



***Introducing First and Second Generation Biofuels into GTAP
Data Base version 7****

By

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GTAP Research Memorandum No. 21

February 2011

***Partial funding for the research underlying this research memorandum was provided by Argonne National Laboratory and the California Energy Commission.**

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Introduction

The first version of GTAP-BIO Data Base was built based on the GTAP standard data base version 6 which represents the world economy in 2001 (Taheripour et al., 2007). That data base covers global production, consumption, and trade of the first generation of biofuels including ethanol from grains (*eth1*), ethanol from sugarcane (*eth2*), and biodiesel (*biod*) from oilseeds in 2001.

Version 7 of GTAP Data Base, which depicts the world economy in 2004, is now published (Narayanan, B.G. and T.L. Walmsley, 2008). However, this standard data base does not include biofuel industries explicitly. The first objective of this research memorandum is to introduce the first generation of biofuels into this new data base. To accomplish this task we will follow Taheripour et al. (2007).

The rapid expansion of the first generation of biofuels in the past decades has raised important concerns related to food-fuel competition, land use change, and other economic and environmental issues. These issues have increased interest in the second generation of biofuels which can be produced from cellulosic materials such as dedicated crops, agricultural and forest residues, and waste materials. To examine the economic and environmental consequences of the second generation of biofuels, a CGE model is an appropriate and essential instrument. A data base which presents the first and second generation of biofuels will facilitate research in this field. Hence the second objective of this research memorandum is to expand the space of biofuel alternatives to the second generation. Given that advanced cellulosic biofuels are not yet commercially viable, we

used the most up to date information in this area to define the production technologies for these industries.

Several changes and modifications are made in the original GTAP-BIO Data Base version 6 over the past three years. In particular, in these modifications the space of GTAP commodities is expanded to capture and represent the direct and indirect links between crop, biofuel, food, feed, and vegetable oil industries. The outlines of these changes and modifications are covered in several papers and reports (for example see Taheripour et al. (2010); Taheripour, Hertel, and Tyner (2010); and Tyner et al (2010). We introduce these modifications into the new version of our data base as well.

This report is organized as follows. First, we explain the steps that we followed to introduce explicitly first generation biofuels into the new data base. Then we explain how the space of GTAP commodities is expanded for the food, feed, and vegetable oil industries. After that, advanced cellulosic biofuel and its related activities along with our assumptions in this area are introduced. Then, we introduce additional data bases which we combined with GTAP-BIO Data Base to support studies in the area of biofuels. The last section of this research memorandum provides a summary of the changes.

1. Introducing first generation biofuels into GTAP Data Base V7

To introduce grain based ethanol (*eth1*), sugarcane based ethanol (*eth2*), and biodiesel from oilseeds (*biod*) into the new data base, we replicate the original work done by Taheripour et al. (2007) with some modifications. Hence in this section we briefly explain the steps which we followed and the data items which we used. In addition, we highlight differences between the new data base and the original one.

1.1. Step one; Production and trade of biofuels in 2004

We collected data on consumption and trade of biofuels in 2004 from several sources including DOE, USDA, Renewable Fuel Association, European Union of Ethanol Producers, European Biodiesel Board, and others. Table A1 represents production of grain based ethanol, sugarcane based ethanol, and biodiesel across the world in 2004. Figures reported in the first two columns of this table are introduced into the GTAP-BIO Data Base version 7 as productions of *eth1* and *eth2* in 2004. However, we observed that the input-output tables of some regions/countries do not support biodiesel production at the levels reported in the third column of Table A1. We adjusted the biodiesel production figures of these regions to the levels that can be supported by their input-output tables. These adjusted biodiesel production figures are reported in the last column of Table 1. This table indicates that Brazil and US are the leading countries in producing sugarcane based ethanol and grain based ethanol, respectively, in 2004. However, these two regions do not produce significant amounts of biodiesel. Some European countries (in particular Germany, France, and Italy) were the main producers of biodiesel in 2004.

