The EC Bioethanol Blend Mandate Policy: Its Effect on ACP Sugar Trade and Potential Interaction with EPA Policies

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Abstract

The study aim was to determine effects of the EC bioethanol blend mandate policy and its potential interaction with the EPA policies on EU/ACP countries. The research analysis focussed on welfare outcomes, changes in trade balance and output of bioethanol crops commodities due to these policies. Emphasis of our analysis was placed on sugar given the economic importance of this commodity to many ACP member states. Absence of an EU bioethanol partial equilbrium model means we had to design one from certain assumptions. One of the assumptions was that subsidies support EU bioethanol production such that just enough is produced to meet the 5.75% and 10% EC blend mandate requirements. For this reason, EU bioethanol production did not affect transport fuel demand and prices.

Using the GTAP model, the study has found that the EC bioethanol blend mandate policy increases bioethanol crops commodities prices resulting in global welfare loss that is highest in the EU region. However, the EC bioethanol blend mandate policy also increases bioethanol crops commodities production in ACP countries and promote ACP export of these commodities to the EU. The EU is able to produce all bioethanol requirements from local sugar beet production. Increasing the amount of sugar beet in bioethanol production minimizes the effect on global food prices and offers greatest benefits to ACP countries through promotion of their sugar industries. Trade liberalising EPA policies result in welfare gain for regions engaged in them. However, the EC bioethanol blend mandate policy's interaction with the EPA policies result in welfare loss, which is again highest in the EU. Combination of the EC bioethanol blend mandate/EPA policies also promotes ACP bioethanol crops production and export.

Overall, the study has contributed to our understanding of biofuel policies and their potential global effects on food markets especially in ACP countries.

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List of Chapters

Chapter 1- Introduction and motivation...**1**-1

Chapter 2 – Literature Review on biofuel and bioethanol

2.0 Introduction **2**-1

2.1 What are biofuels? **2**-2

2.2 Reasons for promotion of biofuels and concerns for their production **2**-5

2.3 Global, USA and Brazilian bioethanol status **2**-17

2.3.1 A closer look at the Brazilian bioethanol industry **2**-20

2.4 Bioethanol and international trade **2**-23

2.5 The EU Strategy for promotion of biofuels **2**-26

2.5.1 The European Commission (EC) Directive on biofuels **2**-26

2.5.2 The Common Agricultural Policy (CAP) support for biofuels….. .... **2**-29

2.6 The EU27 bioethanol status and trade **2**-31

2.6.1 Recent EU27 fuel bioethanol production and consumption status **2**-39

2.6.2 A brief overview of EU27 biodiesel production and consumption **2**-44

2.7 Review of selected studies on EU bioethanol **2**-48

2.8 Summary and conclusion **2**-56

Chapter 3: Bioethanol models review, design and analysis of EU27 bioethanol model

3.0 Introduction and motivation **3**-1

3.1 Review of the global bioethanol models **3**-5

3.2 The bioethanol FAPRI model **3**-10

3.3 Alternative FAPRI bioethanol models **3**-14

3.4 The EU27 bioethanol demand model... **3**-18

3.4.1 Gasoline demand **3**-20
3.4.2 Bioethanol demand **3**-30
3.5 Gasoline and bioethanol equilibrium solution **3**-35
3.6 EU bioethanol supply model **3**-38
3.6.1 Bioethanol supply model results **3**-52
3.7 Subsidy derivation from equilibrium conditions **3**-53
3.7.1 Discussion of equilibrium results **3**-56
3.7 Conclusion and extension **3**-57

Chapter 4 : The EU/global sugar market: production and trade policies
4.0 Introduction **4**-1
4.1 The global sugar market **4**-3
4.1.1 The EU sugar market and trade status **4**-8
4.2 The CAP and its reforms **4**-11
4.3 The Common Market Organization **4**-16
4.3.1 Production quotas **4**-19
4.3.2 Sugar prices and levies **4**-22
4.4 General Trade Agreements between the EU and ACP Countries **4**-26
4.5 The ACP/EU trade Agreements specific to sugar **4**-28
4.5.1 The ACP/EU sugar protocol **4**-28
4.5.2 The Agreement on Special Preferential Sugar (SPS) **4**-32
4.6 ACP sugar industries **4**-37
4.6.1 The Caribbean sugar industries **4**-40
4.6.2 The African/SADC sugar industries **4**-45
4.7 Recent EU/ACP sugar trade regime reforms **4**-50
4.7.1 The EU sugar reform of 2006 .... **4**-50
4.7.2 The EU biofuel policy **4**-55
4.7.3 The EPAs **4**-55
4.8 Conclusion **4**-59

Chapter 5: A review of the GTAP model

5.0 Introduction **5**-1

5.1 CGE and GTAP modeling **5**-2

5.2 Theoretical foundations of the GTAP model **5**-5

5.2.1 Behavioural equations **5**-18

5.2.2 Model closure and linearization **5**-20

5.3 Study application of the GTAP model **5**-22

5.4 Conclusion **5**-30

Chapter 6: Simulating the EC bioethanol blend mandate policy on aggregated ACP countries

6.0 Introduction **6**-1

6.1 Conversion of bioethanol to bioethanol crops commodities equivalent **6**-2

6.2 Transferring the bioethanol crops demanded into the GTAP model …… **6**-13

6.3 Modelling the EC bioethanol blend mandate on petroleum products …… . **6**-17

6.4 EC bioethanol blend mandate policy simulation **6**-21

6.4.1 Country aggregation... **6**-22

6.4.2 Sectoral aggregation... **6**-23

6.4.3 Closure................. .... **6**-25

6.5 Results and discussion...**6**-26

6.6 Conclusion …………………………. **6**-40

Chapter 7: EPA/EC bioethanol blend mandate policy simulation on ACP countries

7.0 Introduction **7**-1

7.1 Modelling the EPA policies on EU/ACP countries **7**-3

7.1.1 Policy simulation…... **7**-3

7.1.2 Results and discussion... **7**-4

7.2 Simulation of the EC bioethanol blend mandate/EPA policy interactions on ACP countries **7**-13

7.2.1 Policy simulation........ **7**-13

7.2.2 Results and discussion........ **7**-13

7.3 Conclusion **7**-25

Chapter 8: Summary, conclusion and extension

8.1 Summary and conclusion **8**-1

8.2 Shortfall of the research and possible extensions **8**-6

Appendix

Figure A3-1: The world bioethanol model........ **A**-1

Figure A3-2: Brazilian bioethanol model **A**-2

Figure A3-3: USA bioethanol model **A**-3

Figure A3-4: Proposed EU-27 bioethanol model **A**-4

Table A6.1: Welfare effects or Equivalent Variation-EV (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate at sugar beet share of s_{sb}=31.1 (s_{sb}=100)........ **A**-5

Table A6.2: Welfare decomposition (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate at sugar beet share of ssb=31.1 (s_{sb}=100) **A**-5

Table A7.1: The welfare effects (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1(100) % **A**-6

Table A7.2: Welfare decomposition (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1 (100) % **A**-6

Bibliography B-1

List of Tables

Table 1.1: Contribution of sugar to some ACP member states GDP in 2003 .... **1**-7

Table 2.1: Change in Life-Cycle GHG emissions per kilometre travelled by replacing gasoline with bioethanol in conventional spark-ignition vehicles **2**-10

Table 2.2: Typical biofuel production systems from agricultural crops **2**-13

Table 2.3: Land and water demand in large-scale biofuel production compared to availability (expressed on a per capita basis) **2**-14

Table 2.4: Recent statistics of Brazilian sugar and bioethanol production **2**-23

Table 2.5: Minimum incorporation % biofuel blend targets for EU member states in place in 2005 and 2010 .... **2**-28

Table 2.6: Estimation of year 2007 and future bioethanol production capacity in EU27 .... **2**-32

Table 2.7: EU market price support for bioethanol through border protection….. **2**-34

Table 2.8: Cost of biofuels in the EU **2**-35

Table 2.9: Cost comparison of biofuels with petroleum fossil fuels (valued at filling stations in €2004/1000L) **2**-35

Table 2.10: Preferential agreements providing duty free and quota free access to the EU bioethanol market... **2**-38

Table 2.11: EU fuel bioethanol consumption (production) from 2000 to 2009 in thousands of barrels per day **2**-41

Table 2.12: EU bioethanol production from bioethanol crops from 2006 to 2012..... .... **2**-44

Table 3.1: Regression results for a static long run EU27 gasoline demand **3**-22

Table 3.2: K-S test for normality for gasoline demand in the EU27 .... **3**-24

Table 3.3: OLS regression summary results for EU27 gasoline demand **3**-26

Table 3.4: OLS unit root estimation for price variable... **3**-27

Table 3.5: OLS unit root estimation for GDP variable **3**-28

Table 3.6: OLS estimation for cointegration testing... **3**-30

Table 3.7: 2004 equilibrium gasoline and bioethanol demand **3**-37

Table 3.8: Bioethanol crops supply elasticities.. **3**-52

Table 4.1: World sugar production statistics in year 2004 (2011) **4**-4

Table 4.2: World sugar exports in year 2004 (2011) **4**-5

Table 4.3: Major global sugar consumers in year 2004 (2011) **4**-6

Table 4.4: The quota distribution of sugar in the EU25 (2004) .... …**4**-21

Table 4.5: The average levy regime for the EU sugar industry from 1990 to 2002….. .... **4**-24

Table 4.6: Sugar quotas of ACP Protocol countries **4**-30

Table 4.7: ACP SP and SPS sugar quotas and average production levels (in tonnes white sugar equivalent) **4**-34

Table 4.8: Summary classification of ACP countries and trade arrangement with the EU.. **4**-35

Table 4.9: Sugar cane production in SADC region in 2010 .... **4**-45

Table 4.10: EU support prices from 2005-2010.. **4**-52

Table 5.1: A typical structure of a Social Accounting Matrix **5**-6

Table 6.1: Bioethanol production from sugar beet at sugar beet share of 31.1%. ..**6**-6

Table 6.2: Bioethanol productivity efficiency of grain crops.................................. **6**-7

Table 6.3: Conversion of EU bioethanol sugar beet share from litres to tonnes equivalent at 31.1% (100%) sugar beet share **6**-8

Table 6.4: Conversion of EU bioethanol sugar beet share from tonnes to sugar equivalent and as a percentage of 2004 sugar production at 31.1% (100%) sugar beet share **6**-8

Table 6.5: Bioethanol crop shares for bioethanol production in billion litres (and million tonnes equivalent) **6**-10

Table 6.6: EU27 uncompensated own price elasticity of demand for bioethanol crop commodities **6**-14

Table 6.7: Calculated % quantity changes {qo (i,r)} at 5.75% (10%) blend mandate and different bioethanol crops shares.......... **6**-16

Table 6.8: Calculated % price changes {pm (i,r)} at 5.75% (10%) blend mandate and different bioethanol crops shares.......... **6**-17

Table 6.9: Elasticity and % change in quantity and price for petroleum products in the EU27 due to the EC biofuel blend mandate **6**-19

Table 6.10: Alterations to the exogenous variable tax variable τ to simulate the effect of the EC bioethanol blend mandate policy **6**-20

Table 6.11: Welfare loss as a percentage of GDP of a 5.75% and 10% EC bioethanol blend mandate at sugar beet share of ssb=31.1 (100%) **6**-26

Table 6.12: Selected results of % change in market prices due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1.......... **6**-29

Table 6.13: Selected results of % change in market prices due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=100%.......... **6**-29

Table 6.14: Selected results of % change in industry output due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1 .... **6**-31

Table 6.15: Selected results of % change in industry output due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=100 .... **6**-32

Table 6.16: Selected results of changes in trade balance (in US$ million) as a result of the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1% **6**-34

Table 6.17: Selected results of changes in trade balance (in US$ Million) due to the EC 5.75% (10%) bioethanol blend mandate at Sugar beet Share of S_{sb}=100%... .... **6**-34

Table 6.18: Selected results of % change in ACP export sales due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1%.......... **6**-37

Table 6.19: Selected results of % change in ACP export sales due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=100% **6**-37

Table 6.20: Sugar export % change to the EU27 from various regions at the different sugar beet shares and blend mandate **6**-39

Table 7.1: Welfare effects of the EPA policies in million US$ (and as a % of GDP) . **7**-4

Table 7.2: Welfare decomposition outcomes (in US$ million) of an EPA policies .. **7**-5

Table 7.3: Bilateral export values (VXMD i,r,s) at world prices from EU27 to other Regions – Baseline Data.. **7**-6

Table 7.4: Bilateral import values (VIWS i,r,s) at world prices from all other regions to EU27- Baseline Data **7**-6

Table 7.5: Export sales of commodity i (% changes) from other regions to the EU27 after EPA/EBAI policies **7**-7

Table 7.6: Export Sales of Commodity i (% changes) from EU27 to other regions after EPA policies **7**-8

Table 7.7: Industry output of commodity i in region r (% change) due to an EPA policies.... .... **7**-9

Table 7.8: Market price of composite import of commodity i in EU27 after EPA policies.... .... **7**-11

Table 7.9: Market price of commodity i in EU27 after EPA policies **7**-12

Table 7.10: The welfare effects (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1(100) % **7**-14

Table 7.11: Selected results of the % cha€nge in market price due to an EC 5.75% (10%) bioethanol blend mandate/EPA/EBAI policies at S_{sb}=6.11%....................... **7**-15

Table 7.12: Selected results of the % change in market price due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=31.1%............................... **7**-15

Table 7.13: Welfare decomposition (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1(100) % **7**-17

Table 7.14: Selected results of the % change in industry output due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=31.1% **7**-18

Table 7.15: Selected results of the % change in industry output due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=100% **7**-18

Table 7.16: Summary % changes in sugar output at various policy combinations for ACP countries.. .... **7**-19

Table 7.17: Selected results of the % change in trade balance (in US$ million) due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=31.1% **7**-20

Table 7.18: Selected results of the % change in trade balance (in US$ million) due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=100% **7**-21

Table 7.19: Summary of changes in sugar trade balance (in US$ millions) at different policy instruments for ACP countries **7**-22

Table 7.20: Selected results of the % change in ACP export due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=31.1 % **7**-23

Table 7.21: Selected results of the % change in ACP export due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=100 % **7**-23

Table 7.22: Summary % changes in sugar export to EU27 at different policy instruments for ACP countries **7**-24

List of Figures

Figure 2-1: Basic schematic view of biodiesel production process **2**-4

Figure 2-2: 2006 world CO_2 emissions from fossil fuel combustion **2**-6

Figure 2-3: The biofuel production cycle **2**-11

Figure 2-4: Global ethanol production shares **2**-18

Figure 2-5: Use of sugar cane and bioethanol in Brazil in 2010 .... **2**-22

Figure 2-6: Average EU27 bioethanol consumption and production from year 2000 to 2009 in thousands of barrels per day **2**-40

Figure 2-7: Selected top EU27 member states bioethanol producers and consumers in 2009 (thousand of barrels per day) **2**-42

Figure 2-8: The estimated average share of bioethanol crops used in bioethanol production in the EU during the years 2006/2007 .... **2**-43

Figure 2-9: Average EU27 biodiesel production and consumption from year 2000-2009 in thousands of barrels per day **2**-45

Figure 2-10: Average EU27 fuel biodiesel and bioethanol production for the year 2000 -2009 in thousand of barrel per day **2**-46

Figure 2-11: Average EU27 fuel biodiesel and bioethanol consumption in thousands of barrels per day **2**-46

Figure 2-12: Selected top EU biodiesel producers and consumers in 2009 in thousand of barrel per day **2**-47

Figure 3-1: EU 27 bioethanol demand model flow chart **3**-19

Figure 3-2: A plot of the EU demand (thousands of barrels/day) and price of gasoline (€/1000L) from 1984 to 2008 .... **3**-21

Figure 3-3: A qq plot for double log model for gasoline demand in the EU27....... **3**-23

Figure 3-4: A residual plot for EU27 gasoline demand................. ....**3**-25

Figure 3-5: The bioethanol blend mandate model with government subsidy....... **3**-32

Figure 3-6: Blend mandate effect on bioethanol demand **3**-34

Figure 3-7: Bioethanol production process from grain crops (dry milling) **3**-40

Figure 3-8: Average selling price of grain in the EU from 1997-2008 (€/100Kg). ...**3**-47

Figure 3-9: Average price of sugarbeet in the EU from 1997-2008 (€/1000Kg)..... **3**-48

Figure 3-10: Annual demand and supply of bioethanol in the EU under different blend mandates in thousands of barrels per day **3**-49

Figure 4-1: Global sugar production and consumption from 2004 to 2011 (in millions of tonnes raw sugar) **4**-7

Figure 4-2: EU, USA and World market sugar prices from year 2002 to 2010 (US cents per pound) **4**-8

Figure 4-3: EU sugar production and consumption (million tonnes) from 2003 to 2011 .... **4**-9

Figure 4-4: EU sugar import and export from 2003 to 2011 (million tonnes) **4**-10

Figure 4-5: CAP expenditure time path **4**-13

Figure 4-6: EU cereal net trade **4**-16

Figure 4-7: The CMO and related policies **4**-18

Figure 4-8: EU sugar quota mechanisms **4**-20

Figure 4-9: EU Intervention price for white sugar from 1968 to 2003 in €/tonne..... .... **4**-23

Figure 4-10: Relative sugar production cost for period 2006-2010 .... **4**-38

Figure 4-11: Caribbean sugar production and consumption **4**-41

Figure 4-12: Caribbean sugar import and export **4**-42

Figure 4-13: Sugar production and export to EU for ACP sugar protocol countries in 2003 .... **4**-43

Figure 4-14: SADC sugar production and consumption **4**-46

Figure 4-15: SADC sugar export markets destinations **4**-47

Figure 4-16: Fiji sugar cane production and area harvested **4**-49

Figure 4-17: ACP estimated revenue loss due to EU sugar reform **4**-54

Figure 4-18: EU sugar policy developments **4**-59

Figure 5-1: GTAP model - closed economy... **5**-8

Figure 5-2: GTAP model - open economy **5**-10

Figure 5-3: Effects of an export subsidy in region *r*.. **5**-12

Figure 5-4: Effect of an export tax in region *r* **5**-13

Figure 5-5: Effect of an import subsidy in region *s* **5**-14

Figure 5-6: Effects of an import tax in region *s* **5**-15

Figure 5-7: Production tree for output (QO) in the GTAP model **5**-18

Figure 5-8: Private household behavioural tree **5**-20

Figure 5.9: A graphical exposition of linearization **5**-21

Figure 5.10: A graphical exposition of equivalent variation **5**-25

Figure 5.11: Allocative and technical efficiency contribution to welfare **5**-29

Figure 6-1: EU bioethanol production by crop type in 2006 .... **6**-3

Figure 6-2: Calculated percentage bioethanol crops share in the EU27 for bioethanol production as has been reported in literature **6**-9

Figure 6-3: Annual bioethanol grain crop production in the EU27 from 1997-2009 (x1000 tonnes) **6**-10

Figure 6-4: Bioethanol crop shares for bioethanol production (at S_w=25.85%, S_r=10.24%, S_c=10.24%, S_b=22.57% and S_{sb}= 31.1%) as a percentage of 2004 EU27 bioethanol crop production **6**-11

Figure 6-5: EU27 annual total petroleum products, diesel and gasoline production (x1000 barrels per day) 1997-2008 .... **6**-18

Chapter 1

1.0 Introduction and Motivation

Biofuel production has been gaining popularity around the world because of the unpredictable and sometimes high prices of fossil fuels, most notably the oil crisis of the 1970s. More recently, biofuels are being promoted due to global warming concerns and the need for cleaner energy. Nations the world over are eager to find alternative forms of energy in an attempt to reduce the dependence on fossil fuels which are costly and have negative environmental effects due to the emissions of Green House Gases (GHG) that have been identified as major contributors to global warming and climate change. Hardin (1968) equated environmental pollution to the tragedy of the commons where agents, in pursuit of their own individual interests, ultimately deplete a common limited resource with adverse long-term consequences. Global concerns about the increasing levels of pollution have therefore given rise to the idea of a carbon tax in an attempt to reduce GHG emissions into the atmosphere.

Besides environmental protection, biofuels are also being promoted as an attempt to improve and diversify farm incomes. In such cases, their production is supported by various protective and market distorting policies. The European Union (composed of 27 member countries and referred to as the EU27), being a signatory to the Kyoto Protocol, has also put in place policies that are aimed at promoting production and use of biofuels in the region.

An example of such policy intervention is the European Commission (EC) Directive on Biofuels passed in 2003, which forms the basis for the EC bioethanol blend mandate. This directive sets a reference value for national indicative targets at 2%, calculated based on energy content, of all transport fuels in the EU region by 2005, increasing to 5.75% by 2010 and 10% by 2020.

Biofuels primarily refer to bioethanol and biodiesel. The words bioethanol and ethanol will be used interchangeably. Biodiesel is produced mainly from vegetable and animal oils/fats by a process called transesterification while bioethanol is produced mainly from sugar crops (e.g. sugar cane and sugar beet) and grain crops (e.g. corn, wheat, barley and rye) by a process of fermentation.

Bioethanol is produced more efficiently and cheaply from sugar cane. Since sugar is not a main food source for man or livestock as is corn, it is a better bioethanol source. Therefore, if well balanced, sugar could produce bioethanol without threatening food security. In this way, it is more sensible for the EU to use more sugar beet or sugar in the production of bioethanol so that the mandate does not have adverse effects on food markets and welfare. This is because the other bioethanol crops commodities like corn and wheat are more vital food sources with few substitutes.

The global leaders in the production of bioethanol are the USA and Brazil, using corn and sugar cane respectively. Bioethanol in the EU27 is produced from a number of crops (referred to as bioethanol crops[1]) which differ from state to state but which are mainly wheat, corn, barley, rye and sugar beet.

The EC bioethanol blend mandate policy is therefore expected to affect the markets for EU27 bioethanol crops i.e. wheat, rye, sugar beet, corn and barley. Because bioethanol production from sugar beet competes with sugar production, the proposed EC bioethanol blend mandate policy is therefore expected to have an effect on the EU sugar market. Since the EU is a global player in sugar trade, a disturbance in its sugar market will be transmitted into the world sugar market. It is

[1] Bioethanol crops are equivalent to bioethanol crops commodities except for sugar cane and sugar beet where the bioethanol crop commodity in this case is sugar.

also expected that the EC bioethanol blend mandate policy will result in increase in the prices of bioethanol crops commodities, worsen food security and decrease overall global welfare mainly because biethanol crops commodities are important food sources.

It is therefore important to analyse the possible outcomes of such disturbances and to determine their implications for African, Caribbean and Pacific (ACP) countries. Policies that have a potential to affect food markets are interesting to ACP countries given the fact that most of them are still food insecure. Further, trade in sugar remains one of the key sources of revenue for many ACP countries and as such, trends and developments that affect global sugar markets are important for these countries.

A number of ACP countries are trading in the EU and world market under various trade agreements. More recently, there has been the Economic Partnership Agreements (EPAs) that have been proposed between the EU and ACP member states. The EPAs involve reciprocal liberalisation of trade between the EU27 and ACP countries. It is therefore important to analyse how the EC biofuel blend mandate policy will interact with such novel trade agreements that are being put in place that will form the framework for future bilateral trade between the EU and ACP.

From these forewords, the aim of the research is therefore the following:

- To develop a model for the EU27 bioethanol market and to determine equilibrium conditions arising from the proposed EC bioethanol blend mandate directive on transport fuel.
- To determine using the GTAP model what effects the EC bioethanol blend mandate policy will have on bioethanol crop commodities markets and on global welfare. Special emphasis is given to its potential effect on the

EU/World sugar markets and therefore its implications on sugar production and trade in ACP countries.

- To analyse the possible interaction outcomes between the EC bioethanol blend mandate policy and the EPA policies and implications of such interactions on bioethanol crops commodities markets especially sugar.

The overall aim of our study therefore to contribute to our understanding of the EU bioethanol market and its international trade perspective especially on ACP countries.

Why study the EU27 sugar and bioethanol markets?

A study of the EU27 sugar and bioethanol markets is important in that bioethanol and sugar compete directly for the same raw material i.e. sugar cane and sugar beet meaning their markets are directly linked. In this way, developments in the bioethanol markets will be transferred to the sugar market and vice versa.

