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ANALYZING TRADE IMPLICATIONS OF U.S. BIOFUELS POLICIES IN A GENERAL EQUILIBRIUM FRAMEWORK

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Abstract

As the biofuels are emerging as promising alternative transportation fuels across the world, they also offer huge potential for international trade in biofuels. A number of trade barriers such as import tariffs and domestic support have limited the scope for trade in biofuels. The purpose of this study is to analyze the implications of U.S. biofuel mandates, subsidies and import tariffs on global trade and welfare. We utilize the GTAP-BIO model, which was developed as a customized version of the Global Trade Analysis Project (GTAP) model capable of analyzing domestic and trade policy issues associated with biofuels (Birur, 2010). We supplement this model with updated and detailed sectoral level information on feedstock crops, different types of first and second generation biofuels and their byproducts. This highly refined data base facilitates the model for simulating changes in cropping patterns at individual crop level, land use changes, commodity prices, etc. We analyze the following policy scenarios in this study: (a) implementation of volume requirements consistent with the U.S RFS2 volumes for the year 2022 relative to a starting point of the base year 2004, (b) reduction in the ethanol specific import tariff from 54 ¢/gallon to 45 ¢/gallon, so that there will be "parity" between the U.S. and exporting country's ethanol price, (c) Complete removal of the U.S. ethanol blenders' credit and import tariff on ethanol, (d) combined implementation of (a) and (c) policy scenarios. This paper offers insights regarding the prospective policy options that can affect potential trade in biofuels amongst the major producing countries, such as the extent to which a removal of U.S. import tariff on ethanol affects pasture and forest land conversion in Brazil.

Key Words: Biofuels, Computable General Equilibrium, land use change.

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Introduction

With the growing popularity of biofuels as alternative transportation fuels across the world, there is huge potential for international trade in biofuels. The countries which are adopting policies requiring large scale use of biofuels may prefer to trade as it offers alternative sources of supply to face any uncertainties. Trade in biofuels also helps in moderating domestic price changes when production costs rise, as experienced in the U.S. in recent years when the prices of corn and soybeans have fluctuated substantially. Due to biofuel blending policies, biofuels are needed in several non-producing regions to blend with petroleum. Though the U.S. Congress has established a revised renewable fuel standard (RFS2) rule that mandates annual production of 36 billion gallons of biofuels by 2022 (U.S. EPA, 2010a), it limits the use of traditional grain ethanol (almost all derived from corn in the U.S.) to 15 billion gallons and the remainder of the volume requirement has to be met by advanced and cellulosic biofuels. Furthermore, the U.S. EPA (2010b) has designated sugarcane-ethanol as an advanced biofuel that meets the minimum greenhouse gas reduction requirement, opening the door for its import. Brazil, with its comparative advantage in growing sugarcane, has massive potential to produce ethanol and is planning to more than double its ethanol production by 2019 from its current level (7.9 billion gallons), mostly to meet the emerging export demand. However, presently there exist a number of trade barriers such as import tariffs and domestic support that have limited the scope for trade in biofuels.

Though international trade in biofuels has been increasing, trade in feedstocks (particularly for oilseeds and vegetable oil) also could play a critical role in indirectly affecting land-use and land-cover change across the countries. Florin and Bunting (2009) indicate that small scale biofuel programs have proven to bring environmental and social benefits with minimal risks, but the large scale biofuels usage polices tend to require international trade with higher economic and environmental risks. For instance, the EU biofuel target of 10% share in transportation liquids by 2020 possibly requires import of biofuels by many member states as they are already net food importers, which directly competes with biofuels for limited land resources (Zah and Ruddy, 2009). The U.S. and Brazil are the leading players in ethanol, with their estimated production of 12.5 and 7.9 billion gallons, respectively in 2010, together accounted for 86 percent of the World's ethanol production. Brazil invested heavily in ethanol during the 1970s energy crisis and now has the world's most advanced production and distribution systems. One impediment to trade in biofuels is that the tariff negates lower production costs. For example, Brazilian production costs of fuel ethanol are 40% to 50% lower (before the U.S. $ appreciation over the Brazilian Real in late 2008) than in the U.S.

