IMPACT OF EU BIOFUEL DIRECTIVES POLICIES ON DEVELOPING ECONOMIES

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Abstract. The Computable General Equilibrium (CGE) based on the top-down bottom-up model was developed for the purpose to assess the impact of the EU Bio-fuel Directive Policy on developing economies. It has been hypothesized that the Bio-fuel Policy in the European Union causes welfare loses in developing countries as well as European Countries (EU members as well as non-members). However, the resulting effect is partly contrary to the hypothesized one. It is because the growing import to meet the EU Bio-fuel PolicyDirective may make increased benefits for the environment and generate ancillary benefits for developing countries. The bio-fuel energy policy creates spillover which is indicated through a growth of welfare; otherwise this policy may exacerbate on the European Union market through reducing in domestic output and loose their competitiveness.

Keywords: bio-fuels, trade policy, CO_2, trade barrier, import, tariff.

Introduction

In recent years, bio-fuels have attracted attention by practitioners, decision makers, and academicians due to advantages as well as disadvantages of their production expansion. As a global leader in the international climate regime, the European Union (EU) has set up the target for renewable energies at 20 % (relative to 1990) in emission of greenhouse gases by 2020 and a 20 % share of renewable energies in the EU energy consumption by 2020 [1]. According to [2] in order to support policies, the EU accounts on import to meet the mandatory quotas. The EU has implemented various regulations defining import duties and tariff preferences which have been applied to trade partners especially from developing countries. The preferential access to the EU market is given for goods from developing countries under the General System of Preferences (GSP), the GSP and bi- or multilateral agreements such as the (so called) Cotonous Agreements (for Africa, Caribbean, and Pacific states). [3] emphasized that key policies and market for bio-fuels in the European Union have close links to vegetable oil and oilseed/feedstock markets in which countries such as Indonesia, Malaysia, and Argentina as major exporting countries from the developing world dominate. In fact, these countries are accused because of environmental issues due to land conversion from forest into tree plantations with considerable extent and contribute to 13 – 14 % of global emissions during 1997 – 1998 of Crude Palm Oil in South East Asian [4].

Concerning the Bio-fuel Policy in the EU, in order to comply with emission reduction targets at national and international levels this Policy may influence international prices through changes in exports and imports. The developed countries are concerned that this Policy may lead to loss of competitiveness as compared to major trading partners with less stringent policies. According to [5] the reduction emission strategies (such as the Kyoto Protocol Policy) reduce the positive spillover of effects to developed countries (i.e., Europe and Japan). It in fact brings benefits for developing countries. Therefore, the bio-fuel trade Policy based on renewable energy directive policy setting in EU may reduce competitiveness of the EU economy and benefit for developing countries. Liberalized agricultural trade is expected to generate considerable competitive pressure on farm producers with the lack of incentives for farmers to engage in environmentally sustainable production practices [6]. Merely Europe and North America make experiments with the cap and trade system to provide economic incentives for the farmers to reduce GHG emissions or sequester carbons.

We embarked our idea on the basis of [7] who elucidates that trading in renewable commodities may reduce welfare in developing countries. In this paper we are avid to reply his hypothesis and focus on two basic exercise issues related to bio-fuels policies, whether or not trade liberalization in bio-fuels will be conducive to mitigating the emission of GHG and welfare reducing for developing countries? The latter objective is whether or not the EU Bio-fuel Policy creates international spillover to non abating regions and loses competitiveness? We hypothesized that the Bio-fuel Policy in the European Union causes welfare losses in developing countries as well as the European Union, but which one is either bigger or lesser, we have assessed by the Computable General Equilibrium (CGE) approach.

The originality of our paper is reconciling the top down and bottom up approach in large scale CGE model intertwining economy, energy, and environment. Our model is able to capture simultaneously the top down and bottom up method with a simple quadratic programming approach. Such an approach is able to reduce complicated modelling of the bottom up approach which commonly applies solely with separate partial equilibrium model. With this approach we figure out how to improve understanding of international trade with bio-fuels and bio-fuel policies in the EU impacting on developing countries.

Materials and Methods

We aggregated GTAP-BIO [8] version with the base year 2001, from 57 sectors to 16 aggregate sectors (i.e., crops, oil seeds, sugar cane and beet, livestock, other agriculture, manufacture, services, ethanol corn base, ethanol sugarcane base, biodiesel, coal, crude oil, petroleum, natural gas, and electricity) and 5 regions (i.e., the European Union, Brazil, China, Indonesia, India, and Rest of the World). This aggregation is necessary to increase the CGE solution more efficiently and reduce complexity in the algorithm and iteration process.

