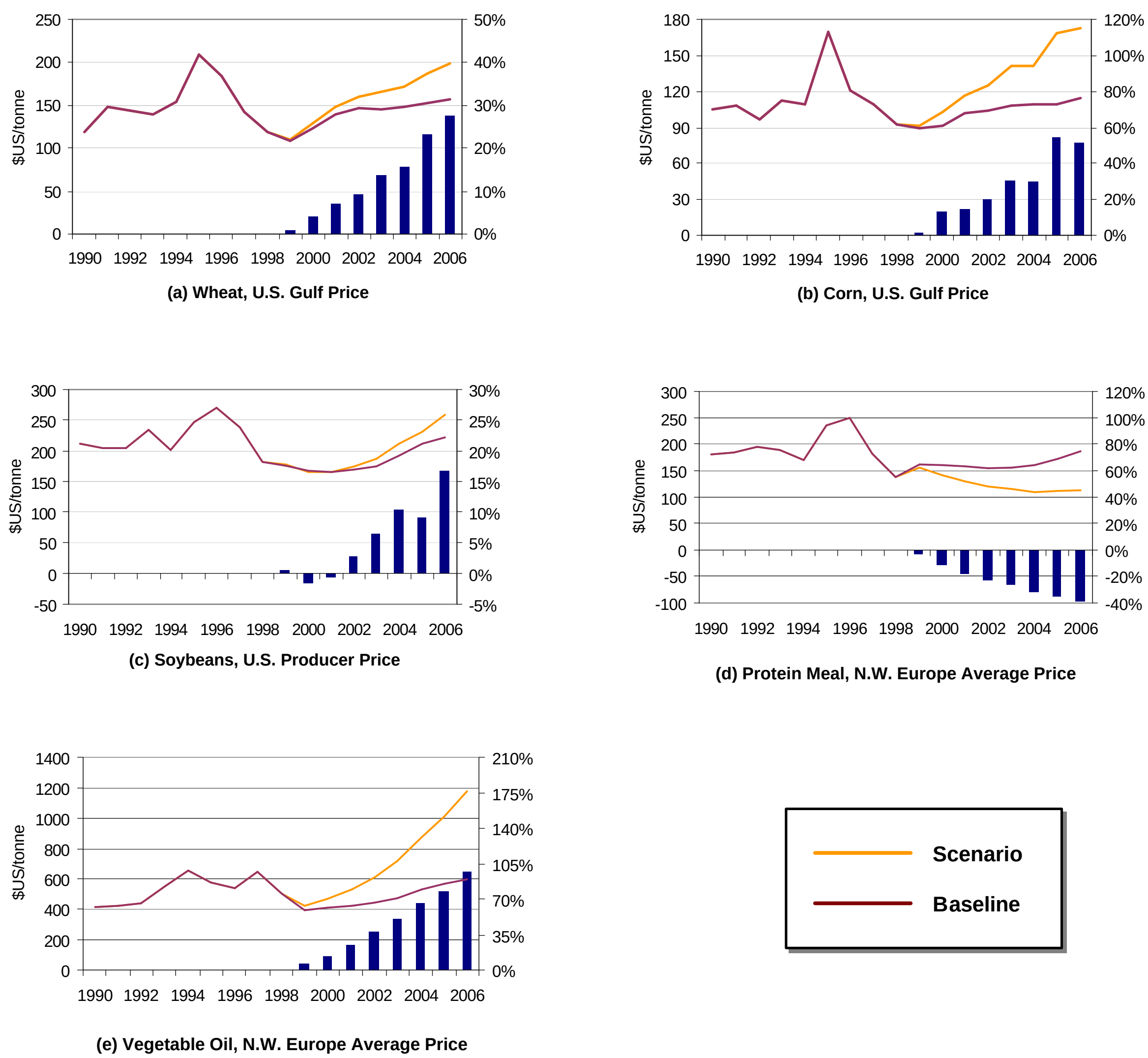

Figure 3: Scenario Price Impact

For oilseeds, the general effect is mixed. Protein meal prices decrease because of the increased supply of semi-processed feed by-products (DDG from the ethanol industry) and oilseed meal (from increased bio-diesel production). The additional demand for vegetable oil that results from increased bio-diesel production increases vegetable oil prices. The impact on oilseed prices is a complex one. Since the major by-product of soybean production is protein meal, the lower prices reduce the soybean demand. However, the large increase in vegetable oil prices partially off-sets the lower protein prices. Additionally, the strong increase in wheat and coarse grain prices ultimately reduces the land available for soybean production which reduces the soybean supply and increases prices.[11] As more and more protein meal (or protein meal substitutes) come on the market every year of the scenario, the soybean crushing industry is adversely affected. The higher vegetable oil prices cannot off-set the impact of higher soybean prices and lower meal prices and ultimately the crushing margins decline dramatically (Figure 4).

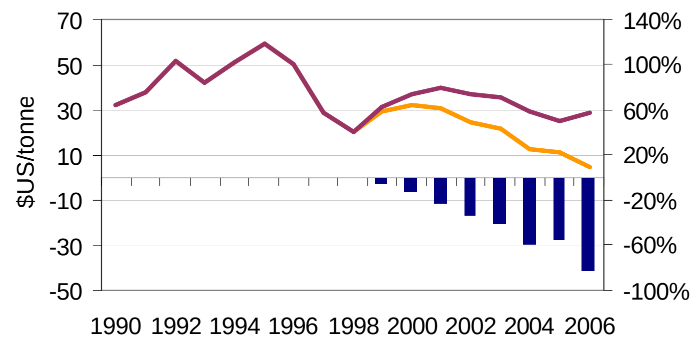

Figure 4: Impact of the Bio-fuel Scenario on the United States Soybean Crushing Margin

In addition to the soybean crushing industry being negatively affected by the bio-fuel program, there is a negative impact felt by the livestock sector. Although some of the key feed ingredient prices fell dramatically (i.e. protein meal), there was a significant increase in feed grain costs. Over the period of analysis, the United States feed cost index for example is six percent higher than the baseline level (12 percent higher in the last three years) which obviously has a negative impact on livestock production.