Table 1. Global Biofuel Production in 2004 (million gallons)

Country Code in GTAP V7	Country Name	Grain Based Ethanol (eth1)	Sugarcane Based Ethanol (eth2)	Biodiesel	Biodiesel (introduced in GTAP7)
BRA	Brazil	0.0	3989.0	0.0	0.0
USA	USA	3410.0	0.0	28.0	28.0
CHN	China	100.5	0.0	0.0	0.0
ESP	Spain	67.1	0.0	3.9	3.9
CAN	Canada	52.8	0.0	0.0	0.0
IND	India	0.0	42.5	0.0	0.0
FRA	France	26.7	0.0	104.5	16.5
SWE	Sweden	18.8	0.0	0.4	0.4
THA	Thailand	0.0	14.8	0.0	0.0
POL	Poland	12.7	0.0	0.0	0.0
ARG	Argentina	0.0	8.4	0.0	0.0
XCB	Caribbean	0.0	7.4	0.0	0.0
DEU	Germany	6.6	0.0	310.7	25.7
AUS	Australia	0.0	6.6	0.0	0.0
JPN	Japan	6.2	0.0	0.0	0.0
PHL	Philippines	0.0	4.4	0.0	0.0
NLD	Netherlands	3.7	0.0	0.0	0.0
LVA	Latvia	3.2	0.0	0.0	0.0
FIN	Finland	0.8	0.0	0.0	0.0
ITA	Italy	0.0	0.0	96.1	96.1
DNK	Denmark	0.0	0.0	21.0	1.0
CZE	Czech Republic	0.0	0.0	18.0	1.0
AUT	Austria	0.0	0.0	17.1	1.1
SVK	Slovakia	0.0	0.0	4.5	4.5
BGR	UK	0.0	0.0	2.7	2.7
LTU	Lithuania	0.0	0.0	1.5	1.5

Sources: DOE, USDA, Renewable Fuel Association, European Union of Ethanol Producers, and European Biodiesel Board

In 2004 trade of biofuel was limited. In this year, Brazil was the leading ethanol exporter in the world. Table 2 shows the Brazilian ethanol exports in 2004. In this year several countries, mainly US and India, were importing ethanol from Brazil. These

figures are introduced in the GTAP-BIO data base version 7 for the trade of *eht2*. In this year trade of *eht1* and *biod* were negligible.

Table 2. Brazil ethanol exports by importing countries
(Million gallons)

Country Code in GTAP V7	Country Name	Imports from Brazil
CHL	Chile	0.5
CRI	Costa Rica	30.5
XCA	El Salvador	7.5
IND	India	125.1
XCB	Jamaica	35.1
JPN	Japan	58.4
MEX	Mexico	1.0
NLD	Netherlands	43.6
NGA	Nigeria	28.2
XSM	Others	68.5
KOR	South Korea	72.8
SWE	Sweden	44.0
TUR	Turkey	3.2
USA	U.S.A.	111.0
VEN	Venezuela	0.1
Total		629.671

Source: Perkins (2006)

1.2. Step two; Sectors to be split and biofuels plant level models

Following the original work reported in Taheripour et al. (2007) the new industries of *eht1*, *eth2*, and *biod* are taken from the GTAP sectors of *ofd*, *crp*, and *vol*, respectively. The production technologies of ethanol industries are also similar to our original work. However, a new technology was introduced for biodiesel production. In the original GTAP-BIO Data Base the biodiesel industry was using oilseeds to produce biodiesel (as the main product) and oilseed meal as the by-product. The biodiesel industry

in the new data base uses crude vegetable oil and only produces biodiesel. Hence, in the new data base, the biodiesel industry does not produce any by-products. Instead, as explained later on in this report, we defined a new industry which uses oilseeds to produce crude vegetable oil and oilseed meals. The new approach models the role of oilseed meals in an economy with biofuels more precisely. Table 3 represents the cost structures of *eth1*, *eth2*, and *biod* industries in the new data base.