Our CGE approach is based on combination of bottom-up and top-down in mixed complementarity format, as outlined by [9]. We have modelled that the economy mimics until 2020 according to FAO-OECD Agricultural Outlook 2020 projections. The outlook provides a good insight and is in line to trajectories of the macro economic prediction that bio-fuels are linked through separated production function for other goods, and also energy goods. The term "other goods" comprises agriculture goods such as crop, livestock as well as agro fuel sectors (i.e., oil seeds, sugarcane and sugar beet). The energy goods consist of fossil fuel production, electricity, and biofuel (i.e., biodiesel, ethanol-1, ethanol-2). The last production function is the transport sector.

For each production the function has been captured by respective aggregates which are characterized by the technology through transformation possibilities on the output side and substitution possibilities among inputs. On the output side, the production is split between the goods produced for domestic markets (on the one hand) and produced for export markets which are subject to a constant elasticity of transformation (CET).

On the input side needed constant elasticity of substitution cost function specifies the substitution possibilities between the capital labour, energy, land, and other resources. At the top level, non-energy inputs are employed in fixed proportions with an aggregate of energy, capital, and labour. The material input of good *i* in sector *j* corresponds to a CES Armington aggregate and the aggregate of labour and capital. The lower level consists of the capital, labour, resource and land trade off with constant elasticity of substitution. We employ several levels of nesting according to specific production for each energy goods to represent differences in substitution possibilities between bio-fuel energy (ethanol-1, ethanol-2, and biodiesel) and fossil fuel energy for other goods and specific in the transport sector and electricity based on bio-fuels as well, which we estimated in top-down and bottom-up decomposition.

The bottom-up model decomposition strategy is utilized for the integrated model in which the energy system bottom-up component can be computed separately form the top-down general equilibrium model. The solution procedure involves iterative solution of the top-down general equilibrium model given net supplies from the bottom-up energy sector followed by solution of the energy sector sub-model based on a locally calibrated set of the demand function for the energy sector outputs. We computed the bottom up model solved as a quadratic program which was separately computed with solely algorithm. The top-down model produces the price of energy and non energy goods – it is utilized as a feedback into the bottom up energy sector model (as a cost function). The decomposition model has been written as a quadratic programming equation in which the summed up profit procedure and consumer surplus *i* maximized subject to supply-demand balances for energy and resource bounds on technologies:

$$\max \sum_{i}^{r} p_{i,r}^{E} \left(1 + \frac{2\tilde{S}_{i,r} - S_{i,r}}{2\varepsilon_{i,r}\tilde{S}_{i,r}} \right) - \tilde{p}_{i,r} p_{E,r}$$

subject to

$$S_{i,r} = \sum_{i}^{r} z_{it} - \sum_{i,tch}^{r} b_{ii,r,tch} z_{i,r,tch}$$

$$g_{e,r} = \sum_{i,tch}^{r} a_{i,tch}^{g} z_{i,tch}$$

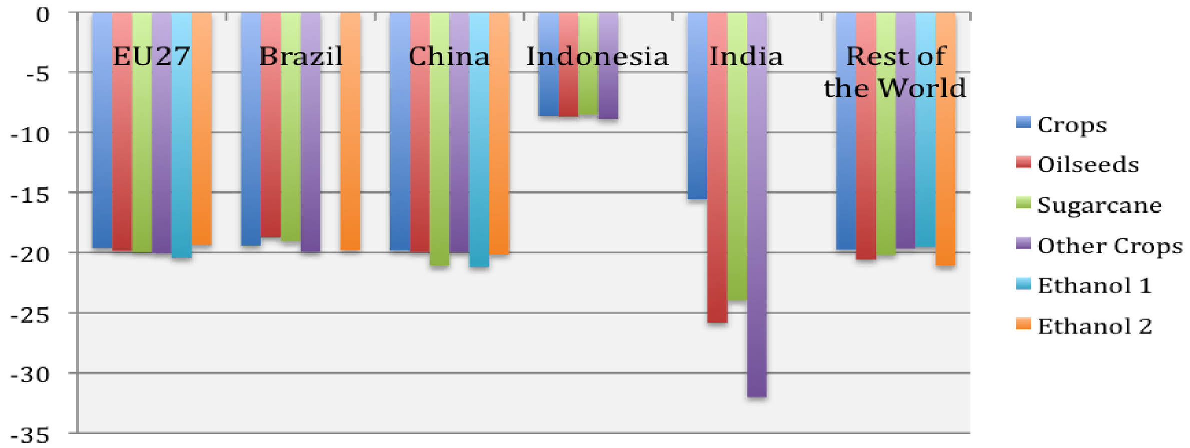
$$0 \le z_{i,r,tch} \le \tilde{z}_{i,r,tch}$$

where *p* – price of energy *E* for each goods *i* in region *r*;
S – energy supply function consisting of $\tilde{S}$ associated with top-down price function;
ε – energy technologies in electricity sectors;
g – cost function associated with;
z – energy capacity constraint, and;
a – cost of energy technologies.