In Canada, the impact of the bio-fuel program is somewhat different. In Western Canada, the predominant oilseed grown is canola which has a high vegetable oil content. Since on a weight basis, vegetable oil represents about 40 percent[12] of the canola seed versus 18 percent in soybeans, the rapid increase in vegetable oil prices under the scenario more than off-sets the negative protein meal effect. We see average prices increase over the final three years of the scenario of 31 percent for wheat, 38 percent for corn, 44 percent for canola and 13 percent for soybeans. The area allocation is modified by these movements in prices, the canola and corn area increase on average 7 percent and 2 percent, respectively, while the wheat and soybean area decline 3 percent and 4 percent, respectively. The increased domestic use of grains in ethanol production translates into average reductions of wheat and coarse grain net exports of -6 percent and -73 percent, respectively over the period of analysis.

Unlike the soybean crushing industry, canola crushing margins improve significantly due to the high vegetable oil prices. The average canola crushing margin over the 1999 to 2006 period is 36 percent higher than the baseline level. Although canola processing expands with the improved crushing margins, the increase in canola production leads to increased net exports of 6.5 percent on average. For the livestock industry in Canada which is highly dependent on feed grains, the impact of the bio-fuel program is more pronounced than it is in the United States. The feed cost index for Canada over the period of analysis increases 12 percent on average (21 percent in the last three years).[13] Combined beef, pork and poultry production declines 1.3 percent on average (-2.4 percent in the last three years).