Though U.S. ethanol prices have been relatively high, the tariff has formed a significant barrier for imports. As Goldemberg et al. (2008) report, Brazil has already reduced 53% of GHGs emission from transportation by using ethanol in place of gasoline. It is argued that elimination of import tariffs on ethanol can provide sufficient ethanol in the U.S. to move towards a cleaner fuel infrastructure with decreased greenhouse gas (GHG) emissions. An additional factor that encourages the tariff removal is the fact that sugar-ethanol is eight times more energy efficient than corn-ethanol (Carlson, 2008). Keeping this in view, in this study, we analyze the implications of the U.S. RFS2 mandates on biofuels, subsidies and import tariff on global trade and welfare.

U.S. Ethanol Policies: Currently the U.S. imposes 2.5% *ad valorem* tariff on ethanol plus a 54 cents per gallon specific duty on imported ethanol. However, about 700 million gallons of ethanol can enter the U.S. duty free each year under Central American Free Trade Agreement (CAFTA) – some of the raw material for which is originally sourced from Brazil (Barros, 2008). Another route being used for importing ethanol is the Caribbean Basin Economic Review Act (CBERA) which allows duty-free import of ethanol if is produced by utilizing at least 50% of the feedstock grown in twenty four CBERA countries. The duty-free non-CBERA feedstock based ethanol is restricted to only 60 million gallons or 7% of U.S. ethanol consumption, whichever is greater (Yacobucci and Schnepf, 2007; Elobeid and Tokgoz, 2008).

The main justification for the U.S. ethanol import tariff has been the fact that the domestic ethanol subsidy can be applied to both domestic and imported ethanol, and the U.S. does not wish to subsidize the use of imported ethanol. The 54 cent tariff was imposed with the intention to offset the earlier 51 cent blenders' credit given for the domestic corn ethanol. Despite this tariff, the U.S. imported 790 million gallons of ethanol from Brazil during 2008 (Elledge, 2009). In recent developments, the U.S. Food, Conservation, and Energy Act (the

Farm Bill) of 2008 stipulated a reduction of the federal blenders' credit from 51 cents per gallon to 45 cents per gallon, starting January 1, 2009. But the import tariff is still about 58 cents (specific duty + *ad valorem* tariff). This is 13 cents higher than the subsidy. Also, the U.S. Congress is reviewing the subsidy as it is set to expire in 2010. With a binding Renewable Fuel Standard (RFS) in place, the subsidy is largely redundant (Tyner and Taheripour, 2008).

In recent years, the U.S. Congress has considered a wide range of domestic and trade policy changes. On March 17th 2009, a Bill named "the Imported Ethanol Parity Act" was introduced which allows for reduction in the specific import tariff on ethanol to ensure "parity" between tariff and ethanol blenders' credit. This would reduce the current 54 cent per gallon tariff to a level at or below the blenders' credit which in turn would lower the expense of importing sugar cane ethanol from Brazil. Moreover, on July 13th 2009, the U.S. Senate introduced another bill named "the Affordable Food and Fuel for America Act" which allows for reduction of the income tax credit and excise tax credit for ethanol and lowering or removing the ethanol import tariff over the next five years. Any change in these protectionist policies is expected to directly impact both domestic and international ethanol markets with repercussions on the agricultural sector. This chapter will focus on these broader impacts of policy reforms.

Brazilian Ethanol Industry: As noted above, Brazil is the second largest producer of ethanol. Brazil started large scale ethanol production during the 1970s' oil crisis and continued with incentives and subsidies along with engineering advances in designing engines that use only hydrated ethanol. By 1984, about 94% of the cars manufactured were running on ethanol, which plummeted to just 1% by 2001 due to chronic inflation and the fall in crude oil prices during late 1990s (UNICA, 2009). The ethanol industry started prospering again in 2003 with the launch of flex-fuel vehicles that can run on gasoline, hydrated ethanol, or any blend of anhydrous ethanol and gasoline (Valdes, 2007). As seen from Figure 1, increased domestic use of ethanol and growing export demand for ethanol and sugar, expanded the sugarcane area rapidly in Sao Paulo region from 12 million acres in 2000 to 19 million acres in 2008 (Zuurbier and van de Vooren, 2008). In 2008, ethanol and sugar each come from half of the total sugarcane area, which is just 2.2% of the total arable land in Brazil. The other major crops grown are soybeans and corn which form 6% and 4% of the arable land, respectively (IBGE, 2009). UNICA (2009) reports that the current cropland area in Brazil (190 million acres) is only 22% of arable land, and still about 30% of the cropland is available for cultivation.