The EU sugar market is one of the most distorted in World Trade due to intervention policies that artificially increase prices. It is therefore interesting to find out the effect of the proposed EC bioethanol blend mandate policy on this market. It is expected that the mandate will increase the price of sugar due to increased demand for sugar beet with important implication for EU sugar policies and trade with ACP countries.

The EU is a major importer of ACP sugar. For this reason, the study of biofuel or specifically, bioethanol and sugar market in the EU will shed some light on potential future trends and developments in ACP sugar industries. This is more so in the current new policy proposals like the EPA and EBAI policies between the EU and ACP/LDCs. Since the EU is a major global player in the sugar industry, any disturbance to its sugar market, as is expected from the bioethanol mandate, will have spillover effects into the world sugar market that is also an important export destination for ACP sugar.

The outcome of the study therefore will help inform ACP countries on their future production decisions. Since the EC bioethanol blend mandate is expected to increase global demand for sugar, more investment in the production of this commodity could be justified despite the recent developments of cuts in EU sugar prices, which negatively affect ACP revenues.

This means a strong link between bioethnol and sugar market is predicted. Such link between commodities that compete for the same raw materials is not unique as has been the case in the USA where there has been an increase in corn price due to the production of transport bioethanol thus strengthening the relationship between agriculture and energy markets.[2]

What is new about our approach in studying the EU bioethanol market under the mandate and our study contribution?

Not many studies have been done on the EC biofuel/bioethanol blend mandate policy especially on its international trade effect. Most studies analyse the EC biofuel blend mandate policy using a general equilibrium approach and draw conclusion on the bigger picture of the possible effects of the EC biofuel policy. As such, they have limited use or applications to countries that are specifically interested in the EU/global market for a specific commodity, in this case sugar.

For example, a study by Banse et al (2008) used a Computable General Equilibrium Model (CGE) with endogenous land supply and concluded that the EU biofuel blend mandate will result in increased demand for biofuel crops regionally and

[2] Please see Andrade et al (2011), Monteiro et al (2009), Banse (2008), Hazell and Pachauri (2006) and Voyiatzis et al (2002).

internationally which will result in increased land use, an EU agricultural trade deficit and an increase in consumer prices for petrol.

Birur et al (2007) also used CGE modelling and concluded that the EU biofuel mandate of 5.75% will result in a 281% increase in biofuels' share of liquid fuel consumption. Barka and Holst (2009), by holding EU27 agricultural production constant concluded that the EU has the potential to reduce oil imports between 6% and 28% by converting eligible agricultural crops into biofuels.

This means that there is a paucity of studies that analyse the EC bioethanol blend mandate policy on a partial equilibrium approach. Further, studies on the EU biofuel market do not attempt to incorporate the potential interaction of the blend mandate policy with other future proposed trade policies like the EPA policies between the EU and ACP. The approach for most EU biofuel studies is therefore not specifically designed to draw policy conclusions more relevant to ACP countries. The study of the EC biofuel policy with special emphasis on sugar output and trade is important for ACP countries and especially for the Southern African Development Community (SADC) countries that have developed sugar industries that form an important part of their economies.

As mentioned before, the EU and world sugar markets are important trade markets for ACP countries and such trade in sugar sustains many of ACP economies. Table 1.1 below shows the contribution of sugar to some ACP member states GDP in 2003.

Table 1.1: Contribution of sugar to some ACP member states GDP in 2003

Country	2003 Sugar		Sugar as % of		Sugar Sector Employment
	Production (MT)	Export (MT)	GDP	Total Agriculture	
Barbados	36 000	35 161	1.8	41.4	9 500
Belize	111 109	100 462	9.5	61.9	10 600
Congo	45 000	42 524	1.0	n/a	1 000
Cote d'Ivore	145 000	31 518	0.9	3.3	5 000
Fiji	330 356	273 756	8.1	93.0	101 600
Guyana	302 000	261 207	15.8	30.0	33 100
Jamaica	153 670	131 117	1.0	13.9	51 500
Madagascar*	35 000	6 837	3.9	n/a	18 000
Malawi*	257 000	118 059	4.9	n/a	21 800
Mauritius*	537 723	517 506	8.0	70.0	51 600
St Kitts and Nevis	22 000	15 921	28.0	74.0	9 400
Swaziland*	615 949	478 648	24.0	51.0	93 000
Tanzania*	217 513	22 723	3.1	5.0	52 000
Trinidad and Tobago	66 914	54 202	0.6	27.8	41 400
Zambia*	229 757	118 784	2.3	15.0	62 000
Zimbabwe*	482 309	124 289	2.3	17.2	162 000
Total	3 587 300	2 332 744			729 500
Source: ACP Sugar group report (2005) *Refers to SADC member state					

As can be seen from the Table 1.1, in 2003 Swaziland sugar export accounted for about 78% of total sugar production and the sugar industry contributed 24% of Swaziland's GDP and formed 51% of total agriculture production. In St Kitts and Nevis, sugar exports accounted for 72% of total sugar production. Sugar industries contributed 28% to their total GDP and formed 74% of total agricultural production.

Further, according to the Swaziland Sugar Association annual report (2006/2007), 27% of sugar sales were to preferential markets, mainly the EU and the USA, with the EU accounting for 85% of these sales. Sales to the world and regional markets (excluding the US and EU market) contributed 22% of total sugar sales for that financial year. This means that sales to preferential and world market accounted for close to 50% of total sugar sales.[3]

These figures show the significance of the sugar industry to some ACP member states and the importance of an analysis of the potential outcomes of factors that will affect the EU and the world sugar market, as the EC bioethanol blend mandate policy is envisaged to do. Changes in the EU27 sugar market will not only have effects on the prices and quantities of ACP sugar exports but also on production levels meaning that the effects will have more spillover consequences for example in terms of employment, land and water utilisation and the environment. It is therefore important to study the nature of the changes the EC bioethanol blend mandate policy might have in an objective way and to draw empirical conclusions.

Analysis of the EC bioethanol blend mandate policy will contribute alternative ways of modelling the EU bioethanol supply by use of the Food and Agriculture Policy Research Institute (FAPRI) adapted model that has previously been used to study mainly the USA agricultural markets. EU bioethanol demand is modelled on the demand for transport fuel by the use of a binding blend mandate and tax rebate. For this reason, the EU bioethanol market is derived from the market for transport fuel. This approach helps set up a bioethanol market in the region, which is currently under-developed with no reliable data. In this way, an EU27 bioethanol model has been set up in line with that of the USA and Brazil, the leading global bioethanol producers.

The supply for bioethanol in the region is derived under an assumption that the EU27 does not allow bioethanol imports. Bioethanol supply in the EU is therefore derived from 'current' bioethanol crops production in the region. This means that some of these bioethanol crops will be diverted from production of bioethanol

[3] The percentages have been calculated from figures cited in the reference report

crops commodities to the production of bioethanol. This is a strong assumption but it will contribute in the analysis of the blend mandate on an upper bound benchmark. The EU27 bioethanol equilibrium conditions are determined which are then used in the GTAP model to study the global spillover effects of the mandate.

The use of the GTAP model also facilitates the analysis of the blend mandate's interaction with other policies. This policy interaction approach to the analysis of the EC biofuel blend mandate policy has never been attempted before, with most existing studies focusing on the analysis of each of these policies in isolation. The outcomes of this study will therefore contribute to the existing knowledge on these policies and their effects on global food markets.

This study will also contribute an initial phase for the analysis of the potential for ACP countries to produce and export bioethanol. This diversification to bioethanol production is especially important in the face of decreasing world sugar prices and increases in the prices of fossil fuels. In this way, ACP countries can also play an important role in endeavours to find alternative forms of energy given the fact that a number of ACP member states especially in the SADC region are low cost sugar producers.

Method of Investigation

The first step of the study is a preview of the EC biofuel blend mandate policy and the reasons behind it (i.e. climate change mitigation, uncertainty and high prices of fossil fuels and the goal of diversifying farm incomes). A literature review focusing on the EU27 and global bioethanol status is then undertaken. This includes a review of literature on bioethanol policies, production costs (which highlights regional production competitive advantages) and environmental and socio-economic implications of the EC bioethanol blend mandate policy.

The global, USA and Brazilian bioethanol models are reviewed and discussed which then help establish an EU27 bioethanol model. The USA bioethanol model is linked to the corn market while the Brazilian one is linked to the sugar market. The EU27 bioethanol model is therefore linked to markets for sugar beet (sugar), corn, wheat, rye and barley which are the crops mainly used to produce bioethanol in the EU region. A partial equilibrium model for the EU27 is then designed and equilibrium market clearing bioethanol quantities determined.

The equilibrium quantity of bioethanol is then converted to equivalent quantities of bioethanol crops commodities using their bioethanol production efficiencies and shares in the EU bioethanol production process. These bioethanol crops commodities equivalents are then transmitted into the GTAP model as an artificial decrease in output of these commodities in the EU27 region. This artificial percentage decrease in bioethanol crops commodities output uses the 2004 EU27 production level of these commodities. This is because the GTAP 7 database used in our study is based on 2004 international trade data.

This decrease in EU bioethanol crops commodities output, which simulates the EC bioethanol blend mandate policy is analysed with emphasis given on its effects on ACP bioethanol crops commodities production and trade and on its global welfare outcomes. For this reason, EU agricultural policies that support crop production are also reviewed together with policies that promote sugar production in the region. Trade policies (historical and future) that form the trade framework between the EU27 and ACP countries are also reviewed. Again special emphasis is given to policies that have sustained the sugar industry in the EU region including those that have facilitated sugar trade between the EU and ACP countries.

Data needed

- EU bioethanol production data (current)

- Bioethanol crops commodities production and prices data (wheat, rye, barley, sugar cane, sugar beet and corn)
- The demand for transport fuel
- Sugar production, imports and exports in the EU
- EU/Global sugar prices and trends
- GTAP data base

Models to be used

- A FAPRI adapted model to derive the EU27 bioethanol supply model
- A transport fuel derived bioethanol demand model
- GTAP model

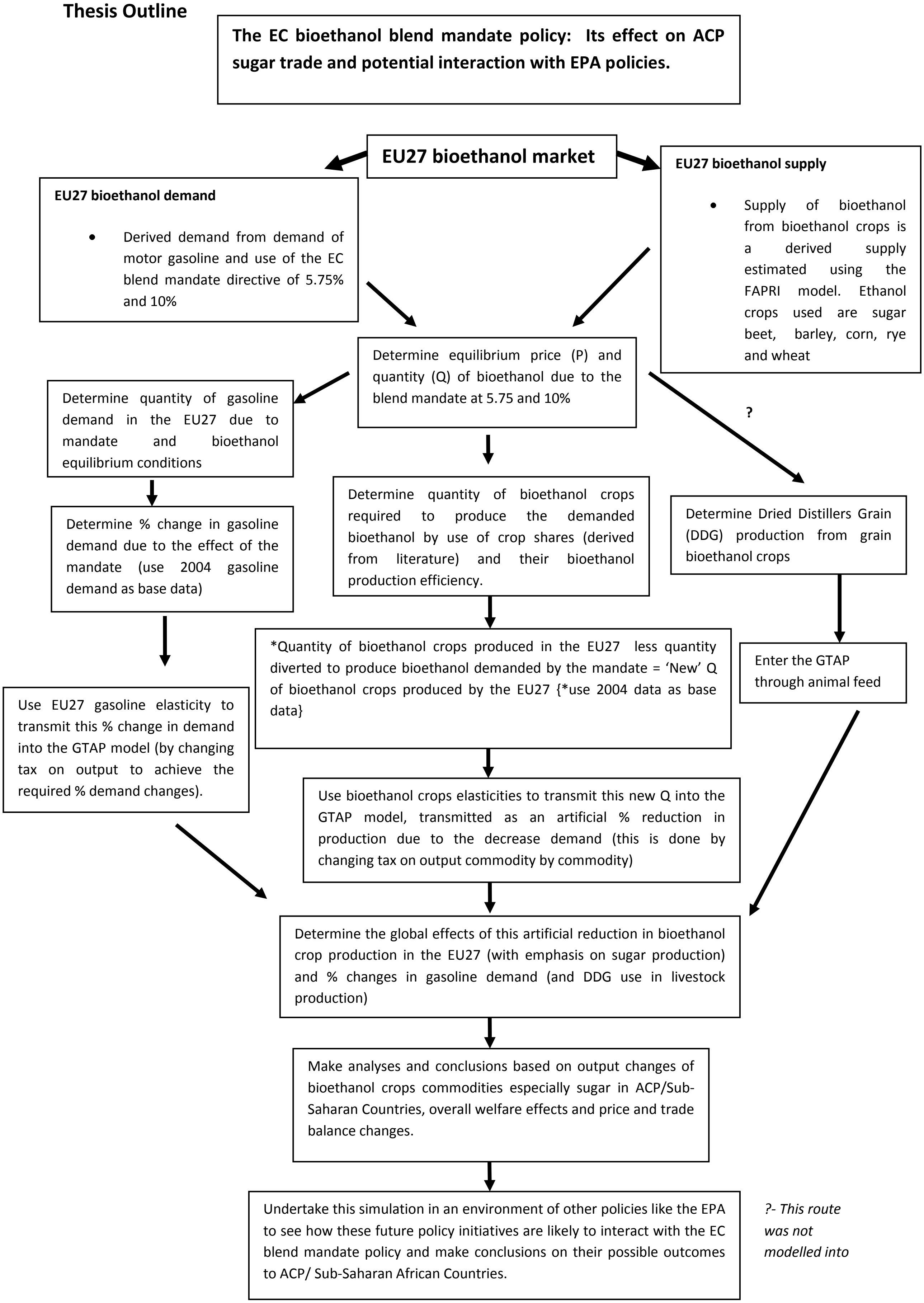
The FAPRI model was developed by the Food and Agriculture Policy Research Institute (FAPRI) at the University of Missouri-Colombia (MU). It is used in the study of supply and demand of major US agricultural commodities i.e. crops and livestock markets, input costs, retail prices, farm incomes and government costs. Its adaptation into the EU bioethanol partial equilibrium analysis is a new initiative.

The bioethanol demand model is a derived demand from the EU27 demand for transport fuel. Key assumptions in this bioethanol demand derivation is that the EC bioethanol blend mandate policy is binding and that there is a full tax rebate for the bioethanol component of the blended fuel mixture.

The GTAP is a CGE model that consists of multiple commodities and multiple regions. It is a standard modelling framework that employs simple but robust assumptions of constant return to scales and perfect competition to achieve Walrasian equilibrium. Given the fact that it comes with software to manipulate the data to the modeler's aim and with its multiregional and multi-commodity database, it is ideal to study policies that have international spillovers.

A more detailed discussion of the models is provided in chapters 3 and 5 of the thesis. The flow diagram below is the schematic outline of our study.

Thesis Outline



The diagram above is a visual flowchart for our study and shows the connection between the EU bioethanol market, the EU transport sector and the markets for bioethanol crops commodities. It highlights the sequences that the study will follow in consideration that all the sections are linked.

The thesis is therefore organised as follows;

Chapter 2 is the review of the EC bioethanol blend mandate policy as well as a literature review on the global and EU27 bioethanol production status and policies that support bioethanol production and trade in the EU. Special emphasis is given to Brazilian bioethanol production status given that it is the lowest cost bioethanol producer. Further, since ACP countries produce sugar from sugar cane the Brazilian bioethanol industry, which is sugar cane based, is of interest to these countries. The chapter also reviews the literature that has been done on the possible effects of the EC bioethanol blend mandate policy on food markets, the environment and its overall socio-economic impact in order to highlight the gaps that our study wishes to investigate.

Chapter 3 reviews the global, USA and Brazilian bioethanol models and from these models an EU27 bioethanol partial equilibrium model is designed. The EU model is based on the link between the bioethanol market and other sectors. The EU27 bioethanol demand is derived from the demand for gasoline while its supply is adapted from the FAPRI model that links bioethanol supply to that of bioethanol crops commodities. Equilibrium conditions of the EU27 bioethanol market are determined and their implications on the EU transport sector analysed.

Chapter 4 is a review of the global, EU and ACP sugar markets status. The chapter also investigates policies that sustain trade between the EU and ACP countries. Since the EU bioethanol market is directly linked to that of agricultural commodities, the policies that sustain agriculture in the EU are reviewed, which include the Common Agricultural Policy (CAP) and specifically the Common Market

Organisation (CMO) that sustains sugar production in the EU region. Reforms in the EU sugar market, which have important implications for ACP countries, are also discussed including future policies that have a potential to affect EU/ACP sugar industries.

Chapter 5 is an overview of CGE modelling techniques and their use in welfare analysis. It also offers a theoretical background of the GTAP model and highlights its usefulness in the analysis of policies that have multimarket and multinational linkages, as is the case with the EC bioethanol blend mandate policy.

Chapter 6 presents the empirical analysis of the EC bioethanol blend mandate policy on ACP countries using the GTAP model. Empirical results are presented and conclusions drawn from the findings in terms of the global welfare effects of the mandate and its implication on bioethanol crops commodities production and trade between the EU and ACP countries with special emphasis on sugar.

Chapter 7 is the simulation of the EPA policies on their own using the GTAP model and their simulation in combination with the EC bioethanol blend mandate policy on ACP countries. Conclusions are drawn from the empirical results of the effects of these policies and their interaction. Again, special focus is given on the welfare outcomes and changes in sugar output and trade between the EU and ACP countries because of these policies.

Finally, **Chapter 8** summarises the key results of the policies under analysis for the EU and ACP regions. The chapter also compares our results with those from previous studies, points out the limitations of our analysis approach and suggests extensions for future research.

Chapter 2

Literature review on biofuel and bioethanol

2.0 Introduction

In this Chapter, we will discuss the background of biofuel production and reasons for their promotion around the world. Global production of biofuels and their international trade status will be reviewed including the various policies that support their production more especially in Brazil and USA. The focus of this study is on bioethanol as opposed to biodiesel because of the direct link between bioethanol production and bioethanol crops commodities markets. For this reason, bioethanol will be discussed in more details.

Brazil and USA are the two main leaders in transport bioethanol production with well developed bioethanol markets. These countries bioethanol programmes therefore warrant reviewing. The Brazilian bioethanol industry, which is sugar based, will be reviewed in detail because of its direct relevance to ACP countries which are major sugar cane producers and sugar traders. This chapter will also review biofuels production processes since these processes, especially that for bioethanol help show the links between biofuels and food production chains. The controversies surrounding the production of biofuels will also be discussed especially their effects on food production and food prices.

Since one of the reasons cited for promotion of biofuel as a transport fuel is the reduction of environmental pollution due to green house gases (GHG), the interaction between biofuel production, biofuel use and the environment will also be discussed. This is more so because various studies, mostly using life-cycle assessment models, have questioned the environmental benefits of biofuels.

Since the focus of our study is on EU27 bioethanol production, the reasons for promotion of biofuels in the EU will be reviewed including biofuel production strategies and status in the region. We will then review the various studies that have been done on the EU27 bioethanol market in order to show the literature gaps which our study aim to address. The bioethanol market in the EU is generally still under-developed and studies on the economics of the EC bioethanol blend mandate are scant. The potential full impact of the EC bioethanol blend mandate policy on bioethanol crops commodities markets remains largely unknown.

In this light therefore, the chapter is structured as follows; in section 2.1 the definition of biofuels is given which will be applicable throughout the thesis. Section 2.2 gives a discussion of reasons behind biofuel production and the controversies surrounding their promotion. The global bioethanol status is reviewed in section 2.3 while section 2.4 gives an overview of bioethanol as an internationally tradable commodity. Section 2.5 discusses the EU biofuel promotion strategy and section 2.6 gives the EU bioethanol production and trade status. In section 2.7 we review studies that have been done on the EU bioethanol programme as guided by the EC bioethanol blend madate policy and section 2.8 is the conclusion.

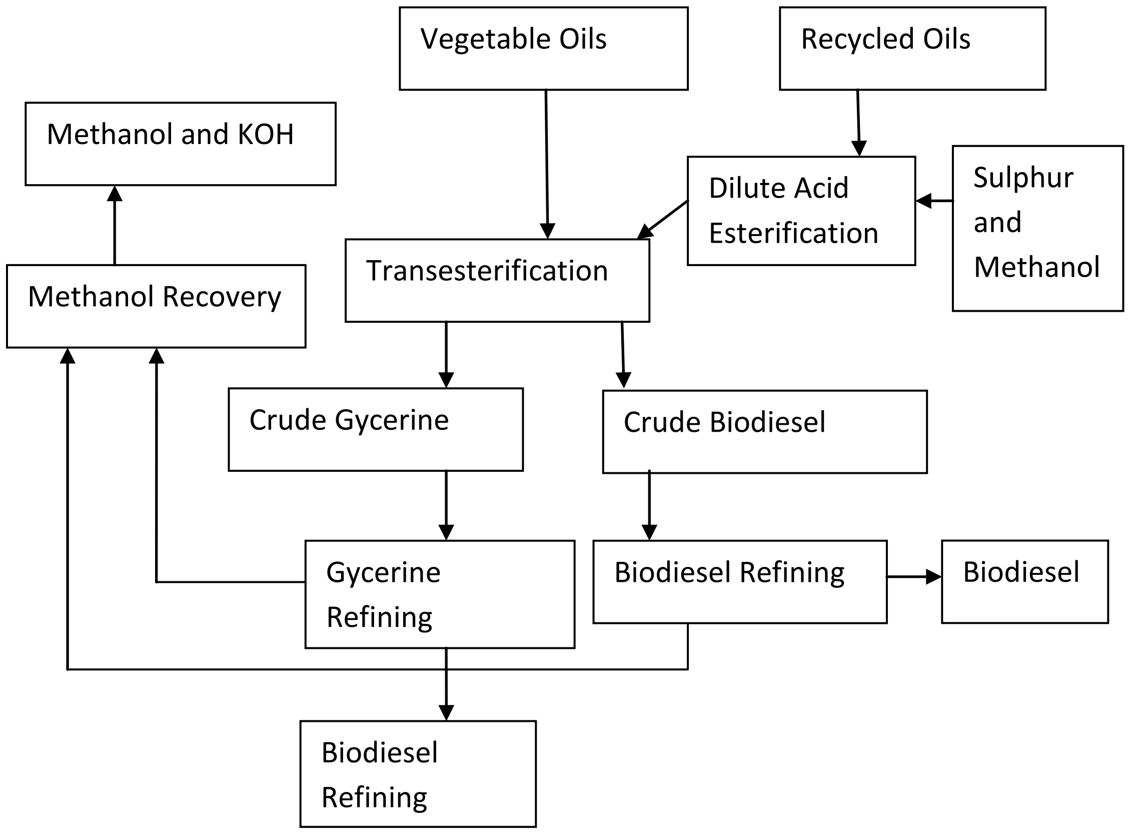
2.1 What are biofuels?

The term biofuel is referred to as liquid or gaseous fuels for the transport sector that are predominantly produced from biomass (Demirbas, 2008). Biofuels are basically divided into two namely bioethanol and biodiesel. Bioethanol is an alcohol obtained by fermenting sugar containing organic materials like sugar cane, sugar beet and most grain crops like corn, wheat barley and rye. This is what is referred to as the primary bioethanol production process and is the bioethanol source that is of importance in this study since it impacts directly on bioethanol crops commodities markets.

Bioethanol can also be produced from lignocellulosic biomass. The conversion includes two processes: hydrolysis of cellulose in the lignocellulosic materials to fermentable reducing sugars, and fermentation of the sugars to bioethanol by help of enzymes (Sun and Cheng, 2001). However, this bioethanol production pathway which is commonly referred to as second generation bioethanol is difficult and still under active research globally. As Balat (2010) noted, bioconversion of lignocellulose to bioethanol is difficult due to: (1) the resistant nature of biomass to breakdown; (2) the variety of sugars which are released when the hemicellulose and cellulose polymers are broken and the need to find or genetically engineer organisms to efficiently ferment these sugars; and (3) costs for collection and storage of low density lignocellosic materials. This bioethanol production process will not be considered in this research because it is still in its infancy and does not have a direct impact on bioethanol crops commodities production and trade, which is the main focus of our study.