As expected, diverting this amount of grain to the production of bio-fuels would have a significant and positive impact on farm income. With the staged implementation of the

11. Normally the reduction in soybean demand caused by a reduced crush margin would result in a decline in soybean prices. However in this case, the pressure put on the land base by competing crops (e.g. wheat and corn) results in a reduction of soybean supply larger than the decline in demand resulting from the declining crush margin. This explains why the price of soybean under this scenario is higher than in the baseline.
12. On a value basis, vegetable oil represented 70 percent of the total value of the oilseeds on average from 1995 to 2000 in the case of canola and only 30 percent in the case of soybeans.

diversion of grain to bio-fuel production, farm income increases gradually, with an improvement in net cash income of $121 million in the first year (1999) but growing to $2,165 million in the sixth year (2004).

13. The feed cost index in AGLINK is a general measure of the price of feed and it is not specific to a feed ration for a certain type of animal. Canada's relatively larger increase in feed costs (when compared to the United States) is linked to its relatively larger share of livestock production accounted for by ruminants versus non-ruminants. As grain occupies a more important share in the ruminant diet (versus protein meal) the significant increase in grain prices directly translates into higher Canadian feed costs. Conversely in the United States, protein meal makes up a larger share because of the larger share of non-ruminant in the overall livestock sector. Thus, a large drop in protein meal prices in the United States acts to a greater extent to off-set higher feed grain prices.

Conclusions

With this analysis we have identified the potential impact on grain and oilseed prices of a major bio-fuel program initiated by OECD member countries from 1999 to 2006. By incrementally raising bio-fuel production each year by one percent of the level of fossil fuel used by the transportation sector, we created a new demand for grains and vegetable oils. By 2006, total bio-fuel production corresponds to eight percent of the fossil fuel used. Although we did not attempt to determine the cost of introducing the bio-fuel program, such a program would have a dramatic impact on feed-stock prices which would ultimately reduce the overall profitability of the bio-fuel industry.

The increase in world and domestic prices for grains and vegetable oils is strong especially toward 2006. Protein meal prices, on the contrary, decline because of the increased supply of animal feed and meal as by-products of ethanol and vegetable oil production. For livestock producers, the decline in meal prices compensates to a certain extent the increase in grain prices. Also, the large impact of increased bio-diesel production on vegetable oil demand favourably increases those oilseeds with high vegetable oil content and in Canada, increases the canola processing industry. This analysis shows that a bio-fuel program of that magnitude by all OECD countries would be very beneficial to Canadian agriculture as a whole and would eliminate most problems related to low farm income. For example, in the sixth year of the analysis (2004), net cash income would be two billion (Canadian) dollars more.

In the longer term, technological innovation is likely to make the production of ethanol from biomass more economical than from grains or vegetable oils. However, the impact on world prices of cereals and oilseeds would still likely be significant because the world supply of food would be lower, since land formerly used to produce food crops would be diverted to biomass crops used for ethanol production. The final impact would depend on how much ethanol would be produced on land currently used for grain production as opposed to land currently devoted to other uses such as forest products. Further research should address two questions. What would be the share of the biomass crop versus forest products in the production of ethanol? How much would the world supply of crops for food be reduced?

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Appendix

Table 1: Combined Gasoline and Diesel Used by the Transportation Sectors of OECD Countries

	Fuel Use (million metric tonnes)			Gasoline/Diesel Share (average %, 1999–2006)	
	Avg 1996-1998	**1999**	**2006 f**	**Gasoline**	**Diesel**
Australia	19.2	19.7	21.5	65.4	34.6
Canada	37.4	39.5	47.2	69.4	30.6
Czech. Republic	3.2	3.4	4.1	57.7	42.3
European Union	235.4	239.9	274.9	45.2	54.8
Hungary	2.5	2.7	3.7	48.7	51.3
Iceland	0.2	0.2	0.2	76.8	23.2
Japan	70.9	72.4	86.1	58.8	41.2
Korea	19.1	17.4	28.7	44.9	55.1
Mexico	30.2	30.6	32.3	71.2	28.8
New Zealand	3.3	3.5	4.5	58.2	41.8
Norway	3.7	3.9	4.6	40.1	59.9
Poland	8.1	8.3	12.2	62.8	37.2
Switzerland	4.4	4.9	5.7	81.7	18.3
Turkey	9.6	9.0	9.8	49.3	50.7
United States	445.4	464.7	536.2	75.7	24.3
Total OECD*	893.0	920.1	1071.9	64.4	35.6

Historical Source: Oil Information 2000, International Energy Agency, Paris.