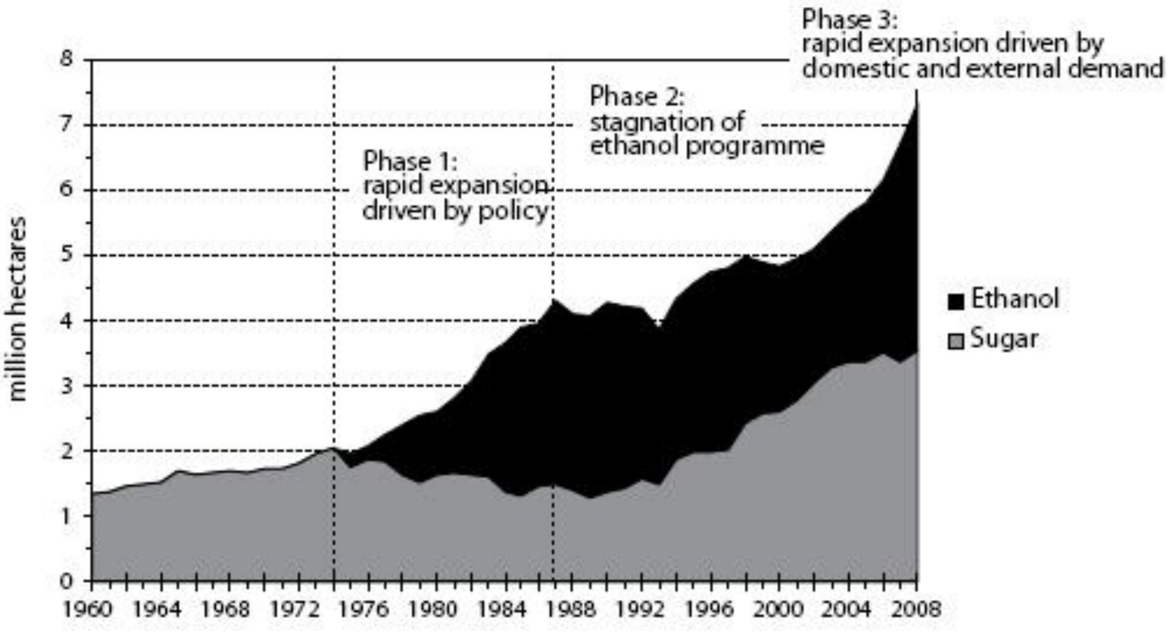

Figure 1. Area under sugarcane cultivation in Brazil.
Source: Zuurbier and van de Vooren (2008)

With its comparative advantage in producing sugarcane based ethanol, Brazil currently exports only 10% of its production. As more countries are in the quest of reducing use of fossil fuels and cutting greenhouse gas emissions, Brazil is expected to be the chief source of biofuels and feedstocks in the next decade. Several life-cycle well-to-wheel studies have shown that Brazilian sugarcane ethanol reduces emission of GHGs by up to 90% and is about 7 times more energy efficient than corn-ethanol (Shapouri et al. 2002, Pimentel et al. 2009; Ferreira Filho and Horridge, 2009). Brazilian Sugarcane Industry Association estimates production of ethanol to be at 12.4 billion gallons by 2015-16, of which 9.1 bgy for domestic use and 3.2 bgy for exports, which requires an increase in sugarcane area from the current 19 million acres to 28 million acres (UNICA, 2008).

Soybean based biodiesel is another emerging sector in Brazil in recent years. Brazil is the second largest producer of soybeans after the U.S. The estimated production for 2008 was 60 million tonnes, harvested in 54 million acres (Mello, 2008). Historically Brazil has been exporting about 40% of its production, mainly to China and European countries. As Kaltner *et al*. (2005) report, the rapid increase in soybean area started only since mid 1990s mainly due to change in international trade policies. The import demand for soybeans rose from European markets when they prohibited feeding meat and bone proteins to animals after the occurrence of mad cow disease. With China's accession to World Trade Organization, Brazil found another major destination for its soybeans.

Brazil has achieved self-sufficiency in crude oil since 2006. Diesel is still a popular fuel for trucks and other public transportation vehicles. In order to generate employment and raise incomes of small farmers by growing soybeans, the Brazilian government passed legislation on biodiesel blending in January 2005, which requires 2% blending of biodiesel with diesel during 2005-2007, 2 to 5% starting 2008, and 5% blending by 2012 (Stattman *et al.*, 2008). Though the production of biodiesel in 2006 was only 18 million gallons (diesel consumption was 9.7 billion gallons), the installed capacity is expected to reach 792 million gallons by 2015. This policy further adds to the incentive for soybean area expansion.