The technology perspectives (*tch*) comprise electricity produced on the base of oil (thermal power); hydro power; coal power (also thermal power) and combustible energy (ethanol or biodiesel).

Results and discussion

We elaborated three scenarios focused on removing the trade barriers of bio-fuel import tariffs (50 %) as well as removing the export subsidies (50 %) in exporter countries. In the third scenario we performed substitution of bio-fuels into the electricity sector according to the EU Bio-fuel Directives Policy which is 20 % of bio-fuels in mixed energy and the transport sector, as well. Our first results are shown in Figure 1, real prices in every region for agricultural products tend to decrease and comply with a long term price movement. These outcomes are caused by inelastic food demand together with a high rate of productivity growth. Our results corroborated [10] that the agricultural prices are rather declining than increasing as studied by [11]. The slow down movement of these price changes are also fostered by a decrease of consumption in developing countries and in world economies, as well.



Source: *Authors´ Calculations, 2012*

Fig. 1. **Agriculture price sector by region and sector in 2020 relative to 2001 (in %)**

In terms of output production the removed trade barriers in scenarios 1, 2 will lead to increase in bio-fuel production in the European Union and Indonesia. The ethanol crops (sugar crops) production increased by 7.71 % for both trade scenarios as well. Increasing subsidies for export in developing countries somewhat changed the production output rather than removed the import tariffs. The removed import tariffs in the European Union significantly reduce bio-diesel production commodities in Indonesia (the major exporter) by 10.18 % – as compared with the baseline reference in 2001. As to the EU agricultural sector the removed trade barriers on bio-fuels, a reduced output of crops and other related sectors has been found (by -1 – -5 %) whereas ethanol-2 and biodiesel production increased by about 7 – 8 %. These occurrences are the result of competition between food and energy security because the EU Bio-fuel Directive Policy attracts domestic producers to shift from agricultural farmers to bio-fuels farmers in order to meet the demand of the policies.

Table 1

Production Output Scenario (in %) from baseline

Regions	Sectors	Scenario 1	Scenario 2	Scenario 3
EU 27	Crops	-5.11	-5.28	-6.98
	Sugarcane	-2.01	-2.05	-3.52
	Other Agriculture	-1.23	-1.22	-1.72
	Ethanol 1	-3.42	-3.47	-5.79
	Ethanol 2	7.73	7.50	8.36
	Biodiesel	8.89	8.89	8.37
Brazil	Crops	-2.96	-0.10	-2.84
	Sugarcane	-4.56	-3.73	-3.95
	Other Agriculture	-3.29	-2.71	-3.93
	Ethanol 1	0.00	0.00	0.00
	Ethanol 2	-5.52	-4.36	-4.35
	Biodiesel	0.00	0.00	0.00
Indonesia	Crops	-3.80	-3.75	-4.14
	Sugarcane	2.57	2.58	2.83
	Other Agriculture	-6.17	-6.17	-6.33
	Ethanol 1	0.00	0.00	0.00
	Ethanol 2	0.00	0.00	0.00
	Biodiesel	-10.18	-10.28	-12.14
Rest of the World	Crops	-1.51	-1.54	-1.94
	Oilseeds	9.85	17.79	20.93
	Sugarcane	-1.06	-1.08	-1.53
	Other Agriculture	-2.40	-2.42	-3.04
	Ethanol 1	-2.98	-3.00	-3.97
	Ethanol 2	-1.74	-1.75	-2.80

Source: *Authors Calculations, 2012*

The expected bio-fuel output reduction (by CGE approach) in Indonesia as the European Union major trading partner fosters the competitiveness of Indonesia due to strengthening the environmental policy in the European Union. This repercussion impact has been proved by decreasing of carbon dioxide due to the above scenarios. In Table 2 there are the results of three scenarios calculations for carbon dioxide emissions (total emissions for each selected region). In scenario 1, the carbon emissions resulted reduced down by -8.68 % from the reference year 2001; this reduction has somewhat changed the scenario 2 (by -8.69 % of carbon emissions) and reduced it by -10.92 % when both policies are included in scenario 3.

Table 2

Carbon Emission Scenario (in%) from baseline

Carbon	Scenario 1	Scenario 2	Scenario 3
EU27	-8.68	-8.69	-10.92
Brazil	2.00	2.85	2.92
China	0.86	0.74	1.07
Indonesia	-18.46	-18.46	-21.07
India	12.80	12.76	12.80
Rest of the World	-1.18	-1.20	-2.37

Source: *Authors' Calculations, 2012*

Our model shows that the EU Bio-fuel Directive Policy is unable to meet the target in 2020 when 30 % of carbon dioxide emission should be totally shrunk [12]. Our results are similar to [10] in the sense that the EU Bio-fuel Directive targets will not be reached in 2020.