Table 3. Cost structures for the first generation of biofuels (figures are in percent)

Cost Items	Ethanol1	Ethanol2	Biodiesel
Feedstock*	39.34	26	81
Chemicals	7.87	2.1	7.1
Energy	12.38	4.5	2
Other	2.6	5	1
Labor	2.89	15.5	3
Capital	34.92	46.9	5.9
Total	100	100	100

* Corn, sugarcane, and crude vegetable oil, respectively.

The cost structures are the same as before. However, their levels are tuned to the price levels of 2004. For the revenue side we assume that the price of ethanol was about \$1.69 per gallon (this is the US average ethanol price in 2004). The price of biodiesel is determined according to its energy content compared with the energy content of ethanol as was done for 2001. In constructing the new data base we take into account the following subsidies and tariffs as well:

- US ethanol subsidy of 0.51 cents per gallon,
- US biodiesel subsidy of 100 cents per gallon,
- US ethanol tariff (2.5% ad valorem plus 54 cents/gal. specific),

We sequentially used the *SplitCom* program to split the original and parent sectors of *ofd*, *crp*, and *vol* to the new sectors of *eth1*, *eth2*, *biod*, *ofdn*, *crpn*, and *voln*. These processes are explained in detail in Taheripour et al. (2007).

1.3. Step 3; Split ethanol between the additive and final fuel

In this step we split ethanol consumption between two parts: ethanol as an additive to gasoline and ethanol as a fuel extender. Following the original work we assigned 75% of ethanol production to the additive role and the rest as a fuel consumed by consumers. In the next sections we describe the modifications to the commodity structure to better highlight the links among the crop, biofuels, food, feed, and livestock industries.

2. Split of standard GTAP food industry into food and feed industries

In the GTAP-BIO Data Bases the *ofdn* industry¹ covers production of all processed foods and animal feeds (for details see Karen Huff et al., 2000). This aggregated industry has major forward and backward links with many industries. It buys raw materials from crop, livestock, processed livestock, and vegetable oil industries and sells its products to several sectors as intermediate inputs and to households as final products. Indeed the *ofdn* covers two major industries of processed food and processed feed. To better understand the implications of biofuel production for these industries we split the *ofdn* industry into two distinct activities of “*food*” and “*feed*”. To accomplish this task we pursued the following assumptions and steps:

- a. All sale items of the *ofdn* industry to the livestock industries (i.e. *ctl*, *oap*, *rmk*, and *wol*) are assumed to be processed feed products. These items are

¹ This sector is known as *ofd* in the GTAP standard data base.

considered as sales of the *feed* industry. We applied the same rule for the imported sales of as well.

- b. In a preliminary split process we divided all cost items (including self use) of the *ofdn* industry between the new industries of *food* and *feed* according to the shares of these new industries in total sales of *ofdn* industry. Then we modified some of these cost shares according to the very detailed US 1997 input-output table obtained from The Bureau of Economic Analysis of the U.S. Departments of Commerce which provides information on the cost structures of feed and food industries.

Given these assumptions we defined column, row, and cross shares for the split process in each region. We introduced the column, row, and cross shares into the *Splitcom* program to split the *ofdn* industry into two new industries. We allow the *Splitcom* program to determine the trade shares as the residual. Table 4 represents the monetary values of outputs of these new industries at market prices by region (aggregated to 19 regions introduced in Table 11) in the new data base.