Biodiesel is basically an alkyl ester obtained from oil plants like sunflower, palm, rapeseed and soybeans by a process of transesterification. The basic production process of biodiesel is shown in Figure 2-1;

Figure 2-1: Basic schematic view of biodiesel production process



Source: adapted from Marchetti et al (2005)

As can be seen from the chemical production of biodiesel the only inputs of agricultural value are the vegetable oils which are not an important direct food source like corn or wheat. This means that biodiesel production competes with food production indirectly through competition for agricultural inputs like water, land and labour.

Global production of biofuels amounted to 62 billion litres (or 36 million tonnes of oil equivalent (Mtoe)) in 2007, which is equal to 1.8% of total global transport fuel consumption in energy terms with Brazil and the United States together accounting for almost three quarters of global biofuels supply (Ajanovic, 2010). As has been noted by Bomb (2006) and Bozbas (2005) the EU mainly produces biodiesel with little progress on bioethanol production. High production costs of EU produced biofuels due primarily to high priced internal biofuel crops relative to fossil fuels are the main impediment to market based expansion of EU biofuel programmes, particularly for bioethanol.

According to an EC report (2006), domestically manufactured biodiesel becomes economic at crude oil prices of about €60 a barrel; domestic bioethanol becomes economic at crude oil prices of €90 a barrel. This means that biodiesel production is less expensive than that of bioethanol which could be the reason why biodiesel production is higher in the EU region. In the next section we discuss the reasons for the promotion of biofuels around the globe and the controversies surrounding their production.

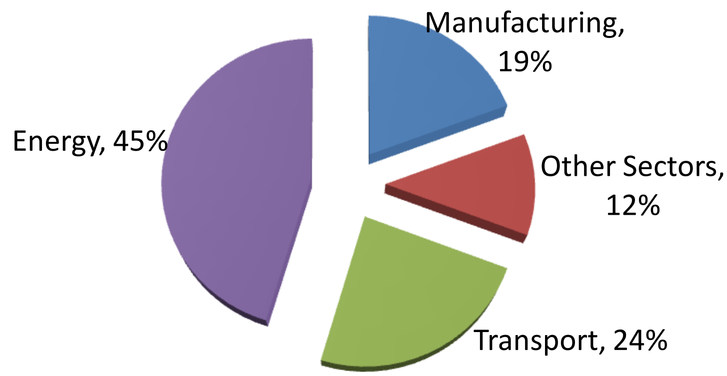
2.2 Reasons and controversies surrounding biofuels production

As mentioned before, the unpredictability and volatility of fossil fuel or specifically oil prices is one of the important drivers that promote biofuels. An example of such unpredictability and volatility is that in June 2008 the oil price reached a high of US$147/barrel but by December of the same year the price had dropped to $45/barrel. A UN report (2009) observed that prices were likely to remain at that level or decline even further due to the financial crisis and recession that depressed oil demand. However, by March 2011 the oil price was hovering around US$110/barrel on concerns of political upheavals in Arab member states despite the fact that the global recession was not completely over. This is an indicator that the prices of oil will remain unpredictable and that economic activity is not their sole driver. Demand for oil drives the demand for gasoline. For example, if crude oil represents half the cost of retail gasoline, a 10% increase in the price of crude would translate into a 5% increase in the price of gasoline, and the demand elasticities for crude oil would be about half those for gasoline (Hamilton, 2008).

Another important reason for the promotion of biofuels is in an attempt to fight global warming. The transport sector has been identified as one important contributor to GHG emission.

Figure 2-2 shows global fossil fuels sector's contribution to CO_2 emission in 2006.

Figure 2-2: 2006 world CO_2 emissions from fossil fuel combustion



Source: OECD report (2010)

The global CO_2 contribution of transport fossil fuels according to an OECD report (2010) was 24% in 2006.

The European Climate Change Programme (ECCP-2007) reported that the EU transport sector was responsible for up to 21% of total EU GHG emission in 2006. The EEA (2006) also noted that the share of transport in total EU25 GHG emission rose from 17% in 1990 to 24% in 2004. Further, according to Hammond et al. (2007), the UK transport sector has the fastest rate of growth in terms of primary (and end-use) energy consumption, and is currently responsible for 30% of UK CO_2 emission. These figures justify the need for renewable forms of energy in the transport sector, thus the promotion of transport biofuels. Fontaras and Samaras,

(2007) noted that the contribution of the road transport sector to EU GHG emission has resulted in the drive to reduce CO_2 emission and fuel consumption from this sector to be an important strategy for the EU to mitigate against climate change.

One important global attempt to reduce GHG emission was the signing of the Kyoto protocol in 1997. Under this protocol industrialized nations committed themselves to reducing their GHG emission by 5.2% below 1990 levels for the years 2008–2012. GHG under the Kyoto protocol refer to carbondioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Perflurocarbons (PFCs), Hydroflurocarbons (HFCs) and Sulphur Hexaflouride (SF_6). GHG are measured in CO_2 equivalent and the carbon footprint refers to their total amount emitted into the atmosphere by individuals. This definition therefore result in climate change discussions centrering around carbon thus giving rise to terms like carbon policies, carbon tax and carbon trading.[4]

In an attempt to meet targets of the Kyoto protocol commitments, three mechanisms were proposed and these are the Clean Development Mechanism (CDM), Joint Implementation (JI) and the International Emissions Trading System (ETS). These mechanisms aim to maximise the cost-effectiveness of climate change mitigation by allowing parties to pursue opportunities to cut emissions, or enhance carbon sinks, more cheaply abroad than at home (Corregidor Sanz et al, 2005).
The EU was one of the forerunners to embrace the Kyoto Protocol and committed to reducing GHG emissions by 8% below its 1990 level in the period 2008–2012. Also in 2005, the EU Emissions Trading Scheme (EU ETS), a carbon trading scheme for GHG was launched within the EU (Wei and Zhang, 2010). However, this carbon trading scheme, which is aimed at reducing industrial pollution will only include

[4] CO_2 equivalents is a metric measure used to compare the emissions from various GHG based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents ($MMTCO_2$ Eq)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. $MMTCO_2$ Eq = (million metric tons of a gas) * (GWP of the gas) –(http://www.epa.gov/climatechange/glossary.html)

aviation from 2012.[5] The exclusion of the transport sector is despite the findings that it is a major contributor to CO_2 emission. Li (2009) identified three mechanisms in which the EU is attempting to reduce GHG emission from the transport sector and these are: (1) commitment of European car producers in 2008 to manufacture cars that do not exceed CO_2 emission of 140g /Km (2) encouraging consumers to choose the most fuel efficient cars and (3) fiscal support that requires member states levying car registration taxes and or circulation taxes to relate at least 50% of the taxes to the level of a vehicle CO_2 emission. The biofuel blend mandate proposed by the EC is therefore yet another method of mitigating against the contribution of transport fuels to GHG emission.

Because its primary feedstock is a vegetable oil or animal fat, biodiesel is generally considered to be renewable and since the carbon in the oil or fat originate mostly from CO_2 in the air, biodiesel is considered to contribute much less to global warming than fossil fuels (Van Gerpen, 2004). Bioethanol, since it is produced from renewable feedstock is also considered a renewable fuel. Bioethanol usually forms 10% (E10) of the blend fuel mixture or up to 85% (E85) as is used in flexi fuel vehicles (FFV) that can use both ethanol and gasoline as fuel. Despite its lower energy content than traditional fossil fuels (bioethanol contains 68% of the energy in a litre of petrol) bioethanol improves the fuel combustion in vehicles, thereby reducing the emission of carbon monoxide, unburned hydrocarbons and carcinogens (Nigam and Singh, 2010). Whitten (2004) reported a reduction in CO_2 emission by up to 30 % when using 10% bioethanol blended with petrol due to the higher oxygen content of bioethanol of about 35%w/w. Moreover, the higher octane number (a measure of fuel tendency to burn more efficiently) of bioethanol has been cited as one further advantage of its use as a transport fuel (Balat and Balat, 2008; Dodic´ et al, 2009; Costa and Sodré, 2010).

[5] Under the EU aviation emissions policy, which will take effect on January 1, 2012, airlines that land in or take off from the EU will be required to buy carbon credits under the EU ETS (Ireland, 2011)

Wang et al (1999) analysed the GHG emission reduction outcomes for various blended fuels from corn based bioethanol in the USA. Their analysis was on per vehicle mile travelled using various blended fuels, with the result based on petroleum use, energy use and emissions associated with bioethanol production. Their study reported the following outcomes;

Use of E10 (10% ethanol and 90% gasoline by volume) achieves:

- 6% reduction in petroleum use,
- 1% reduction in GHG emissions, and
- 3% reduction in fossil energy use.

Use of E85 (85% ethanol and 15% gasoline by volume) achieves:

- 73–75% reduction in petroleum use,
- 14–19% reduction in GHG emissions, and
- 34–35% reduction in fossil energy use.

Use of E95 (95% ethanol and 5% gasoline by volume) achieves:

- 85–88% reduction in petroleum use,
- 19–25% reduction in GHG emissions, and
- 42–44% reduction in fossil energy use.

A study by BIO Intelligence Service (2010) in France concluded that without considering land-use changes, biofuels display positive balances in relation to fossil fuels, with reductions from 24 to 91% of GHG emission level. For bioethanol ppathways, the reductions observed are more important for biofuels from sugar plants than from cereals, with this difference explained by the high yields per hectare of the former.

Generally therefore, the higher the blend mandate percentage the greater the GHG emission reduction. GHG emission reduction also depends on the feedstock used to produce bioethanol and the region where the bioethanol is produced. This supports the observation that different regions have different opportunity costs for the bioethanol production. Table 2.1 below summarises bioethanol GHG emissions savings for different feedstocks and different regions compared to conventional hydrocarbons.

Table 2.1: Change in Life-Cycle GHG emissions per kilometre travelled by replacing gasoline with bioethanol in conventional spark-ignition vehicles

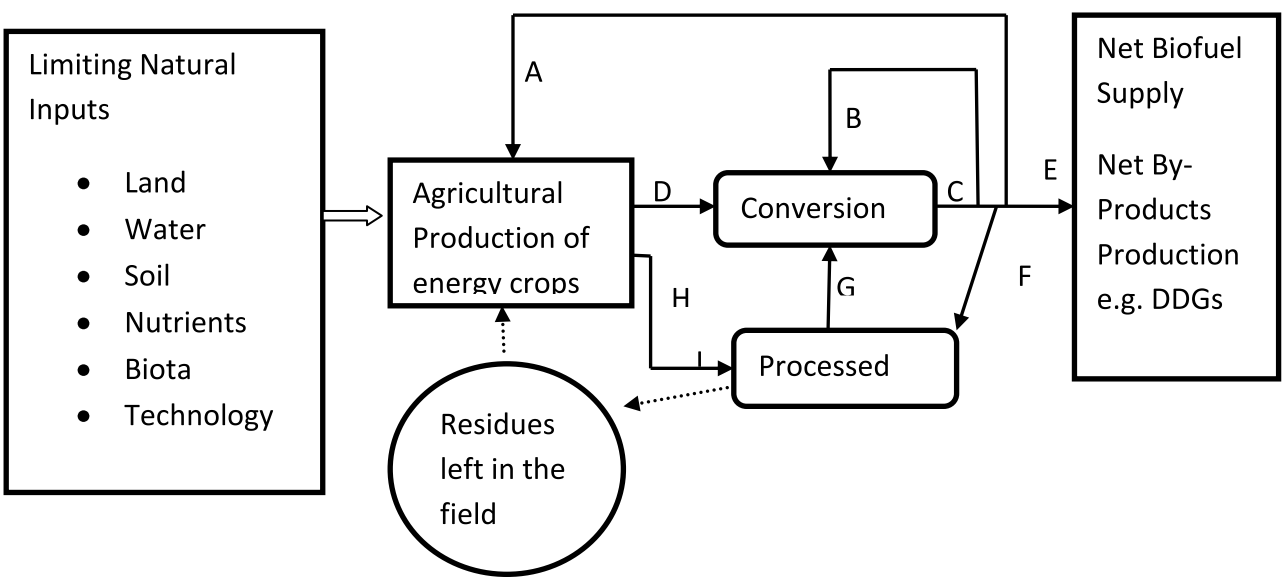
Feedstock	Location	Change	Source
Wheat	UK	−47%	Armstrong and others, 2002
Sugar beet	North France	−35%a; −56%b	Armstrong and others, 2002
Maize, E90	USA, 2015	10%	Delucchi, 2003
Maize, E10	USA	-1%	Wang, Saricks, and Santini, 1999
Maize, E85	USA	-14% to -19%	Wang, Saricks, and Santini, 1999
Cellulose, E85	USA,2005	-68% to -102%	Wang, Saricks, and Santini, 1999
Molasses, E85	Australia	−51%; −24%d	Beer and others, 2001
Wood waste, E85	Australia	-81%	Beer and others, 2001
Molasses, E10	Australia	1%; 3%d	Beer and others, 2001
Sugar, hydrous ethanol	Brazil	−87%; −95%e	Macedo and others, 2004
Sugar, anhydrous ethanol	Brazil	−91%; −96%e	Macedo and others, 2004

Source: Kojima et al, 2007

Table 2.1 shows that generally E85 has more environmental benefits that E10 and that sugar cane bioethanol produced from Brazil has the highest benefit on the environment.

However, contrasting outcomes on the benefits of using bioethanol as a fuel additive means that their promotion remains a controversial issue. Controversies surrounding biofuels production in general are mainly as a result of their competition with food production. They also have debatable GHG reduction benefits when full life-cycle assessment of their production and use is considered. First generation biofuel production therefore comes at a price.
Firstly, their production competes with food production directly by diverting biofuel crops from the food chain to the transport sector. They also compete with food production for land, labour, water and other agricultural inputs making their promotion controversial especially in a world where food shortages still persist in some regions.
Figure 2-3 is a summary of a typical first generation biofuel production cycle.

Figure 2-3: The biofuel production cycle



In the diagram above:
A= Biofuel equivalent for energy inputs used in agricultural production
B= Biofuel equivalent for energy inputs of other residues used in the conversion process
C= Gross Biofuel Production
D= Biomass processed for fuel production (= Quantity x Energy Content per Biomass)
E= Net Biofuel output (and by-products) accessible to society (E= C-B-A-G)
F= Biofuel equivalent for energy inputs used in harvesting and processing residues
G= Energy inputs from residues (= I x heat contents of residues)
H= Crop residue
I= Harvested crop residues used as energy source in the conversion process
Source: adapted from Giampietro et al (1997)

As Figure 2-3 shows, the limiting factors in the production of biofuels are the primary inputs in agricultural production mainly land, water and labour. The diagram also show that the amount of biofuel produced for a given production cycle depend on the energy content of the biomass used. This means that different agricultural crops have different biofuel production efficiencies. Biofuel production produces other useful by-products, for example, Dried Distillers Grain (DDG) that is a by-product of bioethanol production from grain crops. DDG is normally used as an animal feed. Biofuel promotion and production has to be done in consideration of the inputs limiting factors and making sure that they are produced with minimal opportunity cost to society.

In this way, biofuel production should be well investigated in cognizance of the fact that it must not cause environmental degradation and compete with food crops thus threatening food security. Their production therefore needs to be undertaken with careful consideration of aspects like pollution, biodiversity loss and soil degradation, competition for water and other socio-economic dynamics like labour supply and land availability.

Tables 2.2 and 2.3 show the energy contents and the land and water requirements for biofuel production under different environmental conditions.

Table 2.2: Typical biofuel production systems from agricultural crops

Indicators of performance	Biodiesel	Ethanol in temperate areas	Ethanol in sub-tropical areas
Gross energy yield (GJ/Ha/Yr)	20-40	40-80	80-130
Net energy yield (GJ/Ha/Yr)	<0-10	<0-30	50-70
Water requirements (t/Ha/Yr)	4000-7000	4000-8000	10 000-15 000
Best performing system	Oilseed rape	Corn-sorghum	Sugar cane
Land requirement (ha/net GJ	0.1	0.033	0.02-0.014
Water requirements (t/net GJ	500	170	200
Labour requirements (h/net GJ)	4	1	4

Source: Giampietro et al (1997)

Table 2.2 shows that biofuel productivity varies from region to region. For example, it is seen that bioethanol production in sub tropical areas is more efficient that in tropical areas even though it requires more water. However, the choice of which crop or feedstock to use to produce biofuels depends on their relative cost, which also varies from region to region.

Table 2.3 shows the land and water requirement of biofuels in selected countries as a function of their endowment for these factors of production in selected countries.

Table 2.3: Land and water demand in large-scale biofuel production compared to availability (expressed on a per capita basis)

Country	Commercial energy consumption (GJ/yr)	Arable land available (ha)	Fresh water withdrawal (t/yr)	Land demand for biofuels (ha)	Water demand for biofuels (t/yr)	Total arable land demand supply ratio	Biofuel demand/Current withdrawal ratio
Burundi	8	0.2	20	0.16	1600	1.8	80
Egypt	21	0.05	1028	0.42	4200	9.4	4
Ghana	6	0.08	35	0.12	1200	2.5	34
Uganda	8	0.28	20	0.16	1600	1.4	80
Zimbabwe	31	0.29	136	0.62	6200	2.9	46
Argentina	66	0.81	1042	1.32	13200	2.1	13
Brazil	49	0.4	245	0.98	9800	3.0	40
Canada	437	1.75	1688	14.42	74300	8.7	44
Costa Rica	35	0.1	780	0.7	7000	8.0	9
Mexico	54	0.27	921	1.78	9200	7.6	10
USA	325	0.76	1868	10.72	55200	14.6	30
Bangladesh	3	0.08	212	0.06	600	1.8	3
China	25	0.08	462	0.5	5000	7.2	11
India	12	0.2	612	0.24	24000	2.2	4
Japan	134	0.03	732	4.42	22800	148.3	31
France	163	0.32	778	5.38	27700	17.6	36
Italy	113	0.16	996	3.73	19200	24.3	19
Netherlands	202	0.06	994	6.66	34300	112.0	34
Spain	87	0.52	1188	2.87	14800	6.5	12
United Kingdom	155	0.12	253	5.11	26300	43.6	104
Australia	216	2.9	1306	3.02	43200	11.5	33

Source: Giampietro et al (1997)

Table 2.3 shows that the greatest challenge for African countries to produce biofuels is the availability of water and technology since the region is subject to droughts and poor agricultural production technology. In most of the African region there is increasing need for irrigation due to decreasing water availability from the desertification effects of global warming. Indeed the desertification effect of global warming has also been noted by Stringer et al (2009) who argued that given the increases in extreme weather events projected to affect the Southern Africa region, it was essential to assess how household and community-level adaptations have been helped or hindered by institutional structures and national policy instruments.

Land availability for biofuel production is a global problem but it is more of a concern in Europe as the total arable land to supply ratio shows for selected European countries.

Various studies have been undertaken on the controversy surrounding the effects of biofuels production on food production and therefore on food prices. A World Bank report (2008) noted that the price of corn rose by 23% in 2006 and by 60% in 2007/08 due to the bioethanol production programme in the USA. There has been other studies as well that have linked increase biofuel production especially bioethanol to increased food prices (Perini, 2008; Von Braun, 2008; Alexandratos, 2008; Gecan, 2009; Amani and Chad, 2007). These studies mostly analyse the effect of the USA bioethanol production programme from corn and conclude that increase bioethanol production is responsible for the upward pressure on global food prices especially the sharp increase observed in 2008. Michell (2008) identified the USA and EU27 bioethanol production as the cause of rising food prices.

However, other studies have found no link between biofuel production and food prices and some studies have only found beneficial outcomes from biofuel programmes. Nogueira (2009) and Mueller et al (2011) concluded that the sharp increase in food prices of 2008 was due mostly to increase in price of oil rather that the biofuel programme. Ajanovic (2010) analysed the relationship between quantities produced, costs of production and resulting market prices of food and biofuels in the USA and EU. The study concluded that there is no link between increased biofuel production and food prices. Ewing and Msangi (2006) analysed the tradeoff in welfare and food security of biofuel production and concluded that if well balanced, biofuel production can be welfare enhancing. Baka and Holst (2008) analysed the EU biofuel production in the context of WTO trade agreements and concluded that biofuel production in the EU can overcome the current impasse in global trade negotiations.

Still other controversies on the role that biofuels play in reducing GHG emissions and their overall environmental benefits have come up especially in the area of life cycle analysis which has been extensively studied. Life-cycle assessment approach is defined as a methodology for the comprehensive assessment of the impact that a product has on the environment throughout its life-cycle on a ‘‘from cradle to grave’’ analysis (ISO 14040, 2006). Life-cycle assessment outcomes of the environmental benefits of biofuels vary widely mainly depending on the feedstock analysed, location of the study, method of analysis used and the parameters analysed.

In his study on the use of bioethanol as E10 and E85 blend, Niven (2004) concluded that E10 is of debatable air pollution merit, offers little advantage in terms of GHG emissions, energy efficiency or environmental sustainability; and will significantly increase both the risk and severity of soil and groundwater contamination. He further concluded that E85 offers significant GHG benefits but will however produce significant air pollution and involve substantial risks to biodiversity with largely unknown overall sustainability. Puppan (2002) on the other hand analysed the benefits of using E5 produced from sugar beet, winter wheat and potatoes in Germany. The study concluded that E5 fuel has lower impacts on depletion of abiotic resources and climate change, but higher impacts on stratospheric ozone depletion with acidification and human toxicity impacts remaining unchanged.

The adverse effect of biofuel production on the environment has also been attributed to N_2O emission from the biofuel production process (Crutzen et al, 2007; Kaltschmitt, Reinhardt & Steltzer, 1997 and Hu et al, 2004). Kadam (2002) analysed bioethanol production from bagasse in India and concluded that there was no significant benefits in diverting excess bagasse to bioethanol production as opposed to the open-field burning.

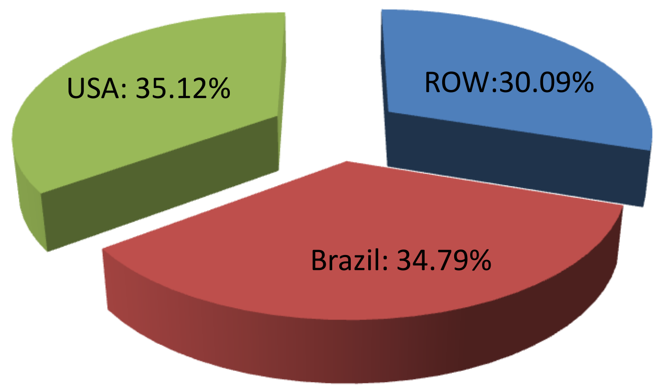
These studies generally show that there are many approaches to life-cycle assessment of biofuels and they all result in contrasting outcomes on the environmental benefits of biofuel. Besides GHG emissions biofuels have also been identified as having other adverse environmental effects. For example, Giampietro et al (1997) mentioned that the distillery waste, which is the principal component of effluent from an ethanol plant, has a biological oxygen demand, a standard measure of pollution after 5 days, of 1000-78000mg/l which poses a waste disposal problem.

Despite the controversies surrounding biofuels, their production is still promoted around the world by various biofuel programmes and policies. Because of the scope of our study, the remaining sections of this chapter will discuss mostly bioethanol as opposed to biodiesel. In the next section we review the global, USA and Brazilian bioethanol production status.

2.3 Global, USA and Brazilian bioethanol status

The two main leaders in global bioethanol production are USA and Brazil. Brazilian bioethanol is produced from sugar cane while USA bioethanol is produced from corn. Brazil is the lowest cost producer while the USA is the global leader whose bioethanol programme is supported by a number of policies that protect the local market from international competition e.g. the US Energy Bill of 2005 discussed later in this section. The global distribution of bioethanol production shares are shown in Figure 2-4.

Figure 2-4: Global bioethanol production shares



Source: by author with data from Elobeid et al (2008)

Brazil is one of the countries that initiated bioethanol production under a national alcohol programme (Proalcohol) which started in the 1970's after the oil shock in an attempt to reduce dependence on fossil fuels. It is also one of the leaders in the promotion and sale of FFVs that can run on ethanol, gasoline or a combination of the two. The Brazilian bioethanol production programme was initially supported by policies that promoted production but in recent years the bioethanol market in Brazil is only controlled by setting a mandatory blending ratio by government depending on the prices of sugar, fuel and bioethanol in the global market.

