GTAP-PBIO: A GTAP Model and Data Base that Incorporates Biofuels Sector of Pakistan

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Abstract-- *This research is the first effort to incorporate Pakistan's biofuels sector into GTAP Data Base. We used dataset on production, cost shares and border trades for Pakistan and other major biofuel producing countries to update the latest version 7 of GTAP Data Base. To capture the real structure of biofuels market, we adopted multi-input-multi-output approach for the production and consumption of biofuels in GTAP Data Base. We have placed special attention on the data on Pakistan to produce a reliable simulation tool. Several necessary changes to the standard model structure were also made. Pakistan is not a big biofuels producer; however, the proposed national and global biofuels mandates can seriously change the structure of agriculture market, food security situation and income distribution in Pakistan. The proposed model can be employed to assess the impacts of global and national biofuels policies on Pakistan.*

Keywords: **CGE model, biofuels, policy, Pakistan.**

I. Introduction

Biofuels have created a complex and widely debated relationship between energy, agricultural and food markets during last decade. The production of biofuels has expanded substantially since 2004. How far the fuel can compete with food uses is a hard question to answer. There has been considerable research on the impact of biofuels on environment, energy, trade and prices, poverty and food security. Most of the literature on the impact assessment of biofuels has two common characteristics; (1) it mainly summarises the effects of biofuels production of Brazil, EU and USA, focussing on domestic and international spillover effects; (2) it uses general or partial equilibrium models (Hertel and Reimer, 2005; compares the methodologies and results of many such studies in detail). For this purpose, mostly the existing PE (partial equilibrium) or the CGE (computable general equilibrium) models have been modified to assess the effects of use of food crops for fuel production. It is recognized that most suitable analytical tool in this regard should be able to account for interactions among energy, food and other commodities, for producers, consumers, importers and exporters of these commodities. To examine the economic and environmental consequences of the biofuels, a CGE model is an appropriate and essential instrument (Taheripour and Tyner, 2011). GTAP (Global Trade Analysis Project) version 7 is one such model that covers the interactions between 57 sectors and 113 regions of the world.

Due to increasing demand for the analytical tools for impact assessment of biofuels, some authors have introduced the biofuels sectors of major biofuel producing countries into GTAP. In addition, several other countries/regions have also been included in GTAP Data Base. The resulting data bases have been used to analyze the effects of biofuels on different stockholders on national and global scales. For instance, Taheripour *et al.* (2007) in their pioneering work, introduced ethanol (produced from both sugarcane and maize feedstocks) and biodiesel (from oilseed feedstock) into the version 6 of GTAP. They also introduced by-products of biofuels into the data base. They used the *SplitCom* program developed by Horridge (2005) to introduce three biofuel sectors into the GTAP Data Base. Yang *et al* (2009) introduced biofuels into standard GTAP Data Base. They disaggregated key biofuels feedstock crops and explicitly included them in the model's data base. They used trade data from UNCOMTRADE and production data from the Food and Agriculture Organization (FAO), to separate maize from cereal grains (gro) and soybeans from oilseeds (osd) by employing "splitting" program (SplitCom) developed by Horridge (2005) was used. They built new production activities for four biofuel industry sectors i.e. sugar ethanol, corn ethanol, soybean diesel, and rapeseed diesel. The authors closely followed the method developed by Taheripour *et al.* (2007) to introduce new sectors into the GTAP Data Base. Most recently, Taheripour and Tyner (2011) introduced first and second generation biofuels into version 7 of GTAP Data Base.

There is no attempt to include biofuels sectors of Pakistan into any CGE model and thus to understand the impacts of the global and Pakistan's national biofuels developments on agriculture, food and the rest of economy. In the wake of rapid boom in global biofuel industry, it is essential to develop an analytical tool suitable to illustrate the linkages between the energy, environment, feed and food industries. This study is the first effort of its kind to introduce biofuel sector of Pakistan into GTAP model. The rest of the study is organised as follows. Section II describes the changes made to GTAP model structure. Section III presents the structure of the data base and the background data. The procedure for introduction of biofuels into the data base is detailed in section IV and summery is presented in section V.