Table 4. Monetary values of outputs of food and feed industries in GTAP-BIO V7 at market prices (US million dollars)

Region*	Food	Feed	Region*	Food	Feed
1 USA	246814	41705	11 Mala_Indo	21387	3180
2 EU27	733821	63189	12 R_SE_Asia	21066	2847
3 BRAZIL	27289	2848	13 R_S_Asia	4479	884
4 CAN	25267	4160	14 Russia	15451	2653
5 JAPAN	151207	16377	15 Oth_CEE_CIS	24708	2858
6 CHIHKG	66813	21049	16 Oth_Europe	18959	1703
7 INDIA	27409	2028	17 MEAS_NAfr	27041	3211
8 C_C_Amer	62098	5289	18 S_S_AFR	27955	3693
9 S_o_Amer	30534	3951	19 Oceania	21894	2331
10 E_Asia	21986	5709			

* Members of these regions are shown in table 11

3. Split of standard GTAP vegetable oil industry into crude and refined vegetable oil industries

In the GTAP-BIO Data Base the “*voln*” industry² covers production of all types of vegetable oils and fats (for details see Karen Huff et al., 2000). This industry produces crude and refined vegetable oils; animal and vegetable fats; and all types of oilseed meals, oil cakes, and other residues resulting from the extraction of vegetable oils and fats. This industry buys all types of oilseeds and animal fats along with other inputs and sells its products mainly to the livestock and processed livestock industries, food industries, processed animal feed industries, chemical industries, services (restaurants and fast food), and households. In an economy with biofuels, the *vol* industry interacts with the biodiesel industry as well.

To better represent the forward and backward links between crop, vegetable oil, livestock, food, feed and biofuel industries and follow the stream of commodities among these industries, we split the *voln* sector into two distinct industries of crude vegetable oil (*cvoln*) and refined vegetable oil (*rvoln*). The former industry crushes oilseeds and produces two commodities: crude vegetable oil and oilseed by-products. The latter industry uses crude vegetable and produces refined vegetable oil. To divide the *voln* industry into the new sectors we pursued the following steps and assumptions:

- a. All sale items of the *voln* industry to the livestock and feed industries (i.e. *ctl*, *oap*, *rmk*, *wol*, and *feed*) are assumed to be animal feed. These items are mainly oilseed meals, oil cakes, and other residues resulting from the extraction of vegetable oils and fats. These items are considered as sales of

² This sector is known as *vol* in the GTAP standard data base.

the *cvoln* industry. We applied the same rule for the imported sales as well.

- b. The self use of the *voln* industry (mainly crude vegetable oil) is considered as an intermediate input for the *rvoln* industry. This item is also included in the sale items of the *cvoln* industry.
- c. In biodiesel producing regions, sales of *voln* to the biodiesel industry are transferred to the *cvoln* industry.
- d. All crop and livestock commodities purchased by the *voln* industry are transferred to the *cvoln* industry.
- e. Other cost items of the *voln* industry are mainly divided between the *cvoln* and *rvoln* based on the sale shares of these two industries in total sale of the *voln* industry. In some cases we modified the cost shares according to the cost shares obtained from the US input-output table.

Given these assumptions we defined column, row, and cross shares for the split process in each region. We introduced the column, row and cross shares into the *Splitcom* program to split the *voln* industry into two new industries. We allow the *Splitcom* program to determine the trade shares as the residual. In some cases we altered the trade shares to match the results with real observation obtained from the Oil World database (Mielke, 2006). Table 5 represents the monetary values of outputs of these two new industries at market prices by region (aggregated to 19 regions introduced in Table 11) in the new data base.

Table 5. Monetary values of outputs of crude and refined vegetable oil industries in GTAP-BIO V7 at market prices (US million dollars)

Region*	Cveg	Rveg	Region*	Cveg	Rveg
1 USA	7976	8198	11 Mala_Indo	6361	11414
2 EU27	6762	30123	12 R_SE_Asia	844	2506
3 BRAZIL	5421	6077	13 R_S_Asia	954	2499
4 CAN	1118	2237	14 Russia	511	1686
5 JAPAN	1657	3946	15 Oth_CEE_CIS	1242	3460
6 CHIHKG	3617	3956	16 Oth_Europe	112	660
7 INDIA	2952	5275	17 MEAS_NAfr	962	2849
8 C_C_Amer	870	3380	18 S_S_AFR	926	2662
9 S_o_Amer	5627	6797	19 Oceania	425	2085
10 E_Asia	865	1206			