The blend ratio set by government has a significant impact on the global sugar and bioethanol markets. Koizumi and Yanagishima (2005) examined the impact in 2010 on the world sugar and bioethanol markets posed by Brazil's required blending of 8% bioethanol in gasoline fuel beginning in 2006 with the following results; world bioethanol prices rise by 0.9 percent and sugar prices rise by 3.5 percent. In Brazil, bioethanol consumption increases by 16 percent, bioethanol exports fall by 3 percent, sugar exports fall by 2.9 percent, local bioethanol prices rise by 4.7 percent, and local sugar prices rise by 5.5 percent. These results highlight the link between bioethanol policies, energy and food markets mainly the markets for bioethanol crops commodities. They also highlight the fact that local bioethanol programmes of large countries or regions have potential global spillover effects.

Bioethanol in the USA is produced mainly from corn and the increased diversion of corn to bioethanol production has been identified as a contributing factor to the global rise in food prices. This is because corn is used as a staple food in many developing countries especially in Africa and is also used as an animal feed. Diverting corn from the food chain to the production of bioethanol is therefore expected to have significant repercussions on global food supply. However, the by-product of bioethanol production from corn called Dry Distillers Grain (DDG) is used as an animal feed. This by-product therefore is expected to have an effect of cushioning the prices of food of animal origin to some extent.

Recent USA production of bioethanol has been promoted by the Energy Policy Act of 2005 which mandated that renewable fuel use in gasoline (with credits for biodiesel) reach 7.5 billion gallons by 2012, with gains in later years in line with growth in the volume of gasoline sold or introduced into commerce (USDA, 2007). In addition, bioethanol demand has been stimulated by the phasing-out of methyl tetrabutyl ether (MTBE) as octane enhancer in fuel engines due to its negative environmental effects and also due to the growing concern with recent oil prices and external dependency (Rosillo-Calle and Walter, 2006).

Historical bioethanol promotion in the USA was based on ethanol-related federal government programmes which began with the Energy Tax Act of 1978 establishing an excise tax credit of $0.40 per gallon of bioethanol used as motor fuel, at blends of up to 10% with gasoline. The level of the excise tax credit was subsequently raised in increments, reaching its highest level at $0.60 per gallon by 1984. Various decreases from that level began in 1990, with the incentive settling at $0.51 per gallon in 2005. The American Jobs Creation Act of 2004 guarantees this level through 2010, and additionally removes the restriction that the credit apply to motor fuels blends with a maximum of 10% ethanol (Collins and Duffield, 2005; IEA, 2006).

For completion, the Brazilian bioethanol industry merits deeper review. Since the focus of our study is to analyze the effects of the EC bioethanol blend mandate policy on bioethanol crops commodities markets with special emphasis to sugar trade, a closer look at the Brazilian bioethanol industry, which is sugar cane based is warranted to offer some motivation on the role of sugar in the production of bioethanol. The Brazilian bioethanol situation also offers a good reference point for ACP countries that are interested in diversifying their sugar industries to producing bioethanol for domestic use and for trade purposes. This diversification could be a justified option for ACP countries given the potential bioethanol market that could be created by a binding EC bioethanol blend mandate in the EU27 region and the recent changes in the sugar industry which aim to cut sugar prices in the EU region. The sugar regime and its support policies for the EU will be reviewed in detail in chapter 4 since they form an important aspect of this research.

2.3.1 A closer look at the Brazilian bioethanol industry

As the lowest cost producer of bioethanol, the second largest producer and consumer, one of the first countries to promote the use of FFVs and also the largest producer of sugar cane, the Brazilian bioethanol industry offers an interesting case study. The Brazilian bioethanol industry therefore offers a good reference point when studying bioethanol markets elsewhere especially if these markets have an impact on trade in sugar. Compared to most ACP regions, Brazil is a lower cost sugar cane and sugar producer. In Brazil, production of sugar for food and fuel does not compete for land as sugar cane plantation occupies only 10% of the total cultivated land and only 1% of total land available for agriculture (Goldemberg, 2007). Low cost sugar cane production is also a reason why Brazil is amongst the global leaders in bioethanol production.

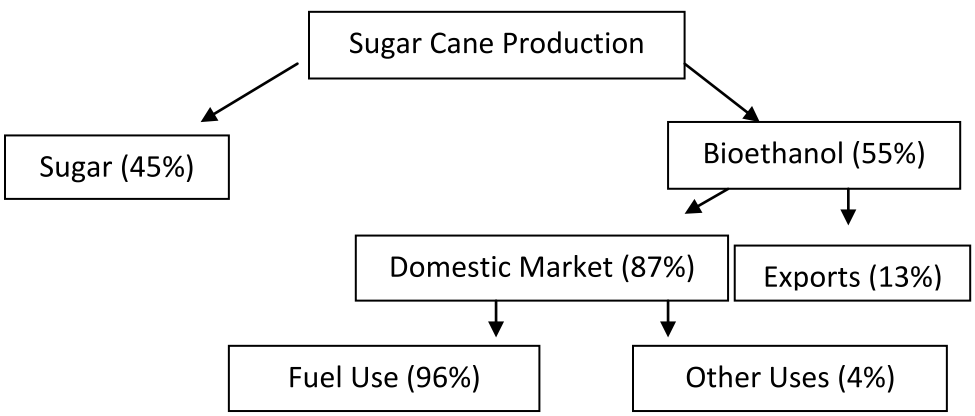
In contrast to most ACP regions, there are several reason that make Brazil a better sugar cane and bioethanol producer.

- Cane cultivation in Brazil, which is water intensive depends on rain rather than on irrigation as is the case in most other cane producing regions like most ACP member states especially in the Sub Saharan African region. Most African regions are subject to drought spells and desertification, which is a phenomenon that is getting worse due to climate change from global warming. This exerts pressure on water availability for agricultural activity and greater demand for irrigation water.
- There is plenty of land in Brazil such that sugar cane does not have to compete with other crops for land. In contrast, land is in short supply in most ACP region since there is competition between crop production and livestock production. Increased urbanization of traditional rural regions in some parts of Africa is also putting strain on the amount of land available for sugar cane and other crop production.
- Brazil has invested significantly in research and commercial cultivation e.g. by use of a number of cane varieties that are resistant to diseases. Lack of investment opportunities in most of Africa and poor technology means the region's ability to produce enough sugar cane and other crops is compromised.
- Most distilleries in Brazil belong to sugar mill/ distillery complexes, capable of changing the production of sugar-to-ethanol ratio. This capability enables plant owners to take advantage of fluctuations in the relative prices of sugar and ethanol, as well as benefit from the higher price that can be obtained by converting molasses into bioethanol. Not much investment in bioethanol plants has been made in Africa making the region less capable of switching to bioethanol production in times of unfavourable world sugar prices.

- FFVs, introduced in March 2003 and capable of running on any mixture of anhydrous ethanol and gasohol, have further increased the attractiveness of building hybrid sugar-ethanol complexes and allayed consumer fears about the consequences of potential bioethanol shortages in Brazil. There are no FFVs in most parts of the world especially in Africa and most of the bioethanol produced there is for export purposes rather than for local consumption and this trend might not change in the near future.

Since 1975 bioethanol has displaced more than 280 billion litre of gasoline and saved more than US$65 billion in the cost of oil imports (Moreira, 2006). The Brazilian sugar cane market in 2006 was divided as shown in Figure 2-5 below:

Figure 2-5: Use of sugar cane and bioethanol in Brazil in 2010



Source: Adapted from Valdes (2011)

The above flow chart shows that the bulk of sugar cane produced in Brazil now goes into the production of bioethanol and most of the bioethanol producted in Brazil is basically used as transport fuel.

Table 2.4 below summarizes the sugar and bioethanol production statistics in recent years.

Table 2.4: Recent statistics of Brazilian sugar and bioethanol production

Crop year	2000-2001	2002-2003	2004-2005	2005-2006	2007-2008
Sugarcane production (million t)	326.1	364.4	416.3	457.9	483.8
Harvest area (million ha)	4.8	5.1	5.6	6.2	6.5
Productivity (t ha^{-1})	67.9	71.3	73.9	74.0	74.4
Sugar production (million t)	16.0	22.4	26.6	26.7	29.2
Alcohol production (billion L)	10.5	12.5	15.2	17.2	18.8

Source: UNICA (2007)

Low cost of producing sugar cane in Brazil means ACP countries cannot compete with that country in sugar or bioethanol production. This makes bilateral policies between the EU and ACP countries that favour ACP export to EU markets key to continued competitiveness of ACP sugar. This justifies the analysis of policies that form the framework of bilateral trade between EU and ACP countries in any study that has trade implications in sugar between the two regions. In the absence of these trade policies, the sugar industries in ACP countries will most likely collapse with detrimental effects to some of these countries' economies. This is one reason why it is important to analysise the EC bioethanol blend mandate policy together with the EPA policies since these are future policies that will form the trade framework between the EU and ACP countries.

2.4 Bioethanol and international trade

International trade in bioethanol or biofuels in general is under the observation of International Energy Agency Bioenergy Task 40 working group whose members are

Netherlands (task leader), Austria, Belgium, Brazil, Canada, European Commission, Finland, Germany, Italy, Japan, Norway, Sweden, UK and USA.

The IEA Bioenergy Task 40 was established under the International Energy Agency (IEA) Bioenergy Implementing Agreement in December 2003. The Task 40 team has reported that global biofuel trade is still not significant mostly because many nations are still not producing or using it in their transport sector to any significant level except in the USA and Brazil.

Junginger (2006) noted that due to the small volumes, biofuel trade is still basically 100% bilateral and identified technical, economic, logistic, social, ecological and international barriers as a hindrance to promotion of such trade. Some of the international barrriers noted include €102/m^2 charged in the EU for denatured ethanol of 80% and above. The USA applies an *ad valorem* duties of 2.5% for imports from Most Favoured Nations (MFN) and 20% from other countries. This means the USA international bioethanol trade arrangement violates WTO rules. Japan applies *an ad valorem* duty of 27% as a MFN status.

Rosillo-Calle and Walter (2006) also observed that the international market in fuel ethanol is in its initial stage and its full development will require the diversification of production in terms of both feedstocks and number of producing countries. They further suggested that sustainable production of fuel ethanol should become a requirement for which certification seems to be a necessity, but should be defined to assure sustainability in a broad sense so that it does not impose additional barriers to trade and that policies should be defined to induce market competitiveness and sustainable development.

A study by Kojima et al (2007) highlights the fact that support policies for biofuels like mandatory blending do not distort trade since they do not differentiate between imported and locally produced biofuels. However, other policies like import tariffs and producer subsidies are market distorting since they have the effect of favoring local production at the expense of foreign production. The study further notes that fuel tax reductions do not discriminate between imported and domestic biofuels in compliance with WTO principles that prohibit adjusting internal taxes and other internal charges to afford protection to domestic products.

However, in the case of bioethanol these tax reductions are often offset by nearly equivalent import tariffs to prevent foreign producers from sharing in the tax reductions provided to domestic consumers. It is well known that the use of tariff is a simple and straight forward way that countries use to protect their local markets and the protection of local biofuel markets is no exception.

An ESMAP report (2005) noted that the benefits of agricultural trade liberalization will likely reduce bioethanol and biodiesel prices in countries with high protection such as the United States and EU and increase incomes of countries such as Brazil that export biofuels. This finding suggest that trade liberilization in biofuels will be welfare enhancing since countries that are high cost producers can import biofuels from those that are low cost producers. Such trade liberalisation policies can therefore favour bioethanol production in low cost sugar cane producers like many ACP countries.

Overall, there is therefore still no significant international trade in bioethanol or biofuels in general. This further complicates attempts of analysing the global impacts that biofuels are having since there are no global market structures and trade data is scant and distorted. Since the focus of this thesis is on the EU27 bioethanol blend mandate, we now turn our discussion to programmes and policies that support biofuel production in the EU.

2.5 The EU Strategy for promotion of biofuels

As in other parts of the world, the main reason for the promotion of biofuels in the EU is mainly due to energy security concerns, reduction of GHG emissions and as a form of farm support. In this light, the EU has put in place a number of initiatives and support policies that aim to encourage the production and use of biofuels in the region. The most notable of these initiatives is the EC biofuel blend mandate directive, which we discuss next.

2.5.1 EC Directive on Biofuels and EU biofuel uptake

After the ratification of the Kyoto Protocol, in 2003 the EC established a goal of deriving at least 2% of EU transportation fuel from biofuels by the end of 2005, then growing the biofuels share by 0.75% annually until December 31, 2010, where it would reach 5.75%. The EU goal of 2% by end of 2005 was not achieved with only 1.4% achieved for transport fuel (Schnepf 2006). According to the EC (2007) the EU is committed to reduce its CO_2 emission by increasing renewable energy use. It has set a target of 20% of renewable energy in total energy consumption with 10% of this being biofuels and this target is set for 2020. This target is for the entire EU with each member state allowed to increase their use of alternative energy resources at a rate consistent with their capabilities.

The 2003 EC directive as outlined in a paper by Hingyi et al (2007) is as follows:

Directive 2003/30/EC of the European Parliament and of the Council, OJ L 123, 17/052003*: The Directive on Biofuels set a reference value for the national indicative targets at 2%, calculated on the basis of energy content, of all fuels for transport purposes placed on their markets by 2005, while the market share of biofuels is set at 5.75% for 2010. In 2007 the European Commission recommends a minimum share of 10% for biofuels by 2020 in its schedule regarding renewable energy.*

Although the above proposal was set as a target for EU biofuel use in the transport sector, it was not binding and countries are allowed to set their own targets. The EC biofuel directive was reviewed in April 2009 by the EU resulting in the enactment and adoption of the Renewable Energy Directive (RED). RED re-set a 10% target for renewable energy in road transport fuels by 2020 and also established the environmental sustainability criteria.

This criteria is that biofuels consumed in the EU have to comply with a minimum rate of direct GHG emission savings of 35% of 1990 emission levels in 2009 and rising over time to 50% in 2017. The criteria also set restrictions on the types of land that may be converted to production of biofuels feedstock crops (Al-Riffai et al., 2010). This means that the EU27 commitment to blend biofuels with fossil fuel in the transport sector still remains alive. However, the blend targets set are still not binding and nations are required to set their own targets. Table 2.5 show some of the targets that have been set by various members of the EU27 for 2005 and 2010.

Table 2.5: Minimum incorporation % biofuel blend targets for EU Member States in place in 2005 and 2010

Germany	2	6.25
Belgium	2	4
Luxembourg	0	2
Denmark	0.1	5.75
Spain	2	5.83
France	2	7
Greece	0.7	5.75
Ireland	0.06	4
Italy	1	3.5
Netherlands	2	4
Portugal	2	7
UK	0.19	3.5
Austria	2.5	5.75
Finland	0.1	4
Sweden	3	5.75
Poland	0.5	5.75
Hungary	0.6	5.75
Czech Rep.	3.7	-
Estonia	2	-
Latvia	2	-
Lithuania	2	5.75
Slovenia	0.65	3
Slovakia	2	5.75
Cyprus	1	2.5
Malta	0.3	-
Romania	-	-
Bulgaria	-	5.75

Source: Strategic Grains (2010)

As can be seen from Table 2.5 each member state is required to set their own percentage Biofuel blend targets guided by the EC blend directive but targets vary from nation to nation. It can be seen however that member states are revising up their blend mandate targets over time. Since the blend mandate is not binding and blending is not uniform across nations, there is still a gap in the literature as to the extent of the penetration and impact that biofuels are having on the transport sector. This observation is also supported by Kutas (2007) who noted the difficulty of estimating the impact of the biofuel mandatory blend requirement in the EU27 since member states have established different obligations that are effective at different periods. He further noted that no studies measuring the impact the blend requirements are having on prices have ever been undertaken.

Since countries in the EU are required to set their own targets, a potential problem for the region will be coming up with ways of making the blend mandate binding. This problem is complicated by the fact that transport fuel was left out of the ETS for the EU meaning that no pollution tax or carbon trading is applicable to the EU transport sector so far. Lucia and Nilsson (2007) discussed the problems associated with implementation of the EC biofuel directive and concluded against a binding blending mandate and that countries should be allowed flexibility, stronger enforcement target measures being not conducive. However, allowing countries to set their own targets means there is a possibility that the blend mandates as enshrined in the directive will never be realised.

Besides the enactment of the EC biofuel directive, the Common Agricultural Policy (CAP) has also been amended to promote biofuel production in the EU region. Since the CAP also supports production of bioethanol crops it is therefore also an important policy for the production of bioethanol in the EU. In the next section we review the CAP support for biofuel production in the EU. The CAP support for the production of bioethanol crops will be reviewed in Chapter 4.

2.5.2 The CAP support for biofuels in the EU

The CAP, which is a system of post world war II EU agricultural subsidies and programmes aimed at raising EU agricultural productivity has in place a number of policies that can be viewed as supporting the production of biofuels in the region.

For example, the CAP reform of 1992 introduced a compulsory ‘‘set-aside’’ land policy where farmers are allowed to produce only non-food crops (including energy crops) on such ‘‘set-aside’’ lands and benefit from a ‘‘set-aside’’ payment of about €63/ha. These set aside payments are in addition to other subsidies that exist in specific states. This means that the promotion of biofuel in the EU come at a huge cost.

In addition, since 2003, farmers have been able to take advantage of a special aid of €45/ha if they produce crops intended for biofuel production on arable land. This aid is limited to 1.5 million ha for the whole of the EU (Bernard and Prieur, 2007). From this policy agricultural producers used more than 0.5 million hectares of the land eligible to receive this aid at a cost to the EU budget of €25.6 million in 2005 alone (Kutas et al, 2007). The pressure therefore that biofuel production exerts on the available land and the associated cost that comes with it means that for the EU to meet her biofuel demand under the blend mandates, production of biofuels will have to go beyond the set aside land. This means therefore that it will impact on the dynamics of other crops and livestock activities should the market remain protected from imports.

On the promotion of biofuels in the EU, Schnepf (2006) noted that for the EU to action policies that promote more use of biofuels there has to be either major agricultural policies that are put in place to increase biofuel production. Alternatively, there must be increased research and investment in developing countries to promote biofuel production at lower costs which can then be exported to the EU market to meet demand.

Increased production of biofuels in the EU, like in all the other regions, have all the associated problems of competing with food security endervours and doubtful environmental benefits. A study by Kuta et al (2007) found that while Biofuels do displace some petroleum and fossil fuels, and reduce GHG emissions, the cost of obtaining a unit of CO_2-equivalent reduction through biofuel subsidies is very high and estimated the subsidy cost per tonne of CO_2-equivalent removed to be between € 575 and € 800 for bioethanol made from sugar beet. This therefore highlights the cost associated with the EU endervours to reduce GHG emissions. Following the global overview of bioethanol we now turn our focus to the bioethanol status in the EU27 in more detail since this is the focus region for our study.

2.6 The EU27 bioethanol status and trade

Bioethanol production in the EU started around 1996. The EU is now the third producer of fuel-bioethanol in the world after the USA and Brazil. Important EU bioethanol producers include France, Germany and Spain. First generation bioethanol in the region is mainly produced from wheat, barley, sugar beet, corn and rye.

EU bioethanol production, although smaller, is increasing and was 0.5 billion litres in 2004, 0.9 billion litres in 2005, and 1.6 billion litres in 2006 (eBio, 2007). This support the observation in Table 2.6 of the previous section that most nations in the EU are going ahead with promoting bioethanol production and reviewing up their blend target commitments.

The increased commitments to produce bioethanol in the EU27 is also shown by the number of bioethanol plants that were planned or under construction in 2007 as Table 2.6 shows.

Table 2.6: Estimation of year 2007 and future ethanol production capacity in EU27

Country	Plants in Operation 2007	Estimated Production Capacity (tonnes)	Plants planned or under construction	Additional production capacity (tonnes)
Total EU27	**46**	**2,991,000**	**76**	**6,988,000**
		EU15		
Austria			1	173,000
Belgium	1	80,000	3	383,000
Denmark			3	126,000
Finland			2	36,000
France	15	999,000	5	683,000
Germany	6	563,000	19	1,451,000
Greece			2	95,000
Ireland				
Italy	3	237,000	4	75,000
Luxembourg				
Portugal			1	100,000
Spain	4	437,000	4	425,000
Sweden	3	120,000	1	122,000
The Netherlands	1	28,000	1	158,000
United Kingdom			5	1,070,000
Sub-Total EU15	**33**	**2,464,000**	**51**	**4,897,000**
		NEW MEMBER STATES (NMS)		
Bulgaria	2	108,000	5	220,000
Cyprus				
Czech Republic	2	84,000	7	352,000
Estonia				
Hungary	2	91,000	7	1,000,000
Latvia	2	17,000		
Lithuania	1	24,000		
Malta				
Poland	2	130,000	2	200,000
Romania	1	14,000	2	160,000
Slovakia			1	109,000
Slovenia	1	59,000	1	50,000
Sub-total NMS	**13**	**527,000**	**25**	**2,091,000**

Source: eBIO, 2006

The number of bioethanol plants planned or under construction means that bioethanol production in the region is at an upward trend as we will see later. This upward trend is despite the fact that blend mandate commitments are still not binding and the hindrances of high bioethanol production costs in the region. The data in table 2.6 therefore helps show the developments of the bioethanol industry in the EU region in recent years. More recent data on the EU bioethanol production and consumption is seen in section 2.6.1 below.

The natural question then is how an increase in the production of bioethanol would affect the global food prices especially the prices of sugar since the production of biofuel or specifically bioethanol competes with food production directly. For example, bioethanol production from sugar beet could have the effect of increasing the prices of sugar and therefore discouraging the production of bioethanol in developing countries in favour of sugar production for export to the EU market. Increases in the price of sugar will lead to more production and thus increase supply and a concomitant decrease in price and a switch back to bioethanol production. This means that the prices of these competing products operate a feedback mechanism that determines production decisions as theory on prices, supply and demand dictates.

Bioethanol production in the EU is supported by policies that are viewed as subsidizing production and various tariff lines that protect the local bioethanol industry from external competition. The estimated price support for bioethanol in the EU as measured by the “price gap” between the EU bioethanol prices and those that prevail in Brazil (taken as a reference for world bioethanol prices) is as shown in Table 2.7 as estimated by Kutas et al (2007).

Table 2.7: EU market price support for ethanol through border protection

Year	2005	2006
EU production of fuel ethanol (million litres)	930	1,565
EU ethanol imports for fuel use (million litres)	250	230
EU ethanol average price (€ /litre)	0.55	0.65
Brazilian ethanol average price (€ /litre)	0.27	0.38
Tansport and handling charges, Brazil to the EU (€ / litre)	0.08	0.08
Price gap (€ / litre)	0.2	0.2
Market price support (€ millions)	184	306

Source: Kutas et al (2007)

Table 2.7 shows that the EU is spending significant sums of money to support bioethanol production in the region and indeed opening up to trade can be beneficial since it can allow the region to import bioethanol from low cost producers like Brazil. The Table also shows that EU bioethanol production has been increasing from 930 million litres in 2005 to 1,565 million litres in 2006. It can be seen also that bioethanol price is relatively higher in the EU than in Brazil and that increased local production is associate with decrease in imports.

High production cost poses the greatest challenge to increased production of bioethanol in the EU27. The cost of bioethanol production in the region from various feedstocks and comparison with fossil fuels production cost and Brazilian bioethanol production is shown in Table 2.8 and 2.9 below.

Table 2.8: Cost of biofuels in the EU

Biofuels	Cost at filling stations €$_{2004}$/1000L			
	Feedstock	Low	Best Estimate	High
A. Cost of bioethanol production using current technology				
	Sugar Crops	875	1265	1855
	Starch Crops	809	1173	1572
	Lignocellulolitic Crops	1148	1448	2435
	Lignocellulotic Residues	1052	1316	2232
	Brazilian Sugar Cane	117	294	351
B. Cost of bioethanol production using future technology				
	Sugar Crpos	671	954	1432
	Starch Crops	653	963	1287
	Lignocellulolitic Crops	699	884	1469
	Lignocellulotic Residues	638	802	1358

Table 2.9: Cost comparison of biofuels with petroleum fossil fuels (valued at filling stations in €2004/1000L)

Feedstock	Bioethanol	Fossil Fuel	Difference
Sugar Crops	1265	366	899
Starch Crops	1173	366	807
Lignocellulolitic Crops	1448	366	1082
Lignocellulotic Residues	1316	366	950
Brazilian Sugar Cane	294	366	-72

Source: Ryan et al (2005)

As shown in the Tables 2.8 and 2.9 above, the cost of biofuels production remains the major impediment in the EU with only Brazilian bioethanol breaking-even with the cost of fossil fuels. It can be seen also from the Tables that second generation bioethanol production, i.e. bioethanol production from cellulose is more expensive that bioethanol production from bioethanol crops (i.e.first generation bioethanol). However, improvements in production technologies are expected to reduce production costs.