As Shean (2003) reports, soybean cultivation has grown at an unprecedented rate in the virgin savannah land called *Cerrado* region (Mid-West of Brazil). Cerrado lands are an easy target for soybean cultivation since it is relatively easy to convert these pasture- lands into cropland. It also has relatively less legal restrictions and the costs of clearing and road building are also low. However, Greenpeace (2009) argues there is an indirect connection between deforestation in the Amazon region and soybean area expansion. As soybean area expands into the pasture land, livestock grazing also moves further towards North clearing up the Amazon biome. Greenpeace reports the deforestation rate at 5 million acres per annum since 1995, of which 70% of forest loss is due to large-scale cattle ranching. It is this indirect land use change which has drawn lots of attention in the debate on biofuels. In this study, we look at these impacts from biofuels policy reforms and the resulting carbon emissions from land conversion.

Study Approach

Several studies in the past have addressed the biofuel tariff and subsidy policy issues mainly in partial equilibrium frameworks by focusing on one or two feedstock commodities in selected regions. The partial nature of all this work suggests the need for a comprehensive analysis. For example, de Gorter and Just (2007) developed a theoretical model that suggests that elimination of the ethanol tariff along with the implementation of biofuel mandates results in an increase in U.S. domestic ethanol price irrespective of the oil price. However, Elobeid and

Tokgoz (2008) found that the same policy experiment would result in increased volatility in U.S. ethanol prices, as the ethanol prices are indirectly determined by the crude oil or gasoline prices. Those authors also found that removal of the blenders' tax credit overrides the tariff removal impacts.

Meyer *et al*. (2009) analyzed the impact of complete and partial elimination of the U.S. import tariff on Brazilian ethanol. The study estimated that reducing the subsidy from 54 cents per gallon by 7 cents has very little impact on U.S. ethanol production (1% decline) and ethanol imports would increase only by 13%. When the import tariff was completely eliminated, the U.S. ethanol production declined only by 9% and imports increased by 128% with a decline in market price by only 5%. However, with the subsidies and import tariff in place at the current level, elimination of the total RFS was found to have a much higher impact on ethanol and corn markets in the U.S.

In a different approach, Farinelli *et al.* (2009) econometrically estimated the determinants of import demand for Brazilian ethanol for six major ethanol importers using quarterly data from 1997 through 2007. Their results suggest that implementation of the RFS in 2005 in the U.S. changed the nature of the import demand for ethanol. Those authors found that, with the implementation of RFS, the import demand for ethanol was price inelastic with respect to its own price and also to that of crude oil price. Interestingly, while the import tariff showed no significant effect in the model, RFS was found to be the only variable significantly affecting the U.S. import demand for Brazilian ethanol. Furthermore, Farinelli *et al.* (2009) also found that the Caribbean import demand is mainly driven by the U.S. ethanol demand.

Though these studies analyze the impacts on the markets that are directly related to biofuels such as corn, ethanol, gasoline, and sugar markets in one or two regions, there are several other interactions such as land-use change and related greenhouse gas emissions that are influenced by these biofuel policies. This explains that the general equilibrium framework is ideal in linking together energy markets with biofuels, agricultural markets with land-use, and international trade. As the previous studies reveal, biofuel incentives in major producing countries have the potential to impact worldwide agricultural and energy markets, and international trade. Therefore, we utilize GTAP-BIO model, which was developed as a customized version of the GTAP model capable of analyzing domestic and trade policy issues associated with biofuels (Birur, 2010). The GTAP-BIO model is a global computable general equilibrium (CGE) model, based on a data base which pertains to the global economy in 2001. This version of the model incorporates Armington assumption (Armington, 1969) of imperfect substitution between domestic ethanol (e.g., corn ethanol) and imported ethanol (e.g., sugarcane ethanol), both at the firms' production structure as well as in private household demand. Birur (2010) augments the firms' production structure with ethanol composite nest where grain and sugar-ethanol are treated as nearly perfect substitutes. In order to distinguish the source of ethanol the consumers buy at the pump, the private household consumption structure is also augmented with a composite ethanol good comprising grain and sugar ethanol. In this study, we supplement this model with updated and detailed sectoral level information on feedstock crops, different types of first and second generation biofuels and their byproducts, which is explained in the following section.