* Members of these regions are shown in table 11

4. Introducing by-products into the data base

Here we introduce two by-products into the data base. The first by-product is Dried Distillers Grains with Solubles (*DDGS*), produced jointly with ethanol from grains. The second by-product is oilseed meals (*VOBP*). To introduce *DDGS* we determined the volume of *DDGS* produced in each region according to ethanol production in each region. Then, we assessed the monetary value of the *DDGS* produced in each region according to the average price of *DDGS* in the US in 2004. In this year US was the main exporter of *DDGS*. Hence we introduced US *DDGS* exports to other regions for the trade of this commodity. As noted earlier in this report we distinguished oilseed meals produced by the *cvoln* industry in section “3.a” of this report. Here, we just explicitly separate them out from the main product and refer to them as *VOBP*. Table 6 represents the monetary values of *DDGS* and *VOBP* at market prices by region in the new data base.

Table 6. Monetary values of outputs of DDGS and VOBP in GTAP-BIO V7 at market prices (US million dollars)

Region*	DDGS	VOBP	Region*	DDGS	VOBP
1 USA	1157	5139	11 Mala_Indo	0	1001
2 EU27	48	2218	12 R_SE_Asia	0	146
3 BRAZIL	0	1289	13 R_S_Asia	0	496
4 CAN	18	488	14 Russia	0	73
5 JAPAN	2	706	15 Oth_CEE_CIS	0	187
6 CHIHKG	34	2126	16 Oth_Europe	0	30
7 INDIA	0	885	17 MEAS_NAfr	0	204
8 C_C_Amer	0	342	18 S_S_AFR	0	224
9 S_o_Amer	0	1103	19 Oceania	0	40
10 E_Asia	0	449			

* Members of these regions are shown in table 11

5. Introducing cellulosic feedstock industries into the data base

The advanced cellulosic biofuels can be produced from different feedstocks including agricultural residues such as corn stover and wheat straw, dedicated crops such as miscanthus and switchgrass, forest residues, and other waste materials. As the first effort aimed at formally introducing liquid advanced biofuels into the GTAP Data Base we introduced the following feedstock industries:

- Corn stover industry, which collects corn stover from croplands and delivers the collected corn stover to the cellulosic biofuel industries,
- Dedicated crop industry, which produces a dedicated crop (Miscanthus) and delivers its output to the cellulosic biofuel industries.

Since these new industries do not operate in real world, we used the most up to date information available in the literature to define the cost structures of these industries and their production technologies. To define the cost structures of these new activities we first determined costs of producing Miscanthus and corn stover according to US prices in 2008. The production costs of these items are shown are in Table 7. This table shows that

the production costs of corn stover and miscanthus are evaluated at \$87.54 and \$115.74 per short ton at 2008 prices, respectively.

Table 7. Costs of corn stover collection and miscanthus production at 2008 prices
(US dollars per dry short ton)

Cost items	Stover	Miscanthus
Fertilizer	13.37	13.37
Harvest	43.02	44.33
Transport	20.52	12.66
Storage	10.63	10.63
Others (including rent)	0.00	34.75
Total cost	87.54	115.74

Source: Miranowski, J., and A. Rosburg. 2010.

Then we adjusted these cost items to the price level of 2004 to make them consistent with the price level of GTAP Data Base. According to our calculations corn stover and miscanthus are priced at \$42.3 and \$55.9 per short ton respectively at 2004 prices based on the difference in corn prices. We converted cost items noted in Table A6 in terms of cost items in GTAP Data Base. These cost structures are shown in table 8. This table indicates that capital is a major cost item in these new industries. This table also shows that items such as transportation, fertilizer, and labor have significant shares in the cost structures of these new industries. As shown in Table 8, unlike the corn stover industry, the miscanthus industry uses land as an input in its production process. The cost of land for miscanthus industry is determined based on a yield rate of 21.4 short tons per hectare and a rent value of about \$30 per hectare.

To introduce the corn stover and miscanthus industries into the data base we assumed that some regions including US, Brazil, China, France, Germany, and UK produce tiny amounts of stover (10000 metric tons) and miscanthus (10000 metric tons)

in 2004 and convert them to advance biofuel. The *SplitCom* program is used to introduce these industries into the data base.

Table 8. Cost structures of corn stover and Miscanthus activities

Cost Items	Corn Stover	Miscanthus
Fertilizer	15.3	11.6
Transportation	23.4	10.9
Fuel	2.0	4.0
Payments to seed company	0.0	8.1
Other costs	7.0	10.0
Labor	10.5	18.
Land	0.0	2.4
Capital (including profit)	41.7	35.0
Total	100.0	100.0

Source: Author's estimates

6. Introducing advanced cellulosic biofuels into the data base

There are several pathways to convert cellulosic materials to liquid fuels. In this experiment we used a thermochemical technology which converts cellulosic materials to bio-gasoline with energy content identical to the conventional gasoline. Two cellulosic biofuel producers which convert cellulosic feedstocks to the advanced biofuel are introduced into the data base. The first advanced biofuel producer (advf1) converts miscanthus to bio-gasoline and the second one (advf2) uses corn stover to produce bio-gasoline. It is assumed that the advanced biofuel industries can convert cellulosic materials to bio-gasoline at a rate of 77.1 gallons per metric ton of feedstock. It is also assumed that the price of bio-gasoline is equal to its production costs and that both bio-gasoline producers follow the same cost structure, which is shown in table 9. This table indicates that capital and feedstock are major cost items for bio-gasoline producers. These industries do not produce by-products. It is also assumed that the advanced biofuel

producers will get \$1.01 subsidy per gallon of fuel in the base case. The *SplitCom* program is used to introduce these industries into the GTAP-BIO.

Table 9. Cost structures of advance biofuel producers

Costs Items	Cost shares
Feedstock	28.2
Energy	1.4
Other costs	23.3
Labor	3.3
Capital	43.8
Total	100.0

Source: Miranowski, J., and A. Rosburg (2010) and National Academy of Sciences (2009)

7. Other modifications and components

In our earlier work on GTAP Data Base version 6 we realized that the input-output table of Malaysia does not properly reflect its palm oil industry. In addition, we noticed that distribution of coarse grains across livestock industries of the US does not match with independent data in this area. We noticed these problems in the version 7 as well. Proper modifications are used to resolve these problems.

To support and facilitate research on the economic and environmental consequences of international biofuel programs, we added several headers to the data base as well. These headers encompass land use and land cover by country and Agro Ecological Zones (AEZ) in 2004, land rents by country and AEZ in 2004, Global liquid biofuel consumption in 2004, emissions data due to production and consumption of all types of energy commodities, and crop production and harvested areas in 2004 by country and AEZ. The land use headers are obtained from Avetisyan, Baldos, and Hertel (2010). These authors provided global land cover and harvested area by AEZ for 2004. The initial distribution of land used by the miscanthus industry across AEZs for the US is

determined according to the USDA reports, and for other regions we used a uniform distribution.

8. Generated data bases

We made several data bases available. The first version presents data for 113 countries and 62 groups of commodities including standard GTAP commodities plus new industries of *eth1*, *eth2*, *biod*, *food*, *feed*, *cveg*, and *rveg* industries. In this version *DDGS* and oilseed meals (*VOBP*) are imbedded in the data of their corresponding industries. However, they are not presented as separate commodities. Henceforth we will refer to this data base as **GTAP-BIO_V7**. The second version includes the second generation of biofuels and their feedstock supporting industries including *misc*, *stover*, *advf1*, and *advf2* as well. Henceforth we will refer to this data base as **GTAP-BIO_ADV_V7**. Finally, we provide an aggregated version of GTAP-BIO_ADV_V7 data base according to the regional and commodity aggregation schedules presented in tables 10 and 11. In this aggregated version the grain based ethanol industry provides two distinct commodities of ethanol and *DDGS* and the crude vegetable oil industry provides two distinct commodities of crude vegetable oil and *VOBP*. The GTAP-BIO_ADV_V7 and its aggregated version are not yet available for public use.