As observed in the ESMAP report (2005), bioethanol economics should be more favourable in petroleum-importing, sugar-exporting, landlocked areas, or in any other situation where transportation costs for imports are high and there are indigenous sources of biofuel feedstock that can be grown at reasonable costs. Lignocellulotic bioethanol is still under research and is at its infancy although it offers hope in solving the environmental, food security and costs problems associated with production of bioethanol from primary bioethanol crops. Ryan et al (2005) argue that it is possible that bioethanol is competitive with fossil fuels once the external benefits to society are accounted for namely the CO_2 emission, security of energy supply and rural development. Such benefits to society can come in the form of employment creation. The high prices of fossil fuels increases the competitiveness of biofuels but question still remain in that production of biofuels also requires an input of these high priced fossil fuels.

Employment benefits of biofuel production has been noted by Whitely et al (2004) who put the number of jobs in rural areas that could be generated by achievement of the EU biofuels targets at 212, 000 and 354,000 in 2010 and 2020 respectively under current policies corresponding to about 1.5%-2.5% of the EU15[6] unemployment in 2005 which was 14.7million (Eurostat, 2005). However, Ryan et al (2005) noted that it is not clear how rural employment generation can be translated to rural development and how many of these jobs would not be removed from food producing activities. These arguments highlight the fact that the promotion of

[6] The EU15 is made of Germany, Greece, Sweden, United Kingdom, Austria, Belgium, Finland, Ireland, Luxembourg, Netherlands, Portuga, France, Denmark, Italy and Spain

biofuels in the EU is also a drive to improve farm incomes, promote rural development and create employment.

The EU is also involved in the international trade in biofuels. For example, the region imported nearly 825,000 gallons of bioethanol in 2004 (Schnep, 2006). About 36% of this volume was imported as normal MFN trade and subject to import duties of €10.2/hectoliter (€0.39/gallon) on denatured alcohol (HS Code 220720) and €19.2/hectoliter (€0.73/gallon) on undenatured alcohol (HS Code 220710). Brazil is the largest bioethanol exporter to the EU with all of its exports made as MFN. During the 2002-04 periods, 25% of EU bioethanol imports were from Brazil. During the same period about 64% of EU bioethanol imports entered under preferential trade arrangements including the Generalized System of Preferences (GSP), the Cotonou Agreement and the Everything But Arms Initiative (EBAI). Pakistan, with a 20% share of EU bioethanol imports, is the largest exporter under preferential trade arrangements. Other bioethanol exporting countries that benefit from EU trade preferences include Guatemala, Peru, Bolivia, Ecuador, Nicaragua, and Panama (unlimited duty-free access accorded under special drug diversion programme and GSP); Ukraine and South Africa (GSP); the Democratic Republic of Congo (EBAI); Swaziland and Zimbabwe (Cotonou); Egypt (Euro-Mediterranean Agreement); and Norway (special quota). The current bioethanol preferential trade agreements between the EU and various countries are shown in Table 2.10.

Table 2.10: Preferential agreements providing duty free and quota free access to the EU bioethanol market

Preferential agreements	Beneficiary countries
Cotonou Agreement	ACP countries: Angola, Antigua and Barbuda, Bahamas, the Barbados, Belize, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Republic of the Congo, Cook Islands, Côte d'Ivoire, Cuba, Djibouti, Dominica, Dominican Republic, East Timor, Equatorial Guinea, Eritrea, Ethiopia, Fiji, Gabon, Gambia, the Ghana, Grenada, Guinea, Guinea-Bissau, Guyana, Haiti, Jamaica, Kenya, Kiribati, Lesotho, Liberia, Madagascar, Malawi, Mali, Marshall Islands, Mauritania, Mauritius, Federated States of Micronesia, Mozambique, Namibia, Nauru, Niger, Nigeria, Niue, Palau, Papua New Guinea, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, São Tomé and Principe, Senegal, Seychelles, Sierra Leone, Solomon Islands, Somalia, Sudan, Suriname, Swaziland, Tanzania, Togo, Tonga, Trinidad and Tobago, Tuvalu, Uganda, Vanuatu, Zambia and Zimbabwe
Everything but Arms Initiative	LDCs: Afghanistan, Angola, Bangladesh, Burkina Faso, Burundi, Benin, Bhutan, Cambodia (Kampuchea), Cape Verde, Central African Republic, Chad, Comoros (excluding Mayotte), Democratic Republic of the Congo, Djibouti, East Timor, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Laos, Lesotho, Liberia, Madagascar, Mali, Mauritania, Maldives, Malawi, Mozambique,

	Myanmar, Nepal, Niger, Rwanda, Samoa, São Tomé and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Tanzania, Togo, Tuvalu, Uganda, Vanuatu, Yemen and Zambia
GSP +	Bolivia, Colombia, Costa Rica, Ecuador, El Salvador, Georgia, Guatemala, Honduras, Mongolia, Panama, Peru, Sri Lanka, South Africa and Venezuela
Western Balkan Countries	Albania, Bosnia and Herzegovina, Kosovo, Montenegro and Serbia
Bilateral agreements	Andorra, Croatia, Egypt, Jordan, Liechtenstein, San Marino, Switzerland and the former Yugoslav Republic of Macedonia

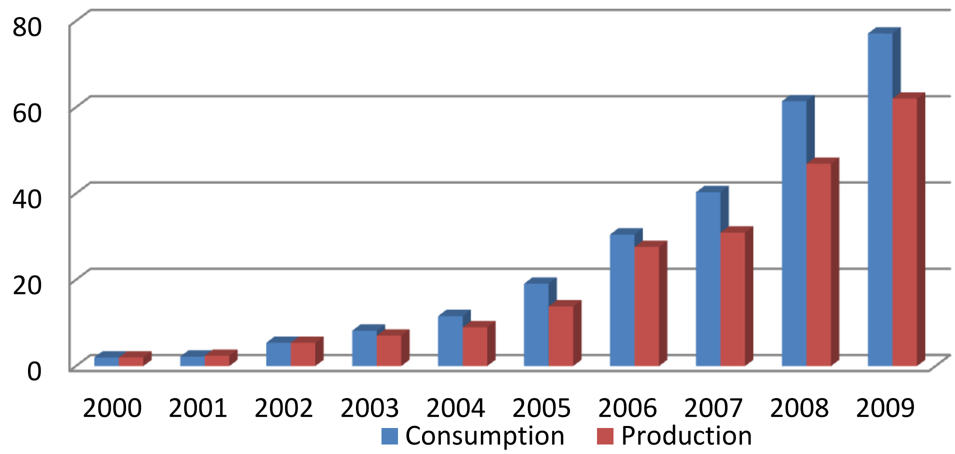
Source: Trade statistics and table adapted from Schnep (2006)

These policies that support EU27 trade in bioethanol with other countries show the importance of analysing the EU bioethanol market effects in recognition of current and future trade policies that define EU trade with other regions like the ACP. It also means that analysis of a policy that has a potential global spillover outcome like the EC biofuel blend mandate cannot be divorced from policies that affect bioethanol crops production and trade since all these policies are interlinked. This is one justification of the need to review policies that support bioethanol crops production and trade in the EU, as will be reviewed in chapter 4 of this study.

2.6.1 Recent EU27 fuel bioethanol production and consumption status

As mentioned before, bioethanol production in the EU27 started in earnest in 1996. Figure 2-6 shows the recent developments in the production and consumption of biofuels in the EU27.

Figure 2-6: Average EU27 bioethanol consumption and production from year 2000 to 2009 in thousands of barrels per day



Source: Energy Information Administration

As shown in the figure, the production and consumption of bioethanol in the EU27 has been increasing in recent years. From year 2003, consumption surpassed production which means that the shortfall in demand had to be imported. The blend mandate was enacted in 2003 and this corresponds to the observed increase in bioethanol use as transport fuel from that year onwards. EU bioethanol demand has therefore been increasing despite the fact that the EC blend mandate directive is not binding. A binding blend mandate is expected to increase bioethanol demand even further. This increase in demand will have the effect of increasing bioethnol crop commodities prices with questionable sustainability outcomes given the fact that most of these bioethanol crops commodities are important food sources as has been observed earlier.

Table 2.11 below shows the consumption (production) of bioethanol by country in the EU27 from year 2003 to 2009.

Table 2.11: EU fuel bioethanol consumption (production) from 2003 to 2009 in thousands of barrels per day

Country/Year	2003	2004	2005	2006	2007	2008	2009
EU-27	4.3(5.1)	13(9.1)	19.7 (15.2)	30.7(27.9)	40.9 (30.9)	61.4 (46.9)	77.1 (62.01)
Austria	0 (0)	0 (0)	0 (0)	0 (0)	0.7 (0)	1.8 (1.5)	2 (2)
Belgium	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.4 (0.4)	1.2 (2.5)
Bulgaria	0 (0)	0 (0)	0 (0)	0 (0)	0.1 (0)	0 (0)	0 (0)
Cyprus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Czech Republic	0 (0)	0 (0)	0 (0)	0 (0.3)	0 (0.6)	1.1 (1.3)	1.9 (1.9)
Denmark	0 (0)	0 (0)	0 (0)	0.1 (0)	0.2 (0)	0.2 (0)	0.1 (0)
Estonia	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Finland	0.1 (0)	0.1 (0.2)	0 (0.1)	0 (0)	0.1 (0)	2.2 (0.9)	2.6 (0.2)
France	1.6 (1.7)	1.7 (1.7)	2.4 (2.5)	4.9 (5)	9 (10)	13.9 (17)	15.3 (21.5)
Germany	0 (0)	1.4 (0.4)	5.7 (2.6)	11.6 (7.8)	10 (7.1)	13 (10)	17 (13)
Greece	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hungary	0 (0)	0 (0)	0.1 (0.6)	0.4 0.6)	0.9 (0.5)	1.6 (1.3)	1.6 (1.4)
Ireland	0 (0)	0 (0)	0 (0)	0 (0)	0.1 (0)	0.6 (0.2)	0.8 (0.2)
Italy	0 (0)	0 (0)	0.2 (0.1)	0 (1.3)	0 (1)	2 (1)	4 (1)
Latvia	0 (0)	0 (0.2)	0 (0.2)	0 (0.2)	0.1 (0.3)	0.1 (0.3)	0.1 (0.3)
Lithuania	0(0)	0 (0)	0 (0.1)	0.2 (0.1)	0.4 (0.3)	0.5 (0.4)	0.5 (0.5)
Luxembourg	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Malta	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Netherlands	0 (0)	0 (0.2)	0 (0.1)	0.7 (0.3)	3 (0.2)	3.6 (0.2)	4.9 (0.2)
Poland	0 (0)	0.8 (0.8)	1 (1.1)	1.8 (2.8)	2.3 (2.7)	4.3 (2)	5.1 (2.9)
Portugal	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Romania	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1.8

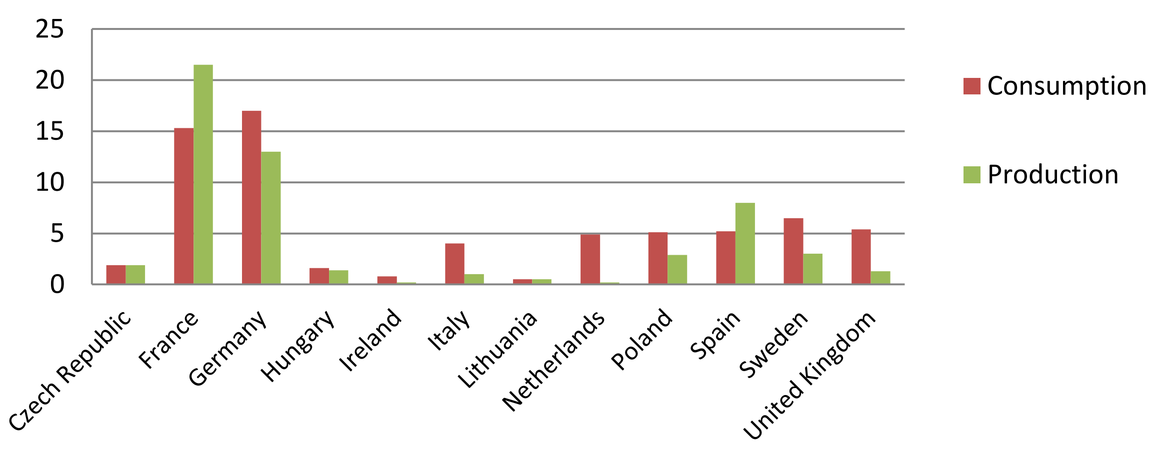
							(0.1)
Slovakia	0 (0)	0 (0)	0 (0)	0 (0)	0.9 (0.5)	1.1 (1.6)	1 (2)
Slovenia	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.1 (0)	0.1 (0)
Spain	0 (3.4)	4.5 (4.4)	3.9 (5.2)	3.9 (6.9)	4.3 (6.2)	4.1 (5.9)	5.2 (8)
Sweden	2.6 (0)	4.5 (1.2)	4.9 (2.6)	5.5 (2.4)	6.2 (1.6)	7.3 (1.7)	6.5 (3)
United Kingdom	0 (0)	0 (0)	1.5 (0)	1.6 (0)	2.6 (0.3)	3.5 (1.2)	5.4 (1.3)

Source: Energy Information Administration-EIA (2011)

Table 2.11 show that France, Germany and Spain are the top EU27 producers and consumers of bioethanol. It also shows that due to the unbinding nature of the EC blend mandate, EU countries differ in their consumption of bioethanol. In other EU member states bioethanol consumption or production is still very low or non existent.

Figure 2-7 also highlights the varying share of bioethanol production and consumption in selected countries of the EU in the year 2009.

Figure 2-7: Selected top EU27 member states bioethanol producers and consumers in 2009 (thousands of barrels per day)

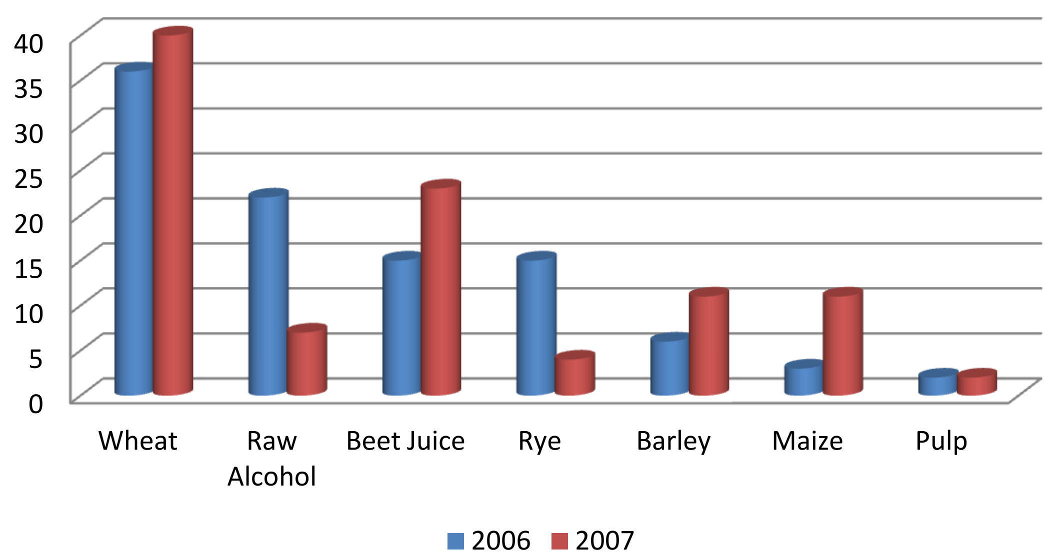


Source: EIA (2011)

Figure 2-7 shows that the main producers of bioethanol in the EU27 in 2009 were Germany, Spain and France with a combined production share of 69%. France has been a major consumer of transport bioethanol in earlier years according to data from EIA although Germany has overtaken France from year 2005 onwards.

As has been mentioned before the EU27 uses various crops to produce bioethanol but the crops used vary from country to country. The crop shares used for bioethanol production are also not constant and vary across time. The most important bioethanol crops used and their varying shares in 2006 and 2007 are shown in Figure 2-8:

Figure 2-8: The estimated average share of bioethanol crops used in bioethanol production in the EU during the years 2006/2007



Source: eBio and F.O Licht (2009)

Figure 2-8 above shows that the main crops used for the production of bioethanol in the EU since 2007 have been increasingly wheat, sugar beet, corn, barley and rye and these are the crops or feedstocks that will be used in determining the supply curve of bioethanol in the EU27. The Figure also shows that the share of crops used to produce bioethanol increased from 2006 to 2007 with the exception of rye share. This means that bioethanol production is also having increasing impact on crop production in the region. Table 2.12 also echoes the increasing and varying crop shares used in the production of bioethanol in the region from 2006 projected to 2012.

Table 2.12: EU bioethanol production from bioethanol crops from 2006 to 2012

	Bioethanol production		**Feedstock production**		**Bioethanol Production**		**Feedstock Production**	
	Million Litres	Share	Million tonnes		Million Litres	Share	Million tonnes	
Total	1 560		Total	For ethanol	10 085		Total	For ethanol
Wheat	504	32.3%	109.3	1.4	4 034	40%	135.9	11.2
Barley	440	28.2%	53.6	1.1	440	4%	46.1	1.1
Corn	200	12.8%	44.6	0.5	1 291	13%	51.9	3.2
Rye	200	12.8%	7.8	0.5	200	2%	9.1	0.5
Beet	88	5.6%	141.7	0.8	3 864	38%	120.7	35.2
Wine	128	8.3%	-	-	256	3%	-	-

Sources: Jank et al (2007)

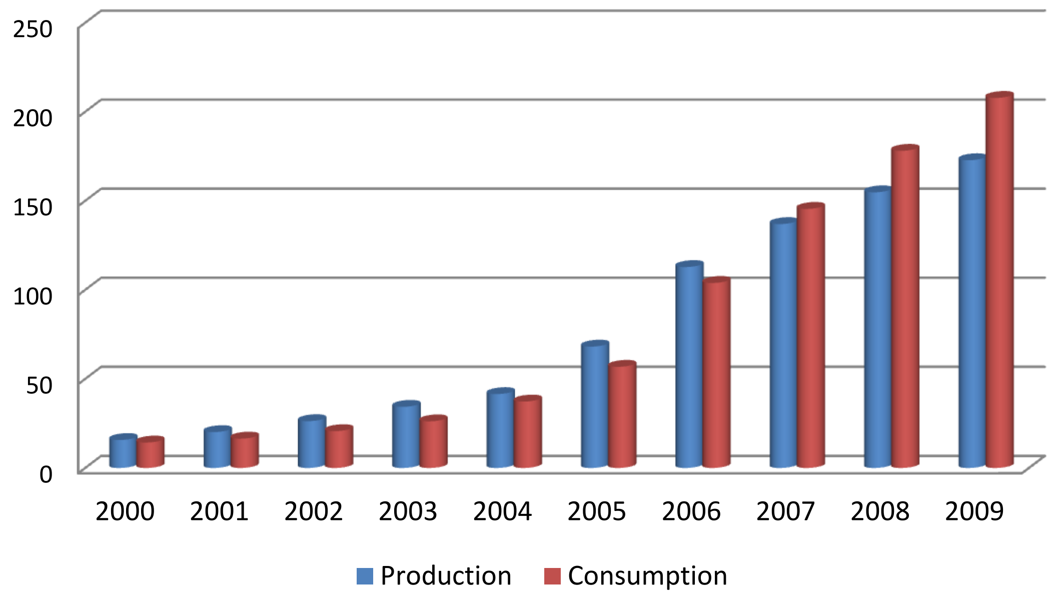
Table 2.12 shows that sugar beet will become more important as a source of bioethanol in the EU27 with an increasing share from 5.6% in 2006 to about 38% by 2012. This means that the EC bioethanol blend mandate is expected to have increasing significance for ACP countries that derive revenue from sugar trade to sustain their economies because of increase diversion of sugar beet from production of sugar to production of bioethanol. For completion of the review of biofuel situation in the EU27 we briefly discuss the biodiesel production status in the region.

2.6.2 A brief overview of EU27 biodiesel production and consumption

As mentioned earlier, biodiesel is the main biofuel produced in the EU27 with bioethanol production still at an infant stage. For this reason, not many studies have been focussed on the bioethanol aspect of the EU blend mandate despite the fact that bioethanol production has more impact on food market that biodiesel.

Figure 2-10 below shows the averageBiodiesel production and consumption in the EU27 from year 2000 to 2009 in thousands of barrels per day.

Figure 2-9: Average EU27 biodiesel production and consumption from year 2000-2009 in thousands of barrels per day



Source: EIA (2011)

Figure 2-9 shows that biodiesel production has been increasing and that from the year 2007 consumption started to outweigh production which means some of the biodiesel had to be imported. It also shows the increasing importance of biodiesel in the transport sector due to growing demand as nations increase their commitment to the blending targets they set. This has been the trend observed for bioethanol.

Figure 2-10 and Figure 2-11 compares bioethanol and biodiesel production and consumption in the EU27 from year 2000 to 2009.