II. Improvements in GTAP Model

First, we made several changes to improve the treatment of biofuels in GTAP model structure. We started with a standard GTAP-E, which is a modified and improved version of GTAP model and covers details on energy production and use in the model. Following the approach developed by Burniaux and Truong (2002), energy-capital substitution relationship was incorporated into standard GTAP-E model. The substitution between biofuels and fossil fuels was also accounted for in the model by adding a nested CES function to GTAP-E model. Increasing biofuels production will increase the demand for feedstock crops. An important input for feedstock crops is land, which is allocated through a constant elasticity of transformation (CET) structure in the standard GTAP model. This structure assumes that different types of land are imperfect substitutes for each other; however, all uses have the same degree of substitutability. While the first assumption seems more plausible, the second assumption makes it difficult for the model to capture the differences in substitutability that will almost surely emerge in the wake of rapid expansion of feedstock crops. For instance, sugarcane crop competes for land with wheat and cotton in Pakistan. However, it would be unrealistic to assume that the land used for cotton or wheat production could be used by sugarcane production with similar level of substitutability.

We overcame this problem by following the method described by Banse *et al.* (2008). They developed a stylized demand structure for land by producers of different crops, which allows for different degrees of substitutability among the land cultivated under different crops. We embedded a land supply curve equation into GTAP framework that allows for the expansion in land supply. We also adopted the methodology from Banse *et al.* (2008) by adding a three-level CET, nested structure to the standard GTAP model.

Standard GTAP model has a multi-input and single-output production relationship and does not account for by-products. However, this structure is not suitable for the realistic representation of biofuels sectors in the model, especially for the biofuels production in USA and EU. Biofuels generate considerable amounts of by-products. For instance, one bushel of maize used in a typical dry milling ethanol plant generates 2.7 gallons of ethanol and 18 pounds of dried distillers grains (DDGS). One gallon of biodiesel from soybean and rapeseed generates 32 pounds and 10.3 pounds soy and rapeseed meal, respectively (Taheripour *et al.,* 2008). Any model without inclusion of by-products would actually ignore significant share of revenue produced by biofuels. Therefore, a constant elasticity of transform (CET) function was adopted to allow for the optimization of output between biofuels and their by-products. Because the by-products are produced as an almost fixed share of their corresponding biofuel products, the elasticities embedded in the CET function are given small values. Similar to Taheripour *et al.* (2008), -0.005 was used in both the bio-ethanol and bio-diesel industrial sectors.

The substitution between the biofuel by-products and other feed for livestock production is also carefully considered in this model. In contrast to the standard GTAP model, two-levels of CES functions are used to reflect such substitution effects in the demand for feed by livestock sectors. In the first level, the substitutions among various feedstuffs in livestock production are allowed by following the general method of Keeney and Hertel (2005). A value (0.9) of the elasticity of substitution in this level of the nesting is assumed, which is based on the research of Keeney and Hertel (2005). In the second level, the substitutions among DDGs and maize, biodiesel by-products (BDBP) and processed feed are also incorporated into our model. Although high correlations among prices provide evidence that biofuel by-products and feedstuff are highly substitutable, there are no direct empirical estimations on these elasticities. Based on the historical simulation, Taheripour *et al.* (2008) calibrated these two elasticities. In this research, the same values were adopted as used by Taheripour (i.e. 30 for the elasticity of substitution between maize and DDGS, and 125 for the elasticity of substitution between BDBP and other processed food).

III. GTAP Data Base

GTAP is a fully documented, publicly available global data base, which contains complete bilateral trade information, transport, and protection linkages among regions and commodities for a single year. The latest version of GTAP Data Base version 7 is based on data for year 2004 and contains details for 113 countries and regions and 57 commodities and. The mathematical relationships assumed in the GTAP model are generally rather simple, and although many markets are recognized, they still have to be very aggregated-particularly for global economic analysis. Hertel *et al.* (2006) describes that all the relationships in a model could be estimated from detailed data on the economy over many years. In practice, however, their number and parameterization generally outweigh the data available. In the GTAP model, only the most important relationships have been econometrically estimated. These include the international trade elasticities (Valenzuela *et al*., 2005) and the agricultural factor supply and demand elasticities (OECD, 2001). The remaining economic relationships are based on literature reviews, with a healthy dose of theory and intuition.