Incorporating Biofuels Related Sectors in the GTAP Data Base

The data base used in the original GTAP-BIO model included only three kinds of biofuels and aggregated crop sectors corresponding to 2001 market conditions. We updated the data to reflect more recent information and incorporated additional data to allow greater disaggregation and better capture the trade effects associated with expanded biofuels production. For this purpose, we used the GTAP v7.1 data base (Narayanan and Walmsley, Ed., 2008), which pertains to the global economy in 2004, as a starting point but incorporate secondary data from the International Energy Agency and the Food and Agriculture Organization to create highly disaggregated explicit biofuels and feedstock sectors for use in our model. The new explicit sectors include crops such as corn, soybean, rapeseed-mustard, palm-kernel, sugar-cane, and sugar-beet; starch based ethanol from corn and wheat; biodiesel from soy-oil, rape-oil, and palm-oil; sugar based ethanol from sugarcane and sugarbeet; cellulosic feedstock such as corn-stover, switchgrass, and miscanthus; the technologies for cellulosic ethanol and cellulosic diesel, and the key by-products of biofuels such as distillers dried grains with solubles (DDGS) and vegetable-oil meal. This highly refined data base facilitates use of the model for simulating changes in cropping patterns, land use, commodity prices, impacts on food and feed markets, etc.

The data base pertaining to 2004 economy is aggregated to permit focus on the sectors and regions of particular interest. For implementing the biofuels policy analyses, we aggregated the data base into 25 regions (Table A1 in Appendix) and 44 economic sectors (Table A2). The sectors are aggregated such that explicit linkages among energy commodities, biofuels, feedstock crops, by-products and other important related sectors can be examined. The regional aggregation is emphasizes more on the biofuels producing regions.

Experimental Design

Currently the U.S. imposes 2.5% ad valorem tariff on ethanol plus a 54 cents per gallon specific duty on imported ethanol. However, about 700 million gallons of ethanol can enter the U.S. duty free each year under Central American Free Trade Agreement (CAFTA) – some of the raw material for which is originally sourced from Brazil. The main justification for the U.S. ethanol import tariff has been the fact that the domestic ethanol subsidy can be applied to both domestic and imported ethanol, and the U.S. does not wish to subsidize the use of imported ethanol. The 54 ¢/gallon tariff is imposed with the intention to offset the 45 ¢ blenders' credit given for the domestic corn ethanol. Despite this tariff, due to lower ethanol prices in Brazil, the U.S. imported 790 million gallons of ethanol during 2008. Though the U.S. Food, Conservation, and Energy Act (the Farm Bill) of 2008 stipulated a reduction of the federal blenders' credit from 51 cents per gallon to 45 ¢/gallon effective from January 2009, the import tariff is still about 58 cents (specific duty + ad valorem tariff) which is 13 cents higher than the subsidy. With this backdrop, we analyze the following policy scenarios in this study: (a) implementation of volume requirements consistent with the U.S RFS2 volumes for the year 2022 relative to a starting point of the base year 2004, (b) reduction in the ethanol specific import tariff from 54 ¢/gallon to 45 ¢/gallon, so that there will be "parity" between the U.S. and exporting country's ethanol price, (c) Complete removal of the U.S. ethanol blenders' credit and import tariff on ethanol, (d) combined implementation of (a) and (c) policy scenarios.

[The results & discussion will be added soon]

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Appendix

Table A1. Aggregation of Regions in the Model.