The (above) reducing trade barriers in the European Union would decrease carbon dioxide significantly in developing economies (example – Indonesia), whereas in other countries such as Brazil, China, and India the carbon dioxide emissions will moderately increase. A direct impact of the EU Bio-fuel Directive Policy on the main trading partner such as Indonesia may increase reduction in Carbon Dioxide Emission, this result may cause unclear perception theoretically that trade is bad for the environment [13]. Tremendous decreasing of carbon dioxide emissions in Indonesia proves that the Bio-fuel Policy in the European Union leads to decreasing of carbon dioxide emissions caused by those scenarios. On the other hand, the reference [14] stated that this hypothesis has proven difficulties in attempting to be empirically demonstrated. A plausible explanation for these results can be that the trade is good for the environment as a consequence of environmental regulation in developed countries. On the other hand, the removed trade barriers in the European Union are accompanied with non-trade barriers requirements such as certification and technology transfer.

The developed countries may force the developing countries to comply with these regulations. Therefore, the efficiency as well as concerning of benign environmental issues may force the firms of the developing countries to enter the European Union markets.

Table 3

Welfare Scenario in comparison with the baseline (in %)

Welfare	Scenario 1	Scenario 2	Scenario 3
EU27	-1.27	-1.27	-1.69
Brazil	-0.75	-0.65	-0.66
China	-0.99	-1.01	-0.99
Indonesia	5.02	5.02	5.14
India	-2.29	-2.29	-2.32
Rest of the World	-0.75	-0.76	-0.91
Total	-0.53	-0.54	-0.69
nonAnnex B	-0.65	-0.66	-0.80
Annex B	-0.48	-0.48	-0.64

Source: *Authors' Calculations, 2012*

Our last result is shown in Table 3 which verifies our hypothesis that the trade with bio-fuels as agriculture commodities leads to reducing welfare in developing countries as well as European countries. Indonesia as an EU trading partner generated ancillary benefit from the bio-fuel trade liberalization. Increasing renewable electricity to 20 % of renewable targets will decrease the welfare in the EU by -1.27 % for both scenarios 1 and 2, and a bigger decrease amount in scenario 3 (-1.69 %). Removing the trade barriers in the EU may reduce national consumption which is bigger than the income effect through trade expansion. The domestic output may decline whilst the import substitution product from developing countries is surge. This condition may be severe to the EU firms which are uncompetitive for the reason of the resource abundance rather than for developing country firms. In fact, the EU firms lose their competitiveness.

For developing country firms, the removing trade barriers would detach and select exporter firms to meet the EU requirements; some of them exit from the market and reduce their production. This circumstance inclined with Table 1 that the outputs increase from 9 % to 20 %. Other firms from the Rest of the World entering the EU markets could overtake the position of Indonesia due to losing their competitiveness. This case is another fact which is beyond scope in our paper, we need further investigation and more sophisticated modeling to assess this phenomenon.

Our paper has proved that the EU Bio-fuel Directive Policy is unable to meet its target goals in 2020 although we simulated that this Policy is good for reducing emissions in the European Union and trading partners as well. Our model also incorporates some weaknesses in the database (filled in 2001) whereas the latest GTAP database is available for 2004 and 2007 March 2012. Another constraint: we were having difficulties to estimate the energy capacity in each country for each sector in our partial equilibrium model although these data are available online at http://www.eia.gov/ (however, detailed information on thermal energy capacity information is unavailable).

Conclusions

We hope our paper may contribute for quantifying the impact of the EU Bio-fuel Directive Policy. Although many authors have conducted research on similar issues, our paper at least has got different perspective and different approach. The model as worked out shows that enhanced demand for bio-fuel crops under the Bio-fuel Directive has a moderate impact on developed economies and in fact good for developing countries. We rejected the hypothesis according to [7] that developing countries may reduce welfare ascribed to trade liberalization. The EU Bio-fuel Directive Policy promotes good and benign practice of environmental issues. We have concluded that the bio-fuel energy policy may benefit and create spillover for developing countries which is demonstrated by increasing in welfare, however also losses for developed countries such as the European Union. The trade liberalization may be harmful for the domestic output and competitiveness although reduction of green houses gas emission is incontestable.

It is recommended to enhance this methodology to improve the refinement of database for the top-down and bottom-up model approach. Consistency and availability of detailed information for the energy capacity and energy cost estimation in the bottom–up model are urgently required to perform good calibration and reducing uncertainties in calibration at the bottom-up and top-down approach. In this paper another scenario has been ignored which would be useful for further refinement of our scenarios, i.e., taxes or subsidies on prices of bio-fuels and substitution between rural and urban households considered for further research.

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