A. Structure of GTAP-PBIO

The standard GTAP model is amenable to modifications to suite the research questions of biofuel policy studies in Pakistan (GTAP-PBIO). For developing a reliable data base for GTAP-PBIO, the key players in the field of global biofuels developments were carefully examined in the light of existing data and literature. Then the original 113 countries/region of GTAP were aggregated down to 17 regions of strategic importance to the biofuels research (Table I). These countries/regions are selected because one/more of the following reasons. They are either; (1) major producers/consumers of biofuels; (2) major exporters/importers of biofuels; (3) and/or major trade partners with Pakistan in recent years.

As mentioned earlier, version 7 of GTAP Data Base contains 57 sectors, however not all of these sectors are important for analysing the impacts of biofuels on agriculture and food commodities in Pakistan. Therefore, to develop the starting point for incorporating biofuels sector into the data base, these sectors were aggregated into 28 sectors. To be used as the feedstock, two original GTAP sectors were split into four new sectors. Using FAO, production, price and trade data, other crop (*ogrc)* sector was split into *maize* and the rest of other crops (*othgro)*, while oilseed crop (*osd)* sector was split into *soybean* and other oilseed crops (*othosd,* Table II).

B. Production of Biofuels

In this study, only first generation ethanol produced from maize (ethanol-1 or eth1), sugarcane, and sugar beet (ethamol-2 or eth2); and biodiesel produced from oil seed crops like soybean, rapeseed, and sunflower (biod) are introduced into GTAP Data Base. Table III provides the total value (million $US) of both ethanols and biodiesel produced by each country/region of the model in 2004. This data were obtained from various sources ranging from International Energy Agency (IEA), RFA Outlook reports, GAIN reports for various countries and some country reports. In most cases, the dollar values of the biofuels were obtained by multiplying the quantities with the US average price for 2004.

Pakistan produced about 33 million gallons of ethanol worth over $US 55 million in 2004. Almost all of this ethanol was produced from molasses, which in turn is a by-product of sugar production from sugarcane and is synthesized in the distilleries attached with sugar mills. These sugar mills also use bagasse to produce heat needed for the production of sugar and ethanol.

C. Production Costs for Biofuels

Production structure of biofuels is very important for splitting procedure. For each type of biofuels, specific plant-level cost of production models was used. Input cost shares from Tiffany and Eidman (2003) were used for eth1. Information from USDA (2006), Geller (1985) and OECD (2006) were used for eth2. For biodiesel, information from Haas *et al.* (2005) was used. Cost structures of all three biofuels commodities were estimated based on the information from above studies (given in Table IV). For Pakistan, the cost of production is based on our own field survey conducted in late 2008. As against Brazil, the feedstock cost is very high for Pakistan.

In general, capital cost accounts for almost half for eth2 and one third for eth1. Feedstock cost shares are more than one-quarter and one-third for eth1 and eth2. As for biodiesel, feedstock cost is more than three quarters, much higher than that for ethanol.

D. International Trade in Biofuels

International trade of a commodity plays the most important role in spilling the inland effects across borders. Trade data for ethanol among the GTAP-PBIO countries were obtained from the United Nations Commodity Trade Statistics Data base (UN comtrade) for 2004[1]. This data base also includes ethanol for industrial and other uses. However, due to unavailability of trade figures to separate fuel ethanols from the total trade, these data are taken as the closest possible approximation of ethanol trade across borders. As shown in Table V, Pakistan exported $US 37 worth of ethanols to other countries (excluding the ROW), which is 98% of Pakistan's total exports in 2004. Over three quarters of Pakistan's ethanol production ends up as exports, however, specific ethanol export data for Pakistan is not reported. An indirect approach was used to calculate Pakistan's ethanol exports to the EU i.e. international transportation and tariff costs were deducted from the total value of ethanol imports from Pakistan by each EU country.

1 UN comtrade reports exports and imports of undenatured ethyl alcohol of an alcoholic strength by volume of 80 % vol. or higher; ethyl alcohol and other spirits, denatured, of any strength, under HS code 2207.

Table I

Countries and Regions Used in GTAP-PBIO Data Base

Name	Details	Corresponding countries in GTAP
AUS	Australia	Australia
CHN	China	China
JPN	Japan	Japan
KOR	Korea	Korea
IDN	Indonesia	Indonesia
MYS	Malaysia	Malaysia
PHL	Philippines	Philippines
IND	India	India
PAK	Pakistan	Pakistan
CAN	Canada	Canada
USA	United States	United States
ARG	Argentina	Argentina
BRA	Brazil	Brazil
EU27	European Union 27	Austria; Belgium; Bulgaria; United Kingdom; Cyprus; Czech Republic; Germany; Denmark; Spain; Estonia; Finland; France; Greece; Hungary; Ireland; Italy; Lithuania; Luxembourg; Latvia; Malta; Netherlands; Poland; Portugal; Romania; Slovakia; Slovenia; Sweden
ZAF	South Africa	South Africa
RUS	Russian Federation	Russian Federation
ROW	Rest of World	All other regions and countries not included in any above regional Classifications

Source: Aggregate based on existing GTAP regions.