Note: f is forecast by AAFC.
* Slovakia excluded.

Table 2: Additional Bio-fuel Production, OECD

	1999	2000	2001	2002	2003	2004	2005	2006
Bio-fuel % of OECD Transport Sector Fuel Usage	1	2	3	4	5	6	7	8
Increase in Bio-fuel Production and Feed-stock Usage (million tonnes)								
Ethanol Production*	2.0	9.5	17.2	25.2	33.6	42.5	51.7	61.4
Corn Oil	0.0	0.4	0.7	1.1	1.5	1.9	2.4	2.8
Wheat Feed-stock	1.9	4.4	6.9	9.6	12.4	15.3	18.4	21.6
Corn Feed-stock	3.2	22.8	43.1	64.1	86.3	109.6	134.1	159.8
Bio-diesel Production*	1.6	3.7	5.9	8.2	10.6	13.0	15.6	18.3
Veg. Oil Feed-stock	1.4	3.3	5.3	7.4	9.5	11.7	14.1	16.5
Total Bio-fuel	3.6	13.2	23.1	33.4	44.2	55.5	67.3	79.7
Total Feed-stock	6.6	30.1	54.6	80.0	106.7	134.8	164.2	195.0
Amount of Livestock Feed Displaced by Increased By-product Production (million tonnes)								
Protein Meal	0.9	4.6	8.3	12.3	16.4	20.8	25.3	30.1
Wheat	0.3	0.8	1.2	1.7	2.2	2.7	3.2	3.8
Corn	0.4	2.7	5.0	7.4	9.9	12.6	15.3	18.3
Total By-product	1.6	8.1	14.5	21.4	28.5	36.1	43.8	52.2

* Note that ethanol and bio-diesel production will not represent exactly 1% of gasoline and 1% of diesel use in OECD countries. This is partially due to Canada and the United States meeting their commitments solely by producing ethanol and the European Union meeting its commitment through relatively higher levels of bio-diesel production. In addition, we assume that the 10% methanol (petroleum based) component required to produce bio-diesel is accounted for by an equivalent amount of increased ethanol production.

Table 3: Additional Bio-fuel Production, United States

	1999	2000	2001	2003	2003	2004	2005	2006
Bio-fuel % of USA Transport Sector Fuel Usage	1	2	3	4	5	6	7	8
Increase in Bio-fuel Production and Feed-stock Usage (million tonnes)								
Ethanol Production	0.0	4.7	9.6	14.7	20.0	25.6	31.4	37.5
Corn Oil	0.0	0.4	0.7	1.1	1.5	1.9	2.4	2.8
Wheat Feed-stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corn Feed-stock	0.0	15.7	31.9	48.5	66.0	84.6	103.9	124.1
Bio-diesel Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Veg. Oil Feed-stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Bio-fuel	0.0	4.7	9.6	14.7	20.0	25.6	31.4	37.5
Total Feed-stock	0.0	15.3	31.2	47.4	64.6	82.6	101.5	121.3
Amount of Livestock Feed Displaced by Increased By-product Production (million tonnes)								
Protein Meal	0.0	2.5	5.1	7.8	10.6	13.6	16.7	20.0
Wheat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corn	0.0	1.7	3.5	5.3	7.2	9.2	11.3	13.5
Total By-product	0.0	4.2	8.6	13.1	17.8	22.9	28.1	33.5