Figure 2-10: Average EU27 fuel biodiesel and bioethanol production for the year 2000 -2009 in thousand of barrel per day

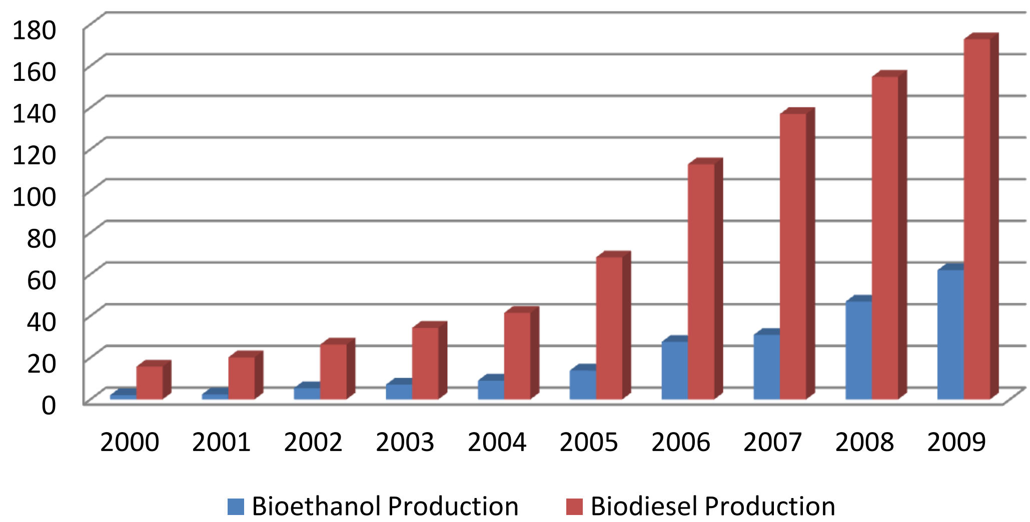
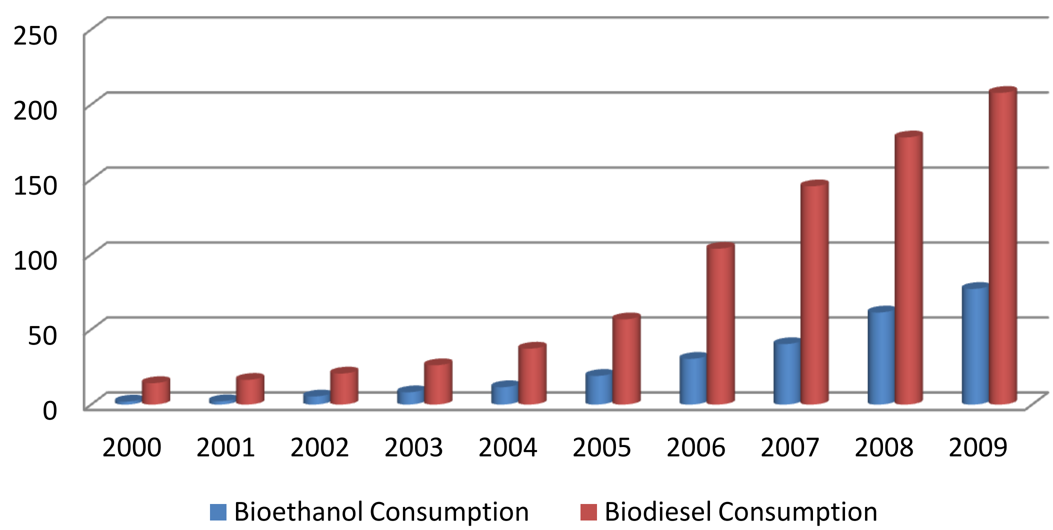


Figure 2-11: Average EU27 fuel biodiesel and bioethanol consumption in thousands of barrels per day

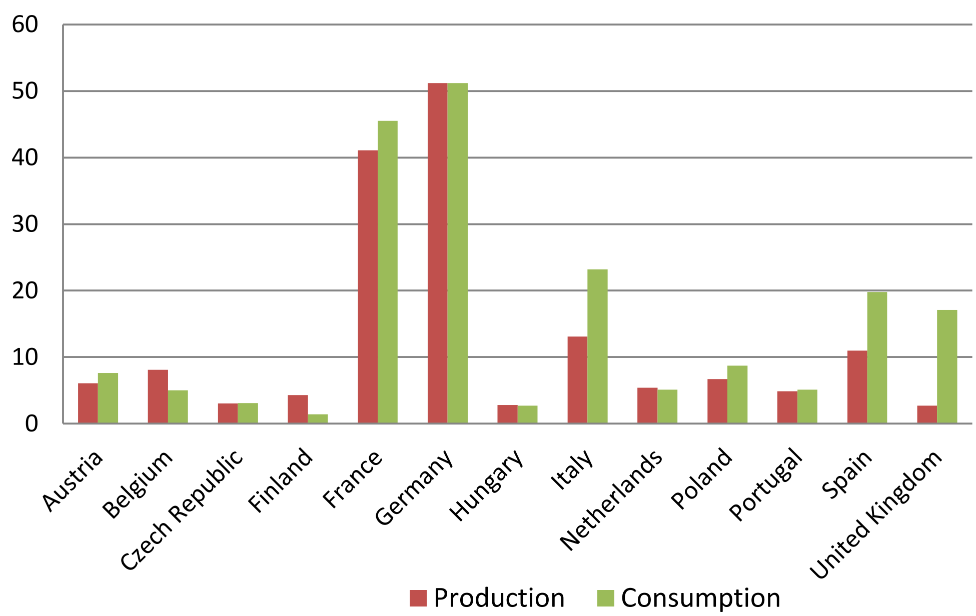


Source: EIA (2011)

Figures 2-10 and 2-11 above show a clear trend of the increasing importance of biofuels in the EU27. The production and consumption of biodiesel is much higher than that of bioethanol with biodiesel accounting for around 73% of total biofuel production and consumption in 2009. One likely reason why biodiesel production is higher than that of bioethanol is that bioethanol production competes directly with important food crops commodities like wheat and corn while biodiesel, being produced from vegetable oil, does not have a direct effect of vital food commodities.

Figure 2-12 below show selected top EU producers and consumers of biodiesel in 2009.

Figure 2-12: Selected top EU biodiesel producers and consumers in 2009 in thousand of barrel per day



Source: EIA (2011)

Figure 2-12 shows that France and Germany are top producers and consumers of biodiesel in the EU27.

Following the overview of biofuels (mainly bioethanol) situation globally and in the EU27 we are now in a position to discuss the studies that have been undertaken on the EC biofuel policy. This is with the view of highlighting the gaps in the existing literature on the economics of the EC biofuel policy which our study aims to address.

2.7 Review of selected studies on EU bioethanol

On the backdrop of our study objectives as outlined earlier, we therefore review the relevant literature especially on the economics of bioethanol blend mandate in the EU27 in order to show the relevance and contribution of our study to existing knowledge. A number of studies have been undertaken on bioethanol or biofuels in the EU but not all of them address the question of the blend mandate economics and its potential effects on ACP countries via bioethanol crops commodities markets. Many of these studies on biofuels markets use CGE modelling but have different objectives and conclusions. For example, Banse et al (2008) analyzed the impact of the EU biofuel policies on world agricultural and food markets and concluded that the EU biofuel directive will not be reached in 2010 and also that a mandatory blending enhanced demand for biofuel crops will have a strong impact on agriculture at European and global level.

However, Banse et al (2008) only focused his study on EU15 member states and used the GTAP6-E, which is the GTAP model that disaggregates energy markets. He modelled the EU15 mandatory blending as a subsidy given to the petro-industry to reduce prices for biofuel inputs. In this way the study did not address the question of the possible partial equilibrium model the bioethanol market could take in the EU following a binding blend mandate and the significance of this bioethanol market on global bioethanol crops commodities. Also, according to our knowledge no study has extended the analysis of the EC biofuel policy’s possible impact on specifically ACP sugar industries and on general welfare of these countries.

The problem of using GTAP 6 directly to study the EU27 bioethanol blend mandate is that in 2001, which is the base year for the GTAP 6 database there was little biofuel produced in the EU region. This means that its global impact analysis outcome when using this database is likely be inaccurate. The short-coming of using the GTAP model directly in studying biofuels has also been noted by Kretschmer and Peterson (2009) in their study that surveyed CGE models integrating bioenergy. Our approach therefore is to design a unique EU27 bioethanol partial equilibrium model and transfer its equilibrium outcomes into the GTAP model to analyse its potential global effects especially on ACP countries.

Kretschmer, Narita and Peterson (2009) used a Dynamic Applied Regional Trade (DART) Model, which is a CGE model to analyze the economic effect of the EU biofuel target basing their approach on the EU emission targets. They concluded that the EU emission target leads to minor increases in biofuel production. They also noted that additional subsidies are necessary to reach the 10% biofuel target, which increases European agricultural prices by up to 7%. As such, their study was not on the effect of the blend mandate and specifically on the economics of bioethanol blend mandate in the EU region. Ajanovic and Haas (2009) analysed the economic challenges of biofuels in the transport sector. Their study focus was on cost of producing biofuels in the EU. In this way, they used data on biofuels feedstock costs, gross conversion costs, distribution costs and subsidies to determine the future economic prospects of biofuel programmes in the EU. Key findings of their study was that problems of first generation biofuels production in the region are lack of available land for growing biofuel crops and that second generation biofuels will be cost effective around 2030 due to increases in prices of fossil gasoline and diesel.

As has been discussed earlier, biofuel programmes in most regions are supported by policies that are meant to increase biofuel production and use in the transport sector. Given this observation therefore, other studies on EU biofuels have focused on analysing support policies that promote biofuel use (Wiesenthal et al, 2008; Londo et al, 2010; Lucia and Nilsson, 2007). These studies are mostly discussion papers with no empirical analysis involved. They generally come into the consensus that for the EU to achieve its ambitious biofuel targets there has to be major policy changes that involve creating favourable economic or legal frameworks to accelerate biofuels market penetration.

Other studies on EU biofuels have focused on specific countries on a case by case basis. In this way, these studies do not follow any specific or common modelling approach. Bomb et al (2007) basically reviewed the biofuel status in Germany and UK. They focus their discussion on the biofuel markets in the two countries based on institutional support and networks involved in biofuels. Hammond et al (2008) reviewed biofuel status in the UK transport sector. They discussed the policy support, land and GHG emission implications of the UK biofuel programmes. Silvestrini et al (2010) discussed the role of some European cities namely Berlin, Milan, London and Helsinki in achieving the EC biofuel targets. In this study the implementation of the EC Biofuels Directive and related voluntary measures at the local level was discussed. This study was also not empirical and was limited to the cities mentioned. Kondili and Kaldellis (2006) discussed the biofuel status in Eastern Europe countries with an important conclusion that Eastern European countries are potential biofuel sources in the region due to their land endowment but noted that because of lack of technology biofuel production in these regions was still low.

Skoulou et al (2010) studied the sustainable management of energy crops for integrated biofuels and green energy production in Greece. Their study focused on the biofuel production chemistry of rapeseed, soyabeans, sunflower and cotton. Key finding of this study was that proper use and integrated management of these energy crops and their residues could result in increase supply of domestic raw material for biodiesel industry and enhance the cohesion of agriculture, energy and environmental policies in Greece. Sobrino and Monroy (2009) made a critical analysis of the EC directive which regulates the use of biofuels in Spain. Their study was driven by the fact that European countries differed in their energy dependence, agricultural sector characteristics and industry profile. They argued that the EC directive on biofuels will therefore have diffferent impacts to individual EU member states. Using fossil fuel prices and bioethanol plant production efficiencies they concluded, by using Spain as an example, that it will be difficult for the EU biofuel programme to compete with fossil fuels.

Gomez et al (2011) also analysed the Spanish biofuel programme but concentrated on the technical and cost aspects of Spanish biofuel production. In their analysis they used cost data for biofuel crops production including investment and transport cost. They concluded that feedstock cost account for 70-75% of production cost in biodiesel plant while it is 45-65% for a bioethanol plant. However, even though the cost of bioethanol crops is lower than that for biodiesel, bioethanol production is expected to have more significant impact on global food markets and welfare that biodiesel production.

Bernard and Prieur (2007) studied the biofuel market and carbon modelling to analyse French biofuel policy. Their study analysed the French 2008, 2010 and 2012 biofuel plan using tax exemption on fossil fuels and GHG emission savings. They also provided an economic marginal analysis and Life-Cycle Assessment using a coupling procedure between a partial agro-industrial equilibrium model and an oil refining model[7]. Their main conclusion was that biofuel competitiveness depends on crude oil prices and demand for petroleum products. Consequently, these parameters

[7]The agro-industrial model is a partial equilibrium model called OSCAR i.e. 'Economic Surplus Optimisation of biofuels' which was developed by the Joint Research Unit in Public Economics, (INA-PG / INRA), Grignon. The French oil refining model is a mono-refinery optimization model based on Linear Programming

should be taken into account by authorities to modulate biofuel tax exemption optimization.

As can be seen from these reviews, these studies use a wide range of modelling approaches to analyse EU biofuel programmes. Most of the analysis of EU biofuels is specific to certain regions only with different thematic approaches. In this way these studies do not address the empirical effects of the EC bioethanol blend mandate and they are not focused on the EU27 member states as a whole.

Still others studies on biofuels in the EU region have focused on biofuel production, land use and GHG emissions from a complete biofuel production cycle. These studies highlight the fact that one of the challenges that the EU faces in terms of its ability to produce biofuels is land availability. They also highlight the fact that the benefits of biofuels in as far as reduction of GHG emissions is concerned should consider CO_2 emissions involved in the biofuel production cycle. Such concerns have been highlighted earlier in the chapter and these studies provide further empirical evidence of their importance. Fischer et al (2010) studied the biofuel production potentials in Europe with focus on sustainable use of cultivated land and pastures. For this study they used agricultural and forestry products trade balance database including production volumes and land use. Their database was country-specific covering the period from 1980 to 2002. Their main conclusion was that in the EU more than half of the biofuel feedstock potential is found in the EU12[8] and they also highlighted the importance of Eastern Europe in biofuel production especially that of Ukraine.

Overmars et al (2011) analysed the indirect land use change (ILUC) on CO_2 emissions due to EU biofuel consumption. Their study therefore used various data

[8] The EU12 countries include Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, United Kingdom

on land use, biofuel production, energy yield of biofuel crops and CO_2 emissions from biofuel production cycles. Their main conclusion was that ILUC emissions alone could shift CO_2 balance for biofuels from reductions to more emissions relative to fossil fuels.

Bringezu et al (2009) analysed the global implications of biomass and biofuel use in Germany. For their study, they focused on recent trends and future scenarios for domestic and foreign agricultural land use and the resulting GHG emissions. Their study basically used data on land use and GHG emission mainly CO_2 in Germany and globally with the main conclusion that an increase in the use of biomass, and in particular biofuels, in Germany would lead to an expansion of cropland requirements in tropical regions. They further concluded that the consumption of biodiesel would increase GHG emissions induced by land-use change in the next decades.

Ozdemir et al (2009) analysed the land substitution effects of biofuel side products and implications on the land area requirement for EU 2020 biofuel targets. The study used various data on land use, biofuel production and energy yield of biofuel crops in the EU. The main conclusion was that the substitution of land area due to use of side products might ease the pressures on land area requirement considerably and should therefore not be neglected in assessing the impacts of biofuel provision worldwide. The studies on the relationship of biofuels to land use and GHG emissions are informative and provide insights into the wide scope of the biofuel literature. However, our study of biofuels will not consider their effects on land use since our analysis will involve bioethanol production from 'current' bioethanol crop production in the EU by diverting some of these bioethanol crops to bioethanol production.

The review of the various literature on biofuels in the EU show that the area is well researched but still there is an obvious paucity of studies that specifically target the EC blend mandate economics in a holistic manner for the EU27 region. For example, there is no study that attempts to develop a partial equilibrium model of the EU27 bioethanol market from the blend mandate where the partial equilibrium EU27 bioethanol model could be considered an *ex ante* model to be transmitted into a more global model in order to analyse the mandate's impact.

Analysis of the economics of the EC bioethanol blend mandate policy is important given the direct impact bioethanol has on food markets as opposed to biodiesel. Such an analysis, important as it is especially for ACP trade and development, is still under researched. As observed in the paper by Banse et al (2008), the economic literature on the impact of biofuels on agricultural markets is still scarce as the boom in biofuels is recent. Because of this he further noted that data availability remains the major impediment in the study of biofuels especially in the EU27.

The problems of data availability on biofuels in the EU27 is made worse by the controversies surrounding the perceived benefits of these biofuels in terms of their role in reducing GHG emission, the adverse effects they might have on the environment and being seen as competing with food production in the world that is still not food secure. These controversies hinder further biofuel production programmes in the EU region meaning data on this commodity remains scant still. Their increased production as per blend mandate commitments or targets is losing its impetus despite the fact that the problems associated with fossil fuels still persist.

From the review of these studies, certain questions still remain on the EC biofuel policies. For example, it is still unknown what the full impact of the EC biofuel blend mandate policy will be in the EU region on a partial equilibrium basis. Further it is not known what determines the price of transport bioethanol or biofuels in the region given the fact that the industry in still underdeveloped.

Further, it is not known how the EC blend mandate will affect trade and welfare between ACP and EU27. This is more so because the EU27 is an important market for ACP countries especially for sugar. The biofuel studies for the EU region so far do not consider the spillover effects of the region's biofuel programmes specifically on ACP countries. This is a concern because most ACP countries are at their developmental stages and are therefore more vulnerable to policies that have a potential to affect food production and trade in agricultural commodities. In this way, our study will develop and extend the EU bioethanol model to analyze its impact on these countries, many of which are mostly reliant on agricultural trade for their growth.

Following these arguments, our approach to designing the EU27 bioethanol market will be on the assumption of a mandatory blend mandate that is binding for all EU27 member states with no bioethanol imports allowed. As such, the demand for bioethanol will be linked to the demand for gasoline. On the supply side there is still the problem of data since bioethanol production for transport fuel in the EU27 started to be significant in year 1996. This therefore means that the bioethanol supply data is of short duration making its time series analysis a challenge. We will also make further assumption that all the bioethanol demanded by the blend mandate is produced from 'current' ethanol crop production in the EU27 such that our analysis will have no bearing on land use as mentioned before.

This approach is reasonable because it will illustrate the possible effects of the EC blend mandate on a current 'as-it-is' scenario. In this way this study will offer a useful upper benchmark for future extensions of this kind of work. Our study will further determine the potential interaction effects between the EC bioethanol blend mandate policy and the Economic Partnership Agreement (EPA) policies between the EU and ACP countries. This extension of the analysis of the EC bioethanol blend mandate policy has never been attempted before. The EPA policies will be discussed in chapter 4 of our study.

2.8 Summary and conclusion

This chapter has looked at the global biofuel status and the reasons for their promotion around the world. It has also reviewed selected regional policies that support biofuel production mainly in the USA, EU and Brazilian. These three regions are the main producers and consumers of first generation biofuels. Biofuel production has important opportunity cost implications. In this way, this chapter has also reviewed the studies that are for and against the promotion of biofuels and the controversies surrounding their production. Most of these controversies hinge on the competition for food production that biofuel production poses. Biofuels are identified as the cause of global increase in food prices since they compete directly with food production for agricultural resources in a world that is still not food secure.

In this chapter, the EC biofuel directive, which forms the basis for our study, has also been reviewed together with other support policies that promote biofuel production in the EU region. Despite the EC biofuel blend mandate directive and other policies that promote biofuels in the EU, their production and use is still low compared to the USA and Brazil where the biofuel market, especially the market for bioethanol is well developed.

The EC bioethanol blend mandate is expected to have an impact on these bioethanol crops commodities with important implications for ACP countries. The underdeveloped biofuel (especially bioethanol) industry in the EU poses a potential problem in studies that aim to analyse the EU bioethanol market. This is mainly due to lack of data on biofuel use in the region and for the fact that there is no uniform blend mandate with individual countries setting their own targets.

Various studies on the EU biofuel (or more specifically bioethanol) blend mandate policy have also been reviewed. The finding has been that there has so far been no study that is specifically directed at analysing the effect of the EC bioethanol blend mandate in the EU on a partial equilibrium approach. This makes the economics of the blend mandate an under-researched area in the region. This is despite the potential implications that the biofuel directive, especially the bioethanol sector will have on bioethanol crops commodities markets in the EU27 and globally.

In the next chapter, we review the various bioethanol models mainly those developed for Brazil and USA bioethanol markets. These models are then adapted to design the EU bioethanol market model i.e. an EU bioethanol supply and demand models that will subsequently be transferred into the GTAP model.

Chapter 3

Bioethanol models review, design and analysis of EU27 bioethanol model

3.0 Introduction and motivation

The purpose of this chapter is to review bioethanol models and then design and analyse a model for the EU27 bioethanol market under a binding blend mandate. Various models have been proposed to study bioethanol markets especially for the USA and Brazil and these are based on the Food and Agriculture Policy Research Institute (FAPRI) modelling approach. In these models, the bioethanol market is linked to those for bioethanol crops commodities, depending on which crop is used in the bioethanol production process. This link is because of the fact that bioethanol and bioethanol crops commodities are substitutes in productions and are therefore horizontally intergrated. For example, bioethanol production has a direct link to the sugar market in Brazil and corn market in the USA. This is because Brazil uses sugar cane to produce bioethanol while the USA uses corn. Since in the EU27 bioethanol is produced from a number of crops, bioethanol production in the region will have a direct impact on the respective bioethanol crops commodities. Because our study places emphasis on sugar markets, a global bioethanol-sugar model will be reviewed to get insights into the link between these two commodities.

In this chapter therefore we will discuss the intuition behind various bioethanol models globally and specifically in the USA and Brazil to enable us to design an EU partial equilibrium bioethanol model. At present, there is no model that analyses the EC bioethanol blend mandate policy on a partial equilibrium basis with the aim of drawing conclusions on its potential effect on bioethanol crop commodities sectors. Our analytical approach therefore and in particular the assumptions made in motivating our model offers an addition to our understanding of the economics of the EC biofuel blend mandate policy. It must be emphasized that the key to our modelling approach are the assumptions made about the EC bioethanol blend mandate and the bioethanol production programme in the EU region. These assumptions makes our analysis unique and provide a upper bound bench mark for the possible impact of the EU bioethanol programme bioethanol crops commodities sectors.

Studies on the EC biofuel policy were discussed in Chapter 2. Most of these studies use a general equilibrium approach as opposed to partial equilibrium analysis. For example, Gohin (2008) used a Computable General Equilibrium (CGE) approach to analyse the impact of the European biofuel policy on the EU15[9] farm sectors. On the demand side they modelled the EC biofuel policy as increasing EU demand and therefore trade in biofuel crops commodities. On the supply side they assumed an increase in EU biofuel crops production using set aside land. Their main conclusion was that domestic EU bioethanol production will meet the regional demand while bioediesel demand will be met by a combination of domestic production and imports.

However, partial equilibrium modelling is ideal in capturing the exact impact of the mandate on EU bioethanol crops commodities markets. Further, partial equilbrium modelling also requires minimal data inputs and this makes it suitable in the study of the EU biofuel market which is still underdeveloped with scant data.

A binding blend mandate means bioethanol and gasoline are compliments and will be consumed in fixed proportions depending on the blend mandate percentage. For the blend mandate not to have an effect on transport fuel consumption, it will be

[9]EU15 member states include Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, United Kingdom, Austria, Finland, Sweden. Even fewer studies has analysed the EC blend mandate and biofuel market in all EU27 countries, which include the EU15 member states plus Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, Romania

assumed that government subsidises bioethanol production such that just enough is produced to meet the blend mandate requirements.

In the EU case therefore, gasoline and bioethanol are perfect complements because of lack of flexi-fuel vehicle that uses either bioethanol or gasoline. In this case, a government subsidy will be designed such that just enough bioethanol is produced to meet the blend mandate in place without the need to change the vehicle type. Subsidizing biofuel use is common practice around the globe. As noted by de Gorter and Just (2008), blender's tax credits and fuel tax exemptions constitute a consumption subsidy that raises the market price of biofuels and hence constitutes an unfair advantage over fuel (oil) production.

Because of the binding blend mandate assumption, the demand for biothanol will depend on the demand drivers for gasoline. For this reason, an EU gasoline demand model will be designed and analysed *apriori.* From this gasoline demand model, the bioethanol demand will be adapted. The model analyses the effect of an EC 5.75% and 10% binding blend mandate, these blend percentages being the EC proposed transport fuel blend targets for 2010 and 2020 respectively. It is envisaged that the higher the blend mandate requirements the higher will be the equilibrium bioethanol quantities and therefore the larger will be the mandate impact on bioethanol crops commodities markets.

Bioethanol supply is driven by the prices of bioethanol and bioethanol crops commodities. This is according to economic theoretical foundations in that bioethanol and bioethanol crop commodities are substitutes in production. Production behaviour will be driven by profit maximisation and therefore the prices of these competing commodities. Because sugar beet is one of the bioethanol crops in the EU27 the EU bioethanol supply will therefore be linked to the EU sugar market. Given the fact that the EU27 is an important global sugar producer and trader the EU bioethanol market will also have spill overs into the global sugar markets. The bioethanol supply market of the EU27 will also be linked to the markets for the other bioethanol crops i.e. barley, corn, wheat and rye. For example, in France in 2003, bioethanol production was from sugar beet with a share of 78%, wheat with a share of 15% and corn with a share of 7% (ONIOL, 2004).

The partial equilibrium model estimates obtained and the subsequent equilibrium conditions will be transferred into the GTAP model (which we discuss in chapter 5) to analyse the global spillovers of the mandate. The GTAP model is an example of a CGE model and will be discussed in details in chapter 5. The idea is that the EU equilibrium bioethanol quantities produced from the various bioethanol crops commodities will 'artificially' depress their output. This 'artificial' depression of bioethanol crops commodities output in the region is due to their divertion to bioethanol production. It is these artificial decreases in EU bioethanol crops commodities quantities that will be transfered into the GTAP model to simulate the global spillovers effects of the EC bioethanol blend mandate policy. To simulate and analyse the full impact of the mandate we assume that the EU produces all their bioethanol requirements within the region. The incorporation of the GTAP model to study the global impact of the EC bioethanol blend mandate policy will be undertaken in chapter 6.

The rest of the chapter is therefore organised as follows; section 3.1 reviews global bioethanol models while section 3.2 discussed the FAPRI bioethanol model especially those of Brazil and the USA. Section 3.3 reviews an alternative FAPRI based bioethanol model again for the USA and Brazil. In section 3.4 we design and analyse the EU27 bioethanol demand model and presents its results. Section 3.5 derives the bioethanol market clearing conditions under the assumption of a bioethanol production subsidy. Section 3.6 is the design and analysis of the EU bioethanol supply model and presentation of its results. In section 3.7 we derive the subsidy level from the equilibrium bioethanol quantities and the discussion of the equilibrium results. Finally, section 3.8 is the conclusion and extension.