Table II

GTAP Sectors

	Name	Description	GTAP-PBIO Code	GTAP Notation
1	rice	Paddy rice	1	1, 23
2	wht	Wheat	2	2
3	maize	Maize	3	3
4	othgro	Cereal grains nec	4	3
5	v_f	Vegetables, fruit, nuts	5	4
6	soybean	Soybean	6	5
7	othosd	Oil seeds	7	5
8	ogrc	Other Crops	8	7, 8
9	milk	Raw and processed milk	9	11, 22
10	mtpd	Meat and meat products	10	14, 19, 20
11	olvs	Other Livestock animal pdts	11	9, 10, 12
12	frs	Forestry	12	13
13	coa	Coal	13	15
14	oil	Oil	14	16
15	gas	Gas	15	17
16	xtcn	Mining and Extraction	16	18, 34
17	cane	Sugarcane	17	24
18	sgr	Sugar	18	6
19	opf	Processed Food	19	21, 25, 26
20	txwp	Textiles and Clothing	20	27, 28
21	lmnf	Light Manufacturing	21	29, 30, 31, 37, 38, 39, 42
22	p_c	Petroleum, coal products	22	32
23	chem	Chemical,rubber,plastic prods	23	33
24	hvmf	Heavy Manufacturing	24	35, 36, 40, 41
25	ely	Electricity	25	43
26	utcs	Utilities and Construction	26	44, 45, 46
27	otp	Transport nec	27	48
28	wtp	Sea transport	28	49

8				
29	atp	Air transport	29	50
30	otsr	Other Services	30	47, 51, 52, 53, 54, 55, 56, 57

Source: Aggregate based on existing GTAP sectors.

Table III

Biofuels Production by Type in 2004 ($US millions)[1]

	Countries	Ethanol-1*	Ethanol-2**	Biodiesel	Total
1	Australia	0	55.8	2.6	58.4
2	China	1629.2	0	2.6	1631.8
3	Japan	1.5	0	0	1.5
4	Korea	1.5	0	2.6	4.1
5	Indonesia	0	74.4	0	74.4
6	Malaysia	1.0	0	0	1.0
7	Philippines	0	37.2	0	37.2
8	India	0	780.8	0	780.8
9	Pakistan	0	55.8	0	55.8
10	Canada	103.1	0	5.2	108.3
11	USA	5974.2	0	46.6	6020.8
12	Argentina	0	71.0	5.2	76.2
13	Brazil	0	3669.9	0	6741.4
14	EU27	305.9	0	992.0	1297.9
15	South Africa	0	185.9	0	185.9
16	Russia	334.6	0	0	334.6
17	ROW	655.7	682.8	53.3	1675.7
	Total	9004.6	5613.4	1110.1	19225.8

Notes:1. Using 2004 price US$1.69/gallon.

** Produced from maize as feedstock. ** Sugarcane feedstock.*

Source: assimilated by author from various sources such as: IEA, RFA outlook reports, GAIN reports by USDA.

Table IV

Cost of Production of Biofuels (% shares)

Main Costs	Ethanol-1	Ethanol-2	Biodiesel	Ethanol-PAK
Feedstock*	39.34	26	81	69.6
Chemicals	7.87	2.1	7.1	4.4
Energy	12.38	4.5	2	0.9
Other	2.6	5	1	3.1
Labor	2.89	15.5	3	4.4
Capital	34.92	46.9	5.9	17.6
Total	100	100	100	100

*Note: * Maize, sugarcane, and processed oilseeds and sugarcane for Ethanol-1, Ethanol-2, biodiesel, and Ethanol-PAK, respectively.*

Based on: Tiffany and Eidman (2003), USDA (2006), Geller (1985), OECD (2006) and Haas et al. (2005) and authors' own survey data.