No.	*Region-Code*	*Region Description*	*Comprising GTAP regions*
1	**USA**	United States	United States of America.
2	**EU27**	European Union 27	Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Bulgaria; Romania.
3	**Brazil**	Brazil	Brazil
4	**Canada**	Canada	Canada
5	**Mexico**	Mexico	Mexico
6	**Japan**	Japan	Japan
7	**China**	China, Hong Kong	China; Hong Kong.
8	**India**	India	India
9	**Russia**	Russia	Russia
10	**SAfrica**	South Africa	South Africa
11	**Argentina**	Argentina	Argentina
12	**Korea**	Korea	Korea
13	**Indonesia**	Indonesia	Indonesia
14	**Thailand**	Thailand	Thailand
15	**Malaysia**	Malaysia	Malaysia
16	**LAEEX**	Latin American Energy Exporters	Bolivia; Colombia; Ecuador; Paraguay; Venezuela.
17	**OthLACA**	Rest of LatinAmerica & Caribbean	Rest of North America; Chile; Peru; Uruguay; Rest of South America; Costa Rica; Guatemala; Nicaragua; Panama; Rest of Central America; Caribbean.
18	**RoWestEU**	Rest of Western Europe	Switzerland; Norway; Rest of EFTA; Ukraine.
19	**EastEU**	Rest of Eastern Europe	Rest of Europe, Rest of Eastern Europe; Albania; Belarus; Croatia.
20	**WestAsia**	Western Asia	Rest of Western Asia; Kazakhstan; Kyrgyzstan; Rest of Former Soviet Union; Armenia; Georgia; Iran; Turkey.
21	**RoSEAsia**	Rest of South and S.East Asia	Taiwan; Phillipines; Singapore; Vietnam; bangladesh; Rest of Oceania; Rest of East Asia; Cambodia; Lao People's Democratic Republic; Rest of South East Asia; pakistan; Sri Lanka; Rest of South Asia.
22	**NAfrica**	Northern Africa	Rest of North Africa; Egypt; Morocco; Tunisia.
23	**WCAfrica**	Western and Central Africa	Nigeria; Rest of Western Africa; Senegal; Central Africa; South-Central Africa.
24	**ESAfrica**	Rest of East Africa and SACU	Ethiopia; Madagascar; Malawi; Mauritius; Mozambique; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Rest of South African Customs Union.
25	**Oceania**	Oceania	Australia; New Zealand.

Table A2. Aggregation of Sectors in the Model

No.	Sector-code	Description	Comprising sectors
1	PaddyRice	Paddy rice	pdr
2	Wheat	Wheat	wht
3	Corn	Corn	corn
4	rCrGrains	rest of Cereal Grains	gron
5	Soybean	Soybean	soyb
6	RapeMustd	Rape-Mustard	rapm
7	Palm	Palm-Kernel	plmk
8	rOilseeds	rest of Oilseeds	osdn
9	Sugarcane	Sugarcane	scane
10	Sugarbeet	Sugarbeet	sbeet
11	OthAgri	All other Crops	ocr, pfb, v_f
12	Ruminant	Ruminants	ctl, wol
13	NonRumnt	Non-Ruminants	oap
14	RawMilk	Dairy Industry	rmk
15	Forestry	Forestry	frs
16	OthPrimSect	OtherPrimary:Fishery & Mining	fsh, omn
17	ProcRumt	Processed Ruminant Meat: cattle,sheep,goats,horse	cmt
18	ProcNRumt	Processed NonRuminant Meat products nec	omt
19	FoodPdt	Food Products nec	ofdn
20	OthFoodPdts	Sugar; Beverages & tobacco pdts, Proc Rice, Dairy Pdts.	sgr, b_t, pcr, mil
21	Chemicals	rest of Chemical,rubber,plastic prods	crpn
22	En_Int_Ind	Energy intensive Industries	i_s, nfm
23	Oth_Ind_Se	Other industry and services	tex, wap, lea, lum, ppp, nmm, fmp, mvh, otn, ele, ome, omf, wtr, cns, trd, cmn, ofi, isr, obs, ros, osg, dwe, wtp, atp
24	RoadTrans	Transport nec	otp
25	Coal	Coal	coa
26	CrudeOil	Crude Oil	oil
27	Electricity	Electricity and heat	ely
28	Gas	Natural gas	gas, gdt
29	Oil_pcts	Petroleum, coal products	p_c
30	Wht-Eth1	Wheat Ethanol	weth1
31	Scn-Eth2	Sugarcane Ethanol	sceth2
32	Sbt-Eth2	Sugarbeet Ethanol	sbeth2
33	Soy-biod	Soy Biodiesel	sbiod
34	Rape-biod	Rape-Mustard Biodiesel	rbiod
35	palm-biod	Palm-Kernel Biodiesel	pbiod
36	Corn-Eth1	Corn Ethanol	ceth (Tcet)
37	DDGS	DDGS	ddgs (Tcet)
38	VegOil	Vegetable Oils	rvol (vol)
39	Oilmeal	Veg Oil-meal	omel (vol)
40	SwtchGrass	Switchgrass	swgrs
41	Miscanthus	Miscanthus	mscts
42	CornStover	Corn Stover	cstov
43	AdvCelEthl	Advanced Cellulosic Ethanol	aceth
44	AdvCelDiesl	Advanced Cellulosic Diesel	acdsl