3.1 Review of the global bioethanol models

A more global bioethanol model has been proposed by Koizumi (2003) to study the global sugar-bioethanol market and the Brazilian bioethanol-sugar market. This model integrates agriculture, energy and the environment. In this model, the world sugar market consists of 14 major producing countries with 11 for the bioethanol market. The global sugar and bioethanol markets are linked together through the Brazilian markets for these two commodities. The proportion of sugar and bioethanol production is driven by exogenously determined domestic prices. Since sugar and bioethanol are substitutes in production, production decision is determined by their relative prices.

National markets for these two commodities are defined by production, consumption, export, import and ending stocks values. The model therefore solves for a market clearing and trade-clearing price. Exogenously specified market intervention prices determine national market supply-demand and trade balance differences. As this model is global, it also integrates EU sugar production and trade programmes, which include production quotas, intervention prices, export subsidies and preferential treatments. Bioethanol consumption is specified as the sum of transport use and other uses. Transportation use is defined as a function of bioethanol and gasoline prices, which is further explained by the exogenously provided crude oil price and the number of vehicles.

In this model production of bioethanol is a function of the area harvested for sugar cane or sugar beet and their bioethanol production efficiency. When the price of sugar is high, the share of sugar cane/sugar beet for bioethanol production goes down and vice versa. Therefore, the relative prices of these competing commodities, i.e. sugar and bioethanol are the main drivers of production decisions on the supply side.

Bioethanol demand is modelled as consumption demand and is a function of domestic price of commodities and income at a given time period. The model then derives exports and imports as functions of production and consumption. It then solves for marketing clearing conditions when exports equate to imports. To show how the Koizumi model is structured we first define its key variables as follows;

Ah = area harvested,
Q = production quota
Y = yield
G = exogenous growth rate
QP = production
ER = extraction rate
SUAL = sugarcane allocation ratio for sugar production
QC = consumption
PQC = per capita consumption
EX = export
IM = import
SS = ending stocks
I = per capita income
POP = population
DP = domestic price
PP = producer price
MP = import price
WP = world price

The indexes used with the variables are defines as follows;

i = all commodities
is = sugar
isc = sugarcane
isb = sugar beet
ie = bioethanol
ia = alternative commodities
im = input for bioethanol production

r = countries/ country groups
t = time

Using the variables above the model then defines production, consumption, import and export of bioethanol to derive the market clearing conditions as discussed next.

Production of sugar cane is determined by the area harvested as shown in equation 3.1 below;

$$\Delta Ah_{is,t} = f\,(\Delta PP_{is,t-1},\ \Delta PP_{ia,t-1}, \Delta Q_{is,t-1}) \tag{3.1}$$

The above equations means that on the productions side, the change in area harvested for sugar ($\Delta Ah_{is,t}$) is a function of change in its lagged price ($\Delta PP_{is,t-1}$) versus the change in lagged price of alternative commodities including bioethanol ($\Delta PP_{ia,t-1}$) and the lagged change in sugar production quota ($\Delta Q_{is,t-1}$) at any time t. The equation means that there would be a negative relationship between the area harvested for sugar cane and the price of alternative commodities, specifically bioethanol.

The quantity of sugar produced ($QP_{is,t}$) is a function of the area harvested for sugar cane/beet ($AH_{isc,t}$/ $AH_{isb,t}$) multiplied by the sugar cane/beet yield ($Y_{isc,t}$/ $Y_{isb,t}$), the sugarcane allocation ratio for sugar production ($SUAL_t$) and the extraction rate for sugar cane/sugar beet ($ER_{isc,t}$/ $ER_{isb,t}$) at time t. These relationships are shown in equation 3.2 below;

$$QP_{is,\,t} = AH_{isc,t} * Y_{isc,t} * SUAL_t * ER_{isc,t} + AH_{isb,\,t} * Y_{isb,t} * ER_{isb,t} \tag{3.2}$$

Equation 3.2 therefore shows that the production efficiency of a source crop for a given commodity is important in determining the final yield for that commodity.

The sugarcane allocation ratio for sugar production ($SUAL_t$) is a function of the ratio of the changes in the domestic price of sugar (DP_{is}) versus that of bioethanol (DP_{ie}) as shown in equation 3.3.

$$SUAL_t = f((DP_{is,t} / DP_{is,t\,0}) / (DP_{ie,t} / DP_{ie,t\,0})) \tag{3.3}$$

The production decisions between sugar and bioethanol and thus the sugarcane allocation ratio for sugar production are with reference to the Brazilian sugar-bioethanol market as shown in equation 3.4. The change in the quantity of bioethanol production ($\Delta QP_{ie,t}$) is a function of the change in its price ($\Delta PP_{ie,t}$), the change in its exogenous growth rate ($\Delta G_{ie,t}$) and change in prices of inputs for bioethanol production ($\Delta PP_{im,t}$) at time *t*.

$$\Delta QP_{ie,t} = f(\Delta PP_{ie,t}, \Delta PP_{im,t}, \Delta G_{ie,t}) \tag{3.4}$$

Bioethanol production will be positively related to its own price and negatively related to the prices of inputs. Consumption of commodity *i* at any given time *t* ($QC_{i,t}$) is a function of its price ($PQC_{i,t}$) and the population ($POP_{r,t}$) in a given region *r* at time *t* as shown in equation 3.5 below.

$$QC_{i,t} = PQC_{i,t} * POP_{r,t} \tag{3.5}$$

Therefore the change in per capita consumption of a given commodity ($\Delta PQC_{i,t}$) is a function of change in its price ($\Delta DP_{i,t}$) versus alternative commodities ($\Delta DP_{ia,t}$) and also a function of change in income ($\Delta I_{r,t}$) in a given region or country *r* at any given time *t*.

$$\Delta PQC_{i,t} = f(\Delta DP_{i,t}, \Delta DP_{ia,t}, \Delta I_{r,t}) \tag{3.6}$$

Consumption of a given commodity generally increases with increase in income if that commodity is a normal good. It decreases with an increase in its own price and a decrease in prices of alternative commodities. Since transport fuel is a normal good, consumption of transport bioethanol will be positively related to income and negatively related to its own price. However, increase in bioethanol price will also increase its supply but this supply increase will depend on the relative price changes of bioethanol versus sugar. These dynamics show the possible complex relationship between the transport sector and agricultural markets as a result of biofuel production programmes.

Export for commodity *i* ($\Delta EX_{i,t}$) is a function of the change in world market price for that given commodity ($\Delta WP_{i,t}$) versus the change in its domestic price ($\Delta DP_{i,t}$) at any given time *t* as shown in equation 3.7.

$$\Delta EX_{i,t} = f\,(\Delta WP_{i,t}\,,\ \Delta DP_{i,t}\,) \text{ or } EX_{i,t} = QP_{i,t} + IM_{i,t} - QC_{i,t} - (SS_{i,t} - SS_{i,t-1}) \tag{3.7}$$

Change in imports ($\Delta IM_{i,t}$) on the other hand is a function of change in the import price for commodity *i* ($\Delta MP_{i,t}$) versus the change in its domestic price ($\Delta DP_{i,t}$) and also a function of change in income ($\Delta I_{r,t}$) for a given region or country *r* at any given time *t*. This relationship is shown in equation 3.8 below:

$$\Delta IM_{i,t} = f\,(\Delta MP_{i,t},\ \Delta DP_{i,t},\ \Delta I_{r,t}\,) \text{ or } IM_{t,s} = EX_s + QCt_s + (SS_{st} - SS_{st-1}\,) - QP_{st} \tag{3.8}$$

Increase in world prices of a given commodity relative to local prices will generally promote export of that commodity. It is expected therefore that increase in blend mandate commitments of nations will increase global demand for bioethanol. This will increase bioethanol exports from efficient producers like Brazil to high cost producers like the EU region.

The ending stock for a commodity *i* ($SS_{i,t}$) is shown in equation 3.9. It is a function of change in domestic production ($\Delta QP_{i,t}$) or domestic consumption ($\Delta QC_{i,t}$) and change in production price ($\Delta DP_{i,t}$) at time *t*.

$$SS_{i,t} = f(\Delta QP_{i,t}, \Delta DP_{i,t}) \text{ or } SS_{i,t} = f(\Delta QC_{i,t}, \Delta DP_{i,t}) \tag{3.9}$$

Following the motivation of the relationship between the variables, the model is then solved when exports equal imports for a given commodity *i* at a given time *t* for a given country or region *r,* i.e.

$$\Sigma EX_{i,r,t} = \Sigma IM_{i,r,t} \tag{3.10}$$

The usefulness of this model is that it shows that production and consumption decisions in the bioethanol market are driven by the price of bioethanol relative to the prices of bioethanol crops commodities, which is only sugar in this case. Trade is a function of local production, consumption and the relative prices of international versus local commodities. The model therefore shows that bioethanol has a direct influence on sugar markets (both locally and internationally) and vice versa since these two commodities are substitutes in production.
Another model that has been used to study bioethanol and its impact on other markets is the FAPRI model which we discuss next.

3.2 The bioethanol FAPRI model

This model was developed by the Food and Agriculture Policy Research Institute (FAPRI) at the University of Missouri-Colombia (MU). The model has therefore been named after the institute that developed it. The FAPRI model is a partial equilibrium model that is applied in supply and demand analysis of major US agricultural commodities. Its base data is derived from input costs, retail prices, farm incomes and government interventions. It also incorporates world trade models in agricultural commodities and estimates supply, demand, prices and trade flows for major international trading regions. The model is useful in the analysis of the effects of market ‘shocks’ (e.g. policy interventions) on farm income and consumption. Its structure with reference to the USA bioethanol production programme is described in details in the FAPRI-MU Report #07-08 (2008).

In this bioethanol FAPRI model, USA bioethanol supply is a function of its own price and the prices for bioethanol crops commodities. Bioethanol in the USA is produced from corn following two production lines which are the Dry and Wet milling production. Bioethanol production from corn (or any grain crop for that matter) results in a by-product called distiller’s grain, which can be wet or dried. The difference between wet and dry milling production cycle is the treatment of the grain in the initial stages of the bioethanol production process. In wet milling the grain is soaked in water and diluted with acid to separate it into its components while in dry milling this process is skipped. Wet milling co-products include corn oil, corn gluten feed and corn gluten meal, all which are used as animal feed. This means that the bioethanol market also has a direct link to the livestock production market through this by-product.

The characteristics of Wet Distillers Grain (WDGs) are different from those of DDGs in that the WDGs contains unfermented residues with up to 70% moisture while DDGs are more concentrated with less water content (about 10%). This means that DDG has a longer shelf life, which reduces its storage and transport costs. WDG has a short shelf life and is therefore not ideal for international trade purposes. It is the dry milling method that is adopted in the analysis of the bioethanol market since it is this method that produces DDG important for trade.

The FAPRI bioethanol supply intuition is quite simple. Bioethanol production from corn is driven by the expected net revenue return per bushel. Bioethanol return from a bushel of corn is a function of its own price multiplied by the amount that can be produced from that given bushel less input costs. In this way, the revenue returns also considers the bioethanol production efficiency of corn. Revenue returns also takes into account the by-products of bioethanol production process, in this case DDGs sold as animal feed. Bioethanol production costs are mainly the corn price and the other costs of corn conversion to bioethanol. Indeed, the cost of bioethanol crops are the biggest hindrance to EU bioethanol production programmes as noted in the previous chapter. This relationship means that high bioethanol prices encourage bioethanol production while high corn prices discourage it and this relationship is intuitively correct.

Bioethanol demand varies depending on whether it used as a mandatory blended fuel or as a voluntary substitute, which can be at a 10% (E10) or 85% (E85) blend. Consumers therefore face different demand decisions depending on the bioethanol policy in place. If used as a mandatory fuel additive, bioethanol acts as a complement to gasoline and in this case consumer choice is limited. If used as E10 or E85 it act as a substitute and consumers can choose between traditional gasoline and the blended hybrids. This means that in the first scenario of mandatory blending, a rise in the price of gasoline will result in decreased demand for bioethanol. In this case, bioethanol and gasoline prices are positively correlated. On the other hand, if bioethanol and gasoline are substitutes, a rise in the price of gasoline will result in an increase in demand for bioethanol as consumers switch to the cheaper alternative. In this case the demand for bioethanol will be negatively related to that of gasoline.

In the mandatory use, the demand for bioethanol is simply the demand for gasoline multiplied by blend mandate percentage. In this case of mandatatory use, the elasticity of demand for bioethanol is the same as that for gasoline. For the purposes of the EU27 bioethanol market it is this mandatory use that will be adopted since our aim is to determine EU bioethanol demand under the 5.75% and 10% mandatory blend mandate as proposed in the EC biofuel directive.

For completion and extensions the voluntary use of bioethanol is also discussed to show how it differs from the mandatory use. The voluntary use of bioethanol is disaggregated into E10 and E85, both based on market conditions. E10 blended fuels can be used in most vehicles while E85 can only be used in Flexi Fuel Vehicles (FFVs). The E10 blend demand is a function of gasoline demand and the blend percentage of 10%. However, since in voluntary use the blend mandate is not binding, demand for bioethanol will also be driven by the relative price of bioethanol to gasoline. Since bioethanol contains about 70% energy content as gasoline, the price of bioethanol becomes competitive with that of gasoline once the price ratio of bioethanol to gasoline is less than 0.7.

In this case the market penetration for bioethanol is defined by a logit function with a maximum point where no bioethanol is sold once the price ratio of bioethanol to gasoline is above 70%. The overall bioethanol demand is therefore a product of the blend mandate percentage and the logit defined bioethanol market penetration. Assuming a binding blend mandate therefore ignores the bioethanol market penetration effect, which simplified the bioethanol demand function. The derivation of the E85 demand is similar to that for E10 with some differences however.

Firstly, for adoption of E85, consumers must have a FFV. This means that the market penetration for E85 will be lower than that for E10 in that it will not only depend on the price ratio of bioethanol to gasoline but also on investment in FFVs. This means adoption of E10 will be quicker if bioethanol becomes cheaper after adjustment for the energy contents. Secondly, use of E85 (due to historical presence of FFVs) will start at a somewhat higher bioethanol- gasoline price that in the E10 case. This makes E85 bioethanol demand more complicated than that for the E10 demand. In the USA therefore there is a complex relationship between bioethanol and gasoline demand depending on whether the blend mandate in place is binding or not, the blend mandate percentage and the presence of FFVs in the economy. For the EU27 we will simplify the bioethanol-gasoline demand relationship by assuming that there is a given binding blend mandate in place and that there are no FFVs in the region.

The above model notwithstanding, in the next section we discuss an alternative bioethanol model, also based on FAPRI modelling approach. This model has again been developed for the USA and the Brazilian bioethanol market.

3.3 Alternative FAPRI bioethanol models

This alternative modelling approach, also based on the FAPRI model, was developed by Elobeid and Tokgoz (2008) for the USA and Brazilian bioethanol programmes. It follows similar reasoning with the previous model in that bioethanol demand is a function motor gasoline demand and the blend mandate policy in place. Bioethanol supply, as in the previous model, is a function of its own price and that of bioethanol crops commodities. However, this model is also extended to include international trade in bioethanol.

In this model, USA bioethanol demand is derived from a cost faced by fuel blenders. The cost of blending fuel is a function of the price of bioethanol, the population, the blend policy in place and the gasoline supply. The demand function for bioethanol per unit of gasoline is then derived by minimizing this cost function following the application of the Shepperd's Lemma. This derives the demand for bioethanol as driven by its own price (less the tax rebate), the population and the blend mandate in place. At equilibrium, gasoline supply is equal to gasoline demand. In this case, the demand for bioethanol at equilibrium is a function of the per unit gasoline bioethanol demand multiplied by the overall demand for gasoline. The demand for gasoline is in itself a function of its own price, the price of bioethanol, Gross

Domestic Product (GDP) and the population. The bioethanol demand model is such that it is assumed that complementarity between bioethanol and gasoline dominates. This complementarity assumption in the model therefore means that a binding blend mandate dominates.

The complementarity assumption between bioethanol and gasoline is basically to recognise the fact that in the USA there are few FFVs and this is the case also for the EU region. The USA bioethanol market price is the prevailing market price of this commodity as determined by market forces of supply and demand. This is unlike the case in the EU region where bioethanol does not have a significant market share and recognised supply and demand drivers that determine its market price. The complementarity assumption between bioethanol and gasoline also means the price of bioethanol will increase with increase in demand for gasoline. As gasoline demand is positively related to GDP and population growth, this trend will also be followed by bioethanol.

The USA bioethanol demand differs from that of Brazil mainly due to the presence of FFVs in the Brazilian market which relaxes the complementarity assumption between bioethanol and gasoline. The Brazilian bioethanol demand is also a function of its own price, the price of gasoline, GDP, the population and the blend mandate in place. However, in Brazil bioethanol demand is divided into hydrous and anhydrous components due to the presence of three kinds of cars namely alcohol cars, FFVs and gasohol vehicles[10]. These cars are identified due to their fuel requirements.

Alcohol cars use hydrous bioethanol only, gasohol cars use a blend of anhydrous bioethanol with gasoline while FFVs use both hydrous and anhydrous bioethanol blended with gasoline. Total bioethanol demand in Brazil therefore is the sum of

[10] The distinction between Anhydrous and Hydrous bioethanol is basically due to the water content. Anhydrous bioethanol contains less the 1% water while hydrous bioethano contain 4-7% water. Conversion of hydrous bioethanol to anhydrous bioethanol is by distillation.

the three types of bioethanol demand. In the Brazilian case therefore bioethanol acts as a substitute and a complement depending on the dominant car type in the market. This means therefore that anhydrous bioethanol and gasoline demand are positively correlated while demand for hydrous bioethanol and gasoline have a negative correlation. This Brazilian situation shows the complex potential interaction between bioethanol and gasoline depending not only on the nature of the blend mandate (i.e. whether it is binding or not) but also on the vehicle type in the economy.

In this alternative FAPRI bioethanol model, as in the previous FAPRI model, USA bioethanol supply is driven by profit maximisation of the firm. This profit maximisation is a function of the expected net revenue return from a bushel of corn converted into bioethanol and its by-products less the input cost, which are basically the corn prices and the price of natural gas used in bioethanol fermentation process. However, this alternative FAPRI bioethanol model, unlike the previous one, include the capacity utilisation of the firm during bioethanol production and the USA ending stocks.

Brazilian bioethanol supply is also driven by profit maximisation of the firm that is determined by the area harvested for sugar cane. The area harvested for sugar cane is a function of the prices of sugar, bioethanol and soybeans, which is a competing crop. The share of sugar cane for bioethanol production therefore is a function of the relative prices of bioethanol and sugar as is the case in the previous model. A high price of bioethanol means less sugar cane is used for sugar production and vice versa. Because of competing crops, the area harvested for sugar cane is positively correlated to the prices of sugar and bioethanol. However, the relative prices of these two commodities determine which one dominates in production. Trade in bioethanol is also included in the model both for the USA and for Brazil. For the

USA, two trading regions are identified namely the Caribbean Basin Initiative (CBI)[11] that benefits from a duty free bioethanol export to the USA and other regions that are subjected to a tariff rate quota. For the case of Brazil, bioethanol trade incorporates only exports given the fact that Brazil is a net bioethanol exporter.

The usefulness of the models reviewed is that they show how the bioethanol market is linked to other commodities markets. In all these models bioethanol demand is linked to the demand for gasoline while bioethanol supply is linked to bioethanol crops commodities markets. Since the EU27 also uses corn and sugar beet to produce bioethanol, the EU27 bioethanol supply model will have some similarity to that for the USA and Brazil. Because of its multicommodity linkages it is therefore expected that the EU27 bioethanol supply or production programme will potentially have more impact on food markets than that of Brazilian or USA. Schematic details of all the possible inter-linkages between the bioethanol markets and other commodites markets for a global, Brazilian, USA and the EU27 bioethanol programmes are shown in Figures A3-1, A3-2, A3-3 and A3-4 respectively in the appendix. Because of the global linkages of the EU bioethanol crops commodities markets, a global CGE model like the GTAP is therefore ideal to analyse the global effects of the EC bioethanol blend mandate.

The USA FAPRI model reviewed in particular also considers the markets for grain crops bioethanol by-products like DDGs which is used as an animal feed as mentioned. In this way, the USA FAPRI model incorporates the livestock sector into the bioethanol market. However, the FAPRI model's shortcoming is that it is better suited to analyzing a biofuel market where such a market already exists and exerts a significant influence on other related sectors. In this way, the model is appropriate

[11] The CBI countries include Jamaica, Costa Rica and El Salvador and they trade with the USA under the Caribbean Basin Economic Recovery Act (CBRA) where rules of origin apply in bioethanol export to the USA. The agreement is that if bioethanol is produced from at least 50% of crops grown in CBERA country then it enters the USA duty free.

for countries with well developed bioethanol markets like the USA and Brazil. This model will therefore have limitations for the case of EU where the bioethanol market is still in its infancy.

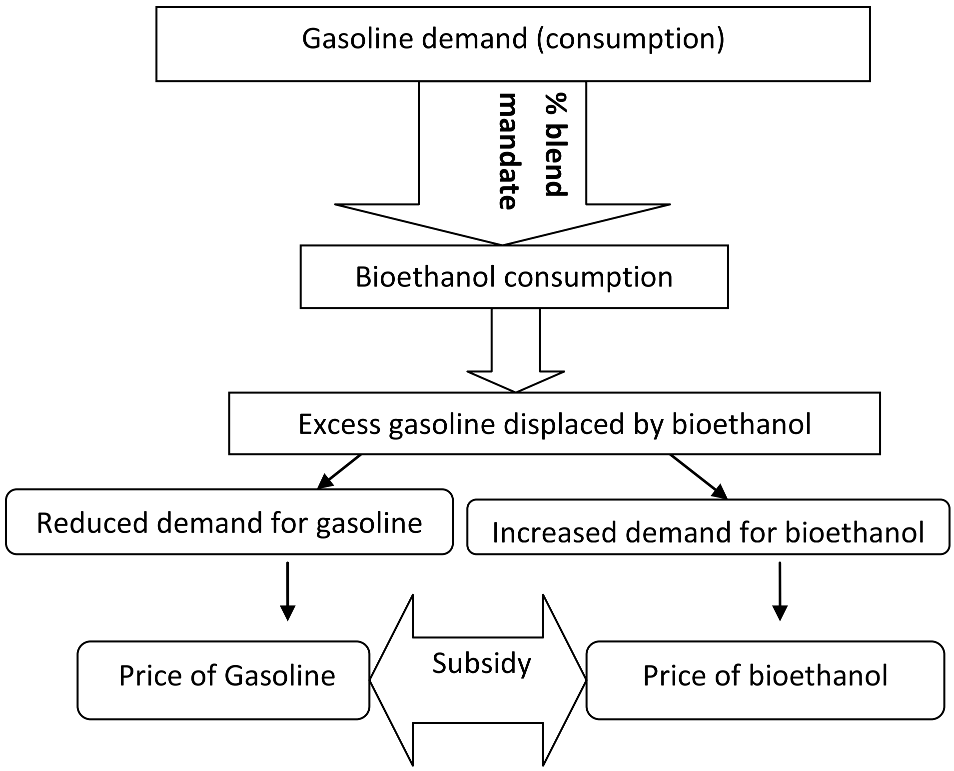
However, the Brazilian and the USA bioethanol models and their empirical results provide good reference benchmark for an EU27 bioethanol model. They also offer good insights on the possible modelling techniques used to study bioethanol market but they have limited applicability to the EU27 where there are few FFVs. Further, the EC bioethanol blend mandate is not binding. The non-binding nature of the EC blend mandate, where nations choose their individual blend targets makes it difficult to analyse bioethanol penetration in all the EU member states. However, the design of the EU27 bioethanol model will be adapted from the FAPRI approach under certain assumptions which forms the key to the model we finally develop as mentioned in the introduction section to this chapter.