Table 4: Additional Bio-fuel Production, Canada

	1999	2000	2001	2003	2003	2004	2005	2006
Bio-fuel % of Canada Transport Sector Fuel Usage	1	2	3	4	5	6	7	8
Increase in Bio-fuel Production and Feed-stock Usage (million tonnes)								
Ethanol Production	0.2	0.6	1.1	1.5	2.0	2.5	3.0	3.6
Corn Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat Feed-stock	0.2	0.4	0.8	1.1	1.4	1.8	2.1	2.5
Corn Feed-stock	0.6	1.6	2.8	3.9	5.2	6.5	7.8	9.2
Bio-diesel Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Veg. Oil Feed-stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Bio-fuel	0.2	0.6	1.1	1.5	2.0	2.5	3.0	3.6
Total Feed-stock	0.7	2.1	3.5	5.0	6.6	8.2	9.9	11.7
Amount of Livestock Feed Displaced by Increased By-product Production (million tonnes)								
Protein Meal	0.1	0.4	0.6	0.9	1.2	1.4	1.7	2.1
Wheat	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.4
Corn	0.1	0.2	0.4	0.5	0.7	0.9	1.0	1.2
Total By-product	0.2	0.7	1.1	1.6	2.1	2.6	3.1	3.7

Table 5: Additional Bio-fuel Production, European Union

	1999	2000	2001	2003	2003	2004	2005	2006
Bio-fuel % of EU15 Transport Sector Fuel Usage	1	2	3	4	5	6	7	8
Increase in Bio-fuel Production and Feed-stock Usage (million tonnes)								
Ethanol Production	0.7	1.8	2.9	4.1	5.3	6.6	7.9	9.3
Corn Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat Feed-stock	0.7	1.9	3.1	4.3	5.6	6.9	8.3	9.7
Corn Feed-stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bio-diesel Production	0.9	2.3	3.7	5.2	6.8	8.4	10.1	11.8
Veg. Oil Feed-stock	0.8	2.0	3.3	4.7	6.1	7.6	9.1	10.6
Total Bio-fuel	1.6	4.1	6.6	9.3	12.1	15.0	18.0	21.1
Total Feed-stock	1.5	3.9	6.4	9.0	11.7	14.5	17.4	20.3
Amount of Livestock Feed Displaced by Increased By-product Production (million tonnes)								
Protein Meal	0.1	0.4	0.6	0.9	1.1	1.4	1.6	1.9
Wheat	0.1	0.3	0.5	0.8	1.0	1.2	1.5	1.7
Corn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total By-product	0.2	0.7	1.1	1.7	2.1	2.6	3.1	3.6

Table 6: Additional Bio-fuel Production, Other OECD Countries

	1999	2000	2001	2003	2003	2004	2005	2006
Bio-fuel % of Other OECD Countries Transport Sector Fuel Usage	1	2	3	4	5	6	7	8
Increase in Bio-fuel Production and Feed-stock Usage (million tonnes)								
Ethanol Production	1.1	2.3	3.6	4.9	6.3	7.8	9.4	11.1
Corn Oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat Feed-stock	1.1	2.0	3.1	4.2	5.4	6.6	7.9	9.3
Corn Feed-stock	2.7	5.5	8.5	11.6	15.0	18.6	22.4	26.4
Bio-diesel Production	0.7	1.4	2.2	2.9	3.8	4.7	5.6	6.5
Veg. Oil Feed-stock	0.6	1.3	1.9	2.7	3.4	4.2	5.0	5.9
Total Bio-fuel	1.8	3.7	5.8	7.8	10.1	12.5	15.0	17.6
Total Feed-stock	4.4	8.8	13.5	18.5	23.8	29.4	35.3	41.6
Amount of Livestock Feed Displaced by Increased By-product Production (million tonnes)								
Protein Meal	0.6	1.3	2.0	2.7	3.5	4.3	5.2	6.1
Wheat	0.2	0.4	0.5	0.7	0.9	1.2	1.4	1.6
Corn	0.4	0.7	1.1	1.5	2.0	2.5	3.0	3.5
Total By-product	1.2	2.4	3.6	4.9	6.4	8.0	9.6	11.2