Table V

Ethanol Trade in 2004 ($US millions)

	Australia	China	Japan	Korea	Indonesia	Malaysia	Philippines	India	Pakistan	Canada	USA	Argentina	Brazil	EU27	South Africa	Russia	ROW
Australia	0	0	4.8	0.01	0.6	0.28	2.22	0	0	0	0.23	0	0	0.01	1.14	0	6.53
China	0	0	16.46	5.19	0	0.02	0	0.2	0.02	0.02	0	0	0	0	0	0	11.06
Japan	0	0.03	0	0.1	0	0	0.23	0	0	0	0	0	0	0	0	0	0.12
Korea	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.21
Indonesia	0	0.01	3.34	0	0	0.01	2.61	0	0	0	0	0	0	0.11	0	0	3.1
Malaysia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philippines	0	0	0.07	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0.07
India	0	0	0.02	0	0	0	0.28	0	0	0	0.01	0	0	0.11	0	0	1.13
Pakistan	0	0	0	0	0	0	0	0	0	0	0	0	0	36.35	0.72	0	3.45
Canada	0.19	0	2.4	0	0	0.07	0	0	0	0	18.11	0	0	1.57	1.55	0	1.48
the USA	6.17	0.23	1.84	0.75	1.73	2.57	0.29	0.39	0	74.88	0	0.1	0.13	79.08	0.13	0	41.82
Argentina	0	0	0	0	0	0	0	0	0	0.02	6.54	0	0.13	0.01	0	0	7.05
Brazil	0	0	44.35	56.01	0	0	0.54	92.96	0	6.94	81.92	0.09	0	88.23	0.1	0	126.66
EU27	0.08	1.75	0.52	0.22	0.16	0.16	0.13	0.86	0.01	0.45	10.3	0.11	0.15	0	0.07	0.07	45.02
South Africa	0.01	0	0.09	1.51	0.36	0.07	1.03	1.53	0	0	21.06	0.06	0	5.12	0	0	34.3
Russia	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0	0	1.32
ROW	0.89	0.17	0	0.42	0.62	1.96	0.15	0.03	0	0.84	66	0.08	0.03	24.88	11.01	2.49	58.86

Source: UNCOMDTRADE data base (2010).

Among other countries, the European Union is the top importer of ethanol in 2004, with total imports of $US 204, which is around 30% of that total trade among BIOGP countries, excluding rest of the world. EU imported most of its ethanol from Brazil ($US 88.2), USA ($US 79) and Pakistan ($US 36.4). The second largest importer of ethanol in 2004 is USA at $US236. Brazil is tops the list of exporters with total exports at $US 371 (excluding exports to the ROW), mostly to India (25%), the EU (24%), the US (22%), Japan (15%) and Korea (12%). US exports ranks second, totalling at $US168 (excluding the ROW). Most of the US exports to Canada, which accounts around 45% of exports from the US, are actually DDGS. The rest of the US exports are destined for the EU. We assumed no international trade in biodiesel, given that there are only few countries producing biodiesel, which is taken as domestically consumed.

IV. Procedure for Introducing Biofuels into GTAP Data Base

The biofuels are incorporated into existing GTAP Data Base using routines from *Splitcom* program developed by Mark Horridge (Horridge, 2005)[2]. We used batch file routines to accomplish each step of the process, which has two major benefits over the original method proposed by Horridge, 2005. First, batch files produce a reusable process of splitting, which can be used quickly create/ modify any new data base. Second, any possible imbalances/errors in resulting data can be easily tracked and removed. The whole process was completed in several steps, which are explained below.

E. *Sept One:* ***Creating Preliminary Weight Arrays***

In order for the production, trade and input-cost data to be read by *Splitcom*, it needs to be transferred to a har file. To accomplish this task, *Xls2har.bat* program is used to transfer data into har file named *biof.har.* In a separate process, the basic GTAP Data Base is aggregated into 17 regions and 4 sectors (17x4 Data Base) into a new file (*wt2.har*). These four sectors are *otp* (Transport nec), *atp*(Sea transport), *wtp*(Air transport) and *tot* (all the other sectors aggregated together). *Wt2.har* and *biof.har* files are later used through a batch file to create a new file (*splitwtfinal.har*), which contains preliminary information on weight arrays. In this array file, all but feedstock inputs are allocated to biofuels according to the input cost ratios. This step also defines that both types of ethanol are treated as one commodity in sales and trade and are channelled to *otp* and *HOU* sectors for domestic consumption.