3.4 The EU27 bioethanol demand model

Following the review of the various bioethanol models in the last section mainly for Brazil and USA we are now in a position to design the EU27 bioethanol model that aim to analyze the effect of the EC bioethanol blend mandate in the region. This EU model is guided by the schematic view of the possible bioethanol market structure in the region as outlined in the Figure A3-4 in the appendix section. First, we construct the EU27 bioethanol demand.

The EU bioethanol market demand model can be designed from the flow chart outlined in figure 3-1:

Figure 3-1: EU 27 bioethanol demand model flow chart



As in the previous models reviewed, the demand for bioethanol in the EU27 is directly linked to the demand for transport fuel following a binding blend mandate assumption.

From the flow diagram above it is apparent that the mandatory blend will increase the demand for bioethanol whilst decreasing that of gasoline by an amount equivalent to the blend mandate percentage in place.

As noted earlier in the chapter, a binding blend mandate implies that the demand for bioethanol will be a derived demand from that of gasoline. To motivate the demand for bioethanol in the EU region therefore, a gasoline demand model is first developed and tested for consistency.

3.4.1 Gasoline demand

Following Elobeid and Tokgoz (2008) the initial demand for gasoline (in millions of gallons) without blend can be modelled as follows;

(3.11)

In equation 3.11 is the EU27 demand for gasoline, is the EU27 real GDP per capita, is the real price of gasoline in the EU27 in constant (year 2000) Euros and is the mean zero error term which is assumed to be normally distributed.

This model is useful in that it relates gasoline demand to its own price and GDP per capita as intuition dictates. A structural form that is widely employed in analysing the demand for fuel is the double log functional form. The justification for using the double log functional form is that in this transformed model the coefficients are now interpreted directly as elasticities so they have direct economic application as opposed to the linear case where the coefficients on the dependent variables represent marginal values.[12] Therefore using the double log linear long run transformation, equation 3.11 is transformed as shown in equation 3.12 below:

(3.12)

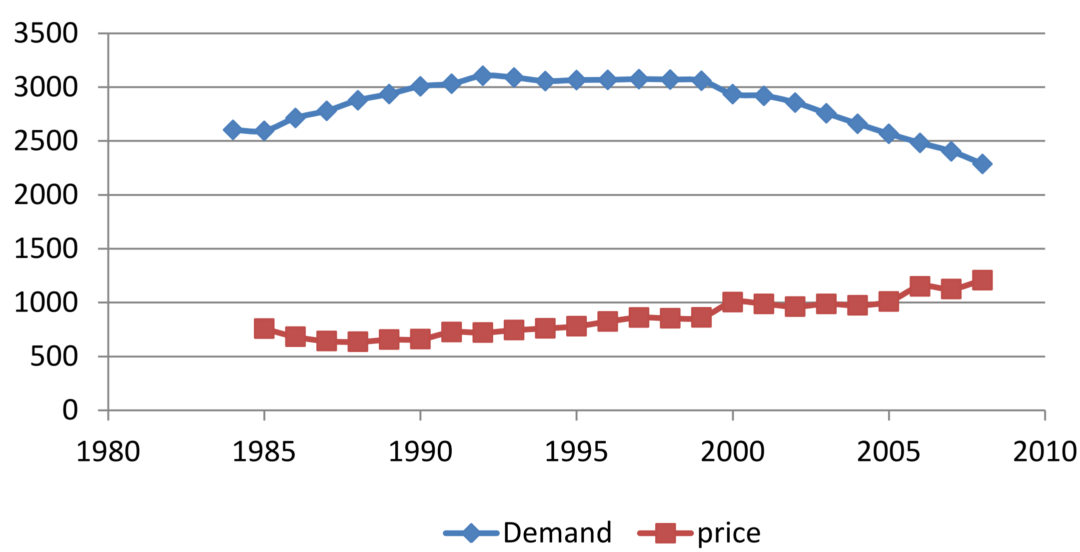
Where again is the EU27 demand for gasoline at time *t*, is the EU27 real GDP per capita at time *t*, is the real price of gasoline in the EU27 in constant (year 2000) Euros at time *t* and is the mean zero error term which is assumed to be normally distributed. In equation 3.12 *t* indicates the annual average for the

[12]The double log linear long run relationship between gasoline demand and GDP has been applied in several studies that analyze energy markets. Please see studies by Bentzen (1994), Ramanathan (1999), Cheung and Thomson (2004 and Polemis (2006)

variables from year 1984 to 2009, the time span for our data set. In the above equation, economic intuitions expects to be negative while and are expected to be positive. The model in equation 3.12 above will form the basis for the analysis of the transport bioethanol market in the EU27 but in order to use it is important to first test its structural specification.

The average annual demand for gasoline in the EU27 from the years 1984 to 2009 is obtained from US Energy Information Administration (EIA). EU27 real GDP per capita data is obtained from International Monetary Fund (IMF) World Economic Data Base. The data used in this analysis dates back further that the formation of the EU27 region and is obtained by aggregating individual member countries data sets. For the case of the fuel prices the average price at the pump inclusive of all taxes across all the EU member states is used and this data is obtained from Eurostat. A plot of gasoline demand and its price from 1984 to 2008 is shown in the Figure 3-2 below;

Figure 3-2: A plot of the EU demand (thousands of barrels/day) and price of gasoline (€/1000L) from 1984 to 2008



Source: Data from EIA

Figure 3-2 above shows that the two variables are inversely related which is in accordance to intuition. The data also show that the price of gasoline has been increasing from the 90s and was above €1/L around year 2000. Demand for gasoline has been relatively flat in the years from 1990 up to 2000. However, from year 2000 onwards gasoline demand went down in response to a price increase around that same year. The distribution of the data shows that there are no outliers that could affect the robustness and validity of our results.

For the analysis of the gasoline model we run the regression for the equations developed in equation 3.12 above. These static long run regression results for the EU27 annual gasoline demand are shown in Table 3.1 below:

Table 3.1: Regression results for a static long run EU27 gasoline demand:

Variable	Coefficient	Standard Error	T statistic	P>|t|
LnY	0.302	0.053	5.651	0.000
LnP	-0.393	0.124	-3.173	0.004
Constant	7.648	0.482	10.050	0.000
N= 26 R-Squared =0.634				

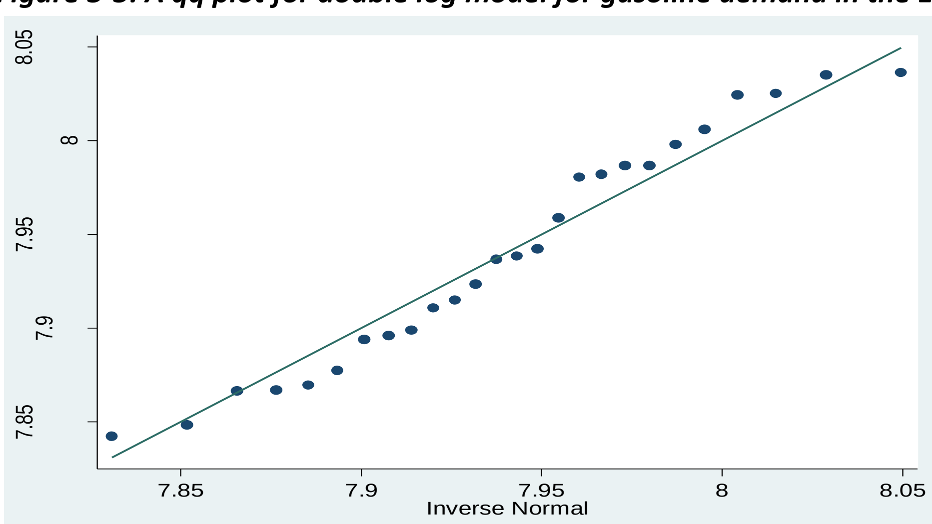
The results reported in Table 3.1 show that all the coefficients are significant and have the expected signs. The regression is also significant and explains 63% of the variation.

The double log model shows that the price elasticity of demand for gasoline is -0.393 when regressing gasoline demand against its own price and GDP per capita. This value is comparable to values obtained in most EU transport fuel demand studies which find long run price elasticities of demand ranging from -0.4 to -0.8 (Godwin et al., 2004; Romero-Jordán et al., 2010; Dahl and Sterner, 1991). However, all these studies used income per capita instead of GDP per capita as is the case in our model. They also studied total transport fuel demand, which includes gasoline and diesel instead of gasoline alone, as is the case in our study. However, the comparable elasticities means the data used for this study and the variables chosen are reliable.

To further work with the model, it is important to test its structure. Formal model tests we use are the test for normality of the errors and the test for heteroskedasticity. Both graphical and numerical methods are used in testing for normality and heteroskedasticity. Graphical methods are useful in that they are easy to perform and give a visual picture of the test outcome, which can then be supported by the more formal numerical approach. In this way, the combination of graphical and numerical testing methods provides practical and robust test results. The graphical method employed for testing normality is the quantile-quantile (qq) plot and for the numerical method we use the Kolmogorov-Smirnov (KS) test.

The qq plot is a plot of a variable against the normal distribution plot. If the variable is normally distributed the two plots should match. The qq plot is easy to perform and interpret using most readily available statistical software and the results for our model are shown in Figure 3-3 below:

Figure 3-3: A qq plot for double log model for gasoline demand in the EU27



The results from the qq plot of the residuals show that they are normally distributed since they trace the normal distribution line.

The qq plot above provide evidence for normality of the residuals but a more objective numerical method for testing normality must also be performed. The K-S test is an example of such numerical method. The K-S method is a means of testing whether a set of observations are from a given continuous distribution and it is a powerful test for small samples (Lilliefors, 1967). As our sample data consist of only 26 observations, this test is preferred.

The null hypothesis being tested is that of normality of the residuals and a low p-value corresponds to rejecting the null hypothesis. P-values are considered significant if they are larger than a critical value of 0.05. The results of the KS test are displayed Table 3.2 below:

Table 3.2: K-S test for normality for gasoline demand in the EU27

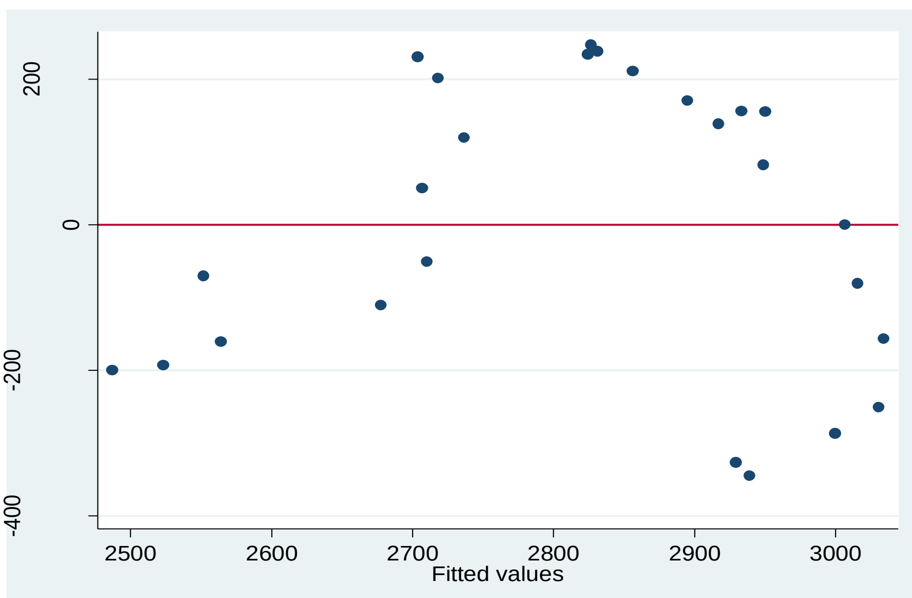
Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
Residual	0.217	0.283	2.97	0.227

The results show that we fail to reject the null hypothesis of normality at rejection region of α=0.05 and conclude that the residuals are normally distributed.

Testing for heteroskedasticity is another important element of analysing the structure and performance of a model for a given data set. Homoskedasticity is one of the basic assumptions of a standard OLS regression model and refers to the case where the variance in the error term is constant. A violation of this assumption results in heteroskedasticity meaning that the calculated estimates of the model are no longer valid. Homoskedasticiy is therefore an important characteristic of a correctly specified model.

To test for heteroskedasticity in our models we use the residuals plot which is an example of a graphical method and the Breusch-Pagan / Cook-Weisberg (B-P/C-W) test which is an example of a numerical method. The B-P/C-W test is a widely used test for homoskedasticity which tests the null hypothesis that the fitted values have a constant variance against the alternative hypothesis of non constant variance or heteroskedasticity. A low p-value below a critical level (chosen to be $\alpha=0.05$ in this analysis) means rejecting the null hypothesis of homoskedasticity leading to the conclusion that heteroskedasticity is present in the regression model run. In the residuals plot the residuals are plotted against fitted values and a trend between the two planes is an indication of heteroskedasticity. The residual plot results for our model are shown Figure 3-4 below:

Figure 3-4: A residual plot for EU27 gasoline demand



The results above show no clear trend between the residuals and the fitted values and therefore we conclude that the double log model specification of EU27 gasoline demand result in errors that are homoskedastic.

The next step was to perform numerical test for heteroskedasticity using the B-P/C-W test and the results supported homoskedasticity with a p-value of 0.9211, which is greater than a critical value of 0.05. The outcome above gives further evidence that the double log transformed model of EU27 gasoline demand result in homoskedastic variances.

The important results of the model are summarised in Table 3.3 below.

Table 3.3: OLS regression summary results for EU27 gasoline demand

*	-0.393 (0.004)
R-Squared	0.634
Adjusted R-Squared	0.602
KS Test (p-value)#	0.227
BP-CW Test (p-value)#	0.921
*p-values in brackets	
#p-values for KS test with H_o: normality and BP-CW with H_o: homoskedasticity of residuals	

Although our data set is rather short with 26 observations, the model is also analysed using a time series approach to determine the long run relationship between the variables by the method of cointregration. Many studies have used cointergration methods to analyze the demand for gasoline in different regions (Bentzen, 1994; Ramanathan, 1991; Rao and Rao, 2009) but none have analysed the EU27 gasoline demand with the aim of deriving the demand for bioethanol.

To test if the variables in the gasoline demand model we have specified have indeed a long run relationship we first test each one of them for unit root by use of the augmented Dickey-Fuller (ADF) test.

The ADF is basically running the regression specified below:

3.13

Which is estimated as an AR(J) process.

The hypothesis of the ADF test is as follows:

H_o : =0 meaning has a unit root

H_1 : ‹ 0 meaning is not unit root and either stationary or trend stationary.

The ADF test shows that the price variable is unit root when a constant is included without a time trend. It is not unit root at all levels when a time trend is included and the results of the test are shown in the Table 3.4 below:

Table 3.4: OLS unit root estimation for price variable

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	-1.787	1.117	-1.600[0.131]
LnP(1)	0.258	0.158	1.638[0.122]
DLnP(1)	-0.488	0.320	-1.523[0.149]
DLnP(2)	-0.654	0.327	-2.001[0.064]
DLnP(3)	-0.271	0.324	-0.836[0.416]
DLnP(4)	-0.590	0.283	-2.084[0.055]
R-squared=0.321 : F-stat. = F(5,15) 1.418[0.274]: S.E. of Regression = 0.066			

Sequential testing of the lags show that the fourth lag (k=4) is significant. At this point the ADF statistics is -2.084 and the critical value -2.630 and we therefore fail to reject the null hypothesis of a unit root and conclude that the logarithm of gasoline price in the EU27 is a unit root process. The unit root test for the natural logarithm of GDP per capita shows that it is not unit root when a time trend is not included but there is evidence of unit root when the time trend is included and the results of the test are shown in the Table 3.5 below.

Table 3.5: OLS unit root estimation for GDP variable

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	5.827	1.842	3.164[0.007]
T	0.031	0.010	2.998[0.010]
LnP(1)	-0.629	0.200	-3.148[0.007]
DLnP(1)	0.514	0.250	2.053[0.059]
DLnP(2)	0.112	0.250	0.447[0.662]
DLnP(3)	0.031	0.206	0.150[0.883]
DLnP(4)	0.530	0.201	2.639[0.019]
R-squared = 5.827 : F-stat. = F(6,14) 2.487[0.075]: S.E. of Regression = 0.080			

In the results shown above, for k=4 the ADF statistics is -2.639 and the critical value -3.240. We therefore fail to reject the null hypothesis of a unit root. Sequential testing of the logarithm of gasoline demand for unit root reveals that it is a stationary process with or without the time trend and a constant. However, since the logarithm of GDP per capita and that of gasoline price have shown some evidence of unit root, it is important to test for cointegration of the variables in order to determine if indeed a long run relationship between them does exist.

Processes that are unit root cannot be estimated by standard OLS techniques for the risk of spurious regression. However, different unit root processes can still be related to each other over time. Even though the logarithm of gasoline demand in the EU did not show a unit root tendency, we still go ahead and perform a cointegration test to determine the long run relationship between gasoline demand, GDP per capita and gasoline price in the EU27. Variables are cointegrated if a linear relationship exists between two or more unit root processes. The test for cointegration establishes the validity of such a relationship.

Testing for cointegration centres on testing whether the error term in a standard regression model is stationary or unit root.

Considering a general regression below:

(3.14)

If is unit root then and are not cointegrated

If is stationary then and are cointegrated

Testing for cointegration is done in 2-steps Engle-Granger test by first estimating the general equation by OLS to obtain residuals and then apply the ADF test on the residual without a constant and a trend to test for unit root i.e.

(3.15)

With H_o : implying no cointegration and

H_I : implying existence of cointegration between and .

The ADF statistic i.e. is compared to critical values from the McKinnon's response surface.

Therefore, to test for cointegration we first regress onto and a Constant in with the variables defined as before. This regression reproduces the results shown in Table 3.1.

From the regression above we store the residuals and use them to test for cointegration. The results from sequential testing are shown in the Table 3.6 below with 3 lags i.e. k=3.

Table 3.6: OLS estimation for cointegration testing

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
R(-1)	-0.441	0.207	-2.134[0.047]
DR(-1)	0.134	0.242	-0.553[0.587]
DR(-2)	0.022	0.223	-0.100[0.921]
DR(-3)	0.303	0.233	-4.303[0.079]
R-squared =0.273 : F-stat. = F(3,18) 2.252[0.117]: S.E. of Regression = 0.050			

At 10% confidence interval the test statistics is obtained from the McKinnon response surface with three variables and a constant and is calculated as follows:

10% c.v = -3.4518-[6.241/26]-[2.79/676] = -3.696

The ADF statistics is -4.303 and the critical Engle-Granger critical value has been calculated as -3.696. This means we reject the null hypothesis of no cointegration between the variables and conclude that cointegration does exist. This means that a long run relationship between the logarithm of gasoline demand, gasoline price and EU27 real GDP per capita exist. Having established a long run relationship between the EU27 gasoline demand, real GDP per capita and the price of gasoline and testing the validity of the model, we now develop the EU27 demand for bioethanol.

3.4.2 Bioethanol demand

A binding bioethanol blend mandate means the demand for bioethanol is derived from that of gasoline as shown in equation (3.16).

(3.16)

Where M is the blend mandate share ϵ [0, 1]

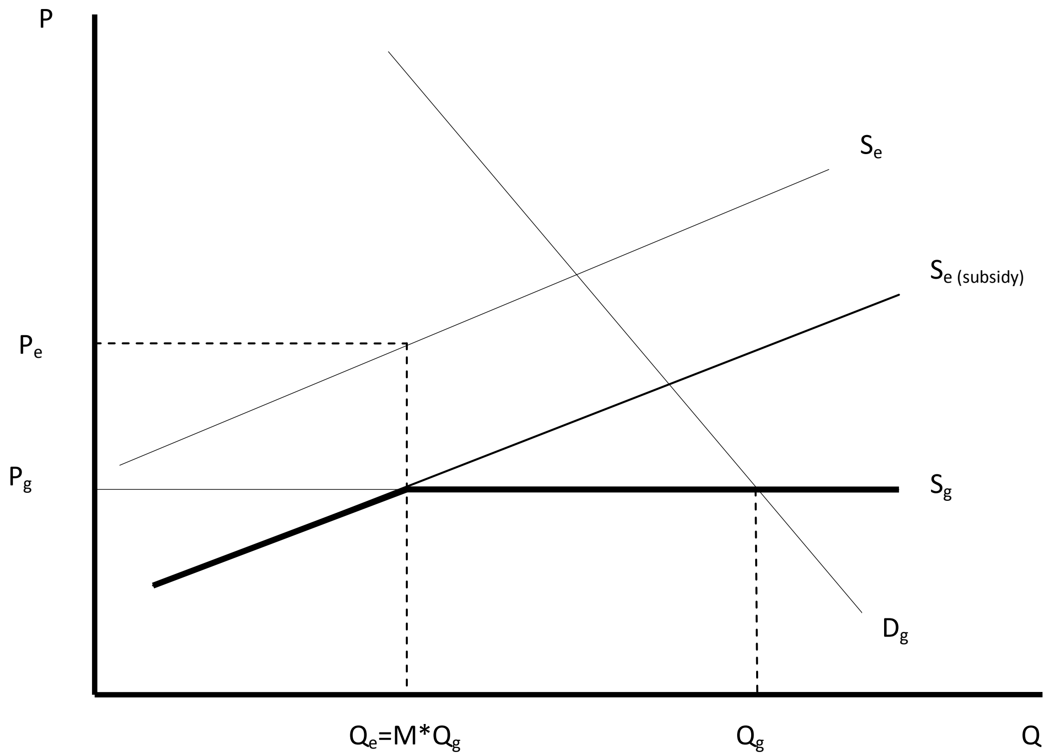
From the equation above the derived demand for bioethanol in the EU27 with a binding mandate at any time *t* (is simply the demand for gasoline at any time t multiplied by the % blend ratio M in energy equivalence as stipulated by the mandate.

Realistically, the demand for transport fuel should be the same with or without the blend mandate such that transport fuel consumers do not really mind what the blend mandate is. The supply of gasoline is flat at the market price, while ethanol supply is upward sloping. Bioethanol might have such a high marginal cost that its supply start at a level above the gasoline price. Thus, without government intervention, no bioethanol is produced. In this case, the government essentially decides the mix of fuel to gasoline by introducing a subsidy. The subsidy is set at a level at which the market clears so that just enough bioethanol (the amount stipulated in the mandate) is produced. For transport fuel consumers not to feel the effect of the mandate, the price of the blended fuel should be the same as that of gasoline. As has been noted by Verboven (2002), the dominant engine characteristic for which consumers have heterogeneous preferences appears to be the fuel cost per mile.

Therefore, the biothanol subsidy will ensure an upward sloping bioethanol supply until enough bioethanol is produced to meet the blend mandate in place. Once the price of bioethanol equals that of gasoline, which corresponds to the quantities of bioethanol required by the blend mandate, no extra bioethanol is produced.

The conceptualisation of this situation is shown in Figure 3-5 below:

Figure 3-5: The bioethanol blend mandate model with government subsidy



Allowing government intervention such that the blend mandate does not affect overall fuel demand and consumption, we have the derive Figure 3-5 as shown above. The aggregate bioethanol supply curve is the upward sloping part of the thick bold line shown in the figure.

P_e= the market price for bioethanol without government subsidy

P_g= the price of gasoline

S_e= the ethanol supply curve

$S_{e\ (subsidy)}$ =supply of ethanol with subsidy

S_g= the gasoline supply curve

D_g= the gasoline demand.

Q_e= M*Q_g= ethanol market clearing quantities, where M is the blend mandate percentage.

Q_g = gasoline market clearing quantities

The amount of subsidy will therefore be the area $Q_e*(P_e - P_g)$. This method subsidy calculation is called the price gap approach and has been applied in various studies that calculate subsidies in the transport fuel market[13]. Because of this government subsidy, we therefore model the effect of the blend mandate on bioethanol crops commodities without effect on the transport fuel sector. This will be via the depression of bioethanol crops commodities output in the EU region by the amount of the equilibrium conditions from the blend mandate as has been mentioned.

The energy equivalent of bioethanol is about 2/3 of that of gasoline. Thus, a 5.75% blend mandate percentage calculated in energy equivalence equates to 5.75%*3/2=8.6% of bioethanol blended with gasoline in volume equivalence. At 10% bioethanol blend mandate percentage the energy equivalence becomes 10%*3/2= 15% in volumetric terms.