Table 10. List of industries and commodities in the new model

Industry	Commodity	Description	Name in the GTAP_BIOB
Paddy_Rice	Paddy_Rice	Paddy rice	Pdr
Wheat	Wheat	Wheat	Wht
CrGrains	CrGrains	Cereal grains	Gro
Oilseeds	Oilseeds	Oil seeds	Osd
OthAgri	OthAgri	Other agriculture goods	ocr, pfb, v_f
Sugarcane	Sugarcane	Sugar cane and sugar beet	c-b
Miscanthus	Miscanthus	A dedicated crop to be used in biofuel	New
Stover	Stover	Collected corn stover to be used in biofuel	New
DairyFarms	DairyFarms	Dairy Products	Rmk
Ruminant	Ruminant	Cattle & ruminant meat production and	Ctl, wol
NonRum	Non-Rum	Non-ruminant meat production	oapl
ProcDairy	ProcDairy	Processed dairy products	Mil
ProcRum	ProcRum	Processed ruminant meat production	Cmt
ProcNonRum	ProcNonRum	Processed non-ruminant meat production	Omt
Forestry	Forestry	Forestry	Frs
Cveg_Oil	Cveg_Oil	Crude vegetable oil	A portion of vol
	VOBP	Oil meals	A portion of vol
Rveg_Oil	Rveg_Oil	Refined vegetable oil	A portion of vol
Proc_Rice	Proc_Rice	Processed rice	Pcr
Bev_Sug	Bev_Sug	Beverages, tobacco, and sugar	b_t, sgr
Proc_Food	Proc_Food	Processed food products	A portion of ofd
Proc_Feed	Proc_Feed	Processed animal feed products	A portion of ofd
OthPrimSect	OthPrimSect	Other Primary products	fsh, omn
Coal	Coal	Coal	Coa
Oil	Oil	Crude Oil	Oil
Gas	Gas	Natural gas	gas, gdt
Oil_Pcts	Oil_Pcts	Petroleum and coal products	p-c
Electricity	Electricity	Electricity	Ely
En_Int_Ind	En_Int_Ind	Energy intensive Industries	crpn, i_s, nfm, fmp
Oth_Ind_Se	Oth_Ind_Se	Other industry and services	atp, cmn, cns, ele, isr, lea, lum, mvh, nmm, obs, ofi, ome, omf, otn, otp, ppp, ros, tex, trd, wap, wtp
NTrdServices	BTrdServices	Services generating Non-C02 Emissions	wtr, osg, dwe
Advf-Stover	Advf-Stover	Bio-Gasoline produced from corn stover	New
Advf-Misc	Advf-Misc	Bio-Gasoline produced from miscanthus	New
EthanolC	Ethanol1	Ethanol produced from grains	New
	DDGS	Dried Distillers Grains with Solubles	New
Ethanol2	Ethanol2	Ethanol produced from sugarcane	New
Biodiesel	Biodiesel	Biodiesel produced from vegetable oil	New

Table 11. Regions and their members

Region	Description	Corresponding Countries in GTAP
USA	United States	Usa
EU27	European Union 27	aut, bel, bgr, cyp, cze, deu, dnk, esp, est, fin, fra, gbr, grc, hun, irl, ita, ltu, lux, lva, mlt, nld, pol, prt, rom, svk, svn, swe
BRAZIL	Brazil	Bra
CAN	Canada	Can
JAPAN	Japan	Jpn
CHIHKG	China and Hong Kong	chn, hkg
INDIA	India	Ind
C_C_Amer	Central and Caribbean Americas	mex, xna, xca, xfa, xcb
S_o_Amer	South and Other Americas	col, per, ven, xap, arg, chl, ury, xsm
E_Asia	East Asia	kor, twm, xea
Mala_Indo	Malaysia and Indonesia	ind, mys
R_SE_Asia	Rest of South East Asia	phl, sgp, tha, vnm, xse
R_S_Asia	Rest of South Asia	bgd, lka, xsa
Russia	Russia	Rus
Oth_CEE_CIS	Other East Europe and Rest of Former Soviet Union	xer, alb, hrw, xsu, tur
R_Europe	Rest of European Countries	che, xef
MEAS_NAfr	Middle Eastern and North Africa	xme,mar, tun, xnf
S_S_AFR	Sub Saharan Africa	Bwa, zaf, xsc, mwi, moz, tza, zmb, zwe, xsd, mdg, uga, xss
Oceania	Oceania countries	aus, nzl, xoc

9. Summary

This research outlines the second effort to formally disaggregate first generation biofuels in GTAP Data Base and presents the first attempt to introduce second generation biofuels in this data base. Following the original work in this area, three types of biofuels (including grain based ethanol, sugarcane based ethanol, and biodiesel) represent the first generation. For the second generation we only introduced bio-gasoline which represents a thermochemical pathway. Here we assume biofuel technologies are the same for all countries with minor adjustments. Given the fact that the second generation biofuels are not commercially viable yet, we relied on the literature in this area. In developing this data base it is assumed that the corn stover and corn industries do not interact. This is a valid assumption as long as considerable amounts of corn stover are available to use with minor consequences for the corn industry.

In our earlier work in this area we recognized that the existing input-output tables in the GTAP Data Base are not very consistent in their treatment of flow of inputs to biofuel sectors and uses of these products. We observed the same problem in the new data base. In particular, in several cases the input-output tables do not represent uses of oilseeds in the vegetable oil industries. Finally, we emphasize that providing original input-output tables with explicit biofuel activities should be considered as a major goal in developing new data bases.

References

- Avetisyan, M., U. Baldos, and T. Hertel, *Development of the GTAP Version 7 land Use Data Base*, in *GTAP Research Memorandum No. 19*. 2010, Purdue University: West Lafayette.
- Huff, K., R. McDougall, and T. Walmsley, *Contributing Input-Output Tables to the GTAP Data Base*, *GTAP Technical Paper Number 1*. 2002.
- Mielke, T., *Oil World Annual 2006*. 2006, ISTA Mielke GmbH: Hamburg, Germany.
- Miranowski, J. and A. Rosburg, *An Economic Breakeven Model of Cellulosic Feedstock Production and Ethanol Conversion with Implied Carbon Pricing*. 2010, Iowa State University: Ames, Iowa.
- National Academy of Sciences, National Academy of Engineering, and National Research Council, *Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts*. 2009: National Academies Press.
- Narayanan, B.G. and T.L. Walmsley, eds. *Global Trade, Assistance, and Production: The GTAP 7 Data Base*. 2008, Center for Global Trade Analysis, Purdue University.
- Perkins, M., *Brazil Biofuels Annual 2006*. 2006, USDA/FAS Global Agricultural Information Network Report BR6008, Washington, D.C.
- Taheripour, F., et al., *Introducing Liquid Biofuels into the GTAP Data Base*, in *GTAP Research Memorandum No 11*, GTAP, Editor. 2007, Purdue University: West Lafayette, IN.
- Taheripour, F., T. Hertel, and W. Tyner, J. Beckman, and D. Birur. *Biofuels and Their By-Products: Global Economic and Environmental Implications*. Biomass and Bioenergy, 2010. 34: p. 278-89.
- Tyner, W., et al., *Land Use Changes and Consequent CO₂ Emissions due to US Corn Ethanol Production: A Comprehensive Analysis, A Report to Argonne National Laboratory*. 2010, Department of Agricultural Economics, Purdue University.