F. *Step Two:* ***Splitting of tot Sector***

As mentioned earlier, *tot* sector is an aggregate of all but three transportation sectors of GTAP Data Base. In this step, *tot* is split up into three basic sectors: *oth* (all but transportation and biofuels sectors combined together), *ethanol* (both *eth1* and *eth2* in a combined state), and *diesel* (biodiesel). The 17x4 Data Base is again used here to create a normalized data file (*intonorm.har*). A TAB file named *splitflow.tab* is used to employ data in *intonorm.har* and *splitwtfinal.har* (from step one) to create the updated data base containing 6 sectors. In this data base, the real feedstocks are still not separated to be used as input for the production of biofuels; still the newly created *oth* sector has been allocated as proxy for feedstock cost share. Note that *oth* sector contains all the feedstock sectors and will be split in later steps.

G. *Step Three:* ***Splitting of oth Sector***

This is the most important and the most complex step of the whole process of splitting GTAP sectors. It accomplishes two major tasks; (1) it restores the original and intended

2 For more information , see http://www.monash.edu.au/policy/splitcom.htm

structure of the data base, which includes new ethanol and biodiesel sectors, along with 30 original sectors mentioned in section II. (2) It completes the production and consumption structure of biofuels (excluding by-products) sectors in newly created data base. First, a 17x27 data base is normalized into *intonorm.har*. This normalized form contains information on all the regions and sectors (excluding three transportation sectors) described in section II. A TAB file *old2new.tab* reads this information from the normalized data file and creates full weights arrays file *basic.har,* which contains data on sales, cost, self-uses, and trade of 27 sectors for all 17 regions. Another TAB file named *BFSHRS.tab* is used to separate the domestic and imported shares of all the inputs for biofuels production. For instance, imported share of *cane* for the production of *eht2* is obtained by calculating the share of imported *cane* in the total sales of *cane* in each country. This imported share is multiplied by the input share of *cane* needed in the production eth2. After the imported share is accounted for, the rest of input of *cane* for *eth2* production is set to come from domestic sources. This data is stored in a file named *BFSHRS.har*. A TAB file *sharupdat.tab* is used to merge the information in *basic.har* and *BFSHRS.har* to create an updated weights file named *fnlshr1.har*. The data base produced in step two is normalized and using information from *fnlshr1.har* is split into new balanced data base. At this stage, the data base contains flows for all the regions and sectors (apart from by-products of biofuels) consisting of 17 regions and 32 sectors.

H. *Step Four:* ***Creating Dry Distilled Grains (DDGS)***

By-products of biofuels cannot be ignored in a CGE model, as they can substantially reduce the production cost of biofuels. *DDGS* is split from eth1 sector using 9.449% share of total production for eth1 in a TAB file named *splitwgt.tab*. In the case of *eth2*, a tiny share of 1% of *eth2* production is set to be split as *DDGS* for Pakistan and other major *eth2* producers i.e. Brazil, India, and South Africa. All of the *DDGS* production is diverted as animal feed, while the ethanol is consumed by households (*HOU*) and land transportation (*otp*) sectors. None of the newly produced ethanol or DDGS is used in own-production. Based on the exports data for 2004, 45% of *DDGS* is set to be exported from USA, while this ratio is 5% for the rest of regions producing *DDGS* from *eth1*. For the major *eth2* producing regions, only 1% of *DDGS* is used as exports. Using above weights, stored in *splitwght.har* file, new data base is created, which now contains 33 sectors.

I. *Step Five:* ***Creating BDBP***

This step splits biodiesel by-product (*BDBP*) sector from *biodiesel* sector. In doing so, 23% of biodiesel production is set as BDBP for all the biodiesel producing countries, except for EU27, where this ratio is 18.7%. Similar to *DDGS*, all of *BDBP* is diverted to be sold as feedstock for animal sectors (*mtpd, olvs, and milk*). Almost all, 95%, of *BDBP* is set as soled in domestic market.

This step also completes the introduction of biofuels into GTAP-PBIO. Before using the new data base for other simulations, it was tested for data consistency and parameter accuracy. To overcome any problems caused by zeroes in the data base file, these zeroes were replaced with a very tiny number. More parameters were also added to parameters file (*default.prm*) to fulfil the needs of new data base.

V. Summary

In recent year, some researches have been conducted to modify GTAP Data Base to include biofuels. However, no study has focussed on including Pakistan as a separate region in any such models on biofuels. In this work, we have introduced Pakistan's biofuels sector into GTAP model. The model contains separate biofuels sectors for other major global biofuels players. Particularly, we incorporated specific data on cost of production, consumption and international trade in biofuels for Pakistan. We noticed that Pakistan could not be treated on similar basis in GTAP as other biofuels producers due to following reasons. Pakistan's sugar based ethanol production has much higher share of feedstock (sugarcane) in total cost structure. Most of the ethanol produced has exported to other countries, especially to the EU. Therefore, a separate treatment of biofuels sector was necessary for understanding the impact of national and international biofuels policies on Pakistan. We have employed a more efficient method (using *batch files*) to introduce new sectors into GTAP database. This method can help the researcher to trace any error/mistakes in the splitting process of the sectors and can be easily replicated. Future research can further refine this model by incorporating more precise data on biofuels in Pakistan and other countries. We believe that with the availability of up-to-date data on biofuels markets, we will be better able to understand the dynamics of biofuels markets in Pakistan and in the rest of the world.

References

Banse, M., Meijl, H.V., Tabeau, A., Woltjer, G., 2008, Will EU biofuel policies affect global agricultural markets? Research Report, Agricultural Economics research Institute (LEI), Hague .

Burniaux, J. M. and Truong, T. P., 2002, GTAP-E: An Energy-Environmental Version of the GTAP Model. GTAP Technical Paper No. 16.

Geller H.S., 1985, Ethanol Fuel from Sugar Cane in Brazil. Annual Review of Energy, 10, 135-164.

Haas M.J., McAloon, A.J., Yee, W.C., and Foglia, T.F., 2005, A Process Model to Estimate Biodiesel Production Costs. Bioresource Technology, 97, 671-678.

Hertel, W. T, and Reimer, J. J., 2005, Predicting the Poverty Impacts of Trade Reform. Journal of International Trade & Economic Development 14 (4) 377-405.

Hertel, T. W., Keeney, R., Ivanic, M., and Winters, L. A., 2006, Distributional Effects of WTO Agricultural Reforms in Rich and Poor Countries. World Bank Policy Research Working Paper 4060.

Horridge M., 2005, SplitCom - Programs to Disaggregate a GTAP Sector. Centre of Policy Studies, Monash University, Melbourne, Australia. http://www.monash.edu.au/policy/SplitCom.htm .

Keeney, R., and Hertel, T.W., 2005, GTAP-AGR: A framework for assessing the implications of multilateral changes in agricultural policies. GTAP Technical Paper No. 24. Center for Global Trade Analysis, Purdue University , West Lafayette .

Organization for Economic Cooperation and Development (OECD)., 2001, Market Effects of Crop Support Measures, OECD Publications, Paris.

Organization for Economic Cooperation and Development (OECD)., 2006, Agricultural Market Impacts of Future Growth in the Production of Biofuels. OECD, AGR//CA/APM(2005)24/FINAL.

Taheripour, F., Birur, D. K., Hertel, T. W. and Tyner, W. E., 2007, Introducing Liquid Biofuels into the GTAP Data Base. GTAP Research Memorandum No. 11. Revised May 1, 2008.

Taheripour, F. and Tyner, W.E., 2011, Introducing First and Second Generation Biofuels into GTAP Data Base version7. GTAP Research Memorandum No. 21.

Tifanny D.G. and Eidman, V.R., 2003, Factors Associated with Success of Ethanol Producers. Department of Applied Economics, University of Minnesota, Staff Paper P03-7.

UNCOMTRADE, 2010. United Nations Commodity Trade Statistics Database | Statistics Division. http://comtrade.un.org/db/

United States Department of Agriculture (USDA)., 2006, The Economic Feasibility of Ethanol Production from Sugar in the United States", US Department of Agriculture.

Valenzuela, E., Anderson, K. and Hertel, T., 2007, Impacts of Trade Reform: Sensitivity of Model Results to Key Assumptions. Centre for International Economic Studies Working Papers 2007-09, University of Adelaide, Centre for International Economic Studies.

Yang, J., Huang, J. K., Qiu, H. G., Rozelle, S., and Sombilla, M. A., 2009, Biofuels and the Greater Mekong Subregion: Assessing the impact on prices, production and trade. Applied Energy: 86 (S37-S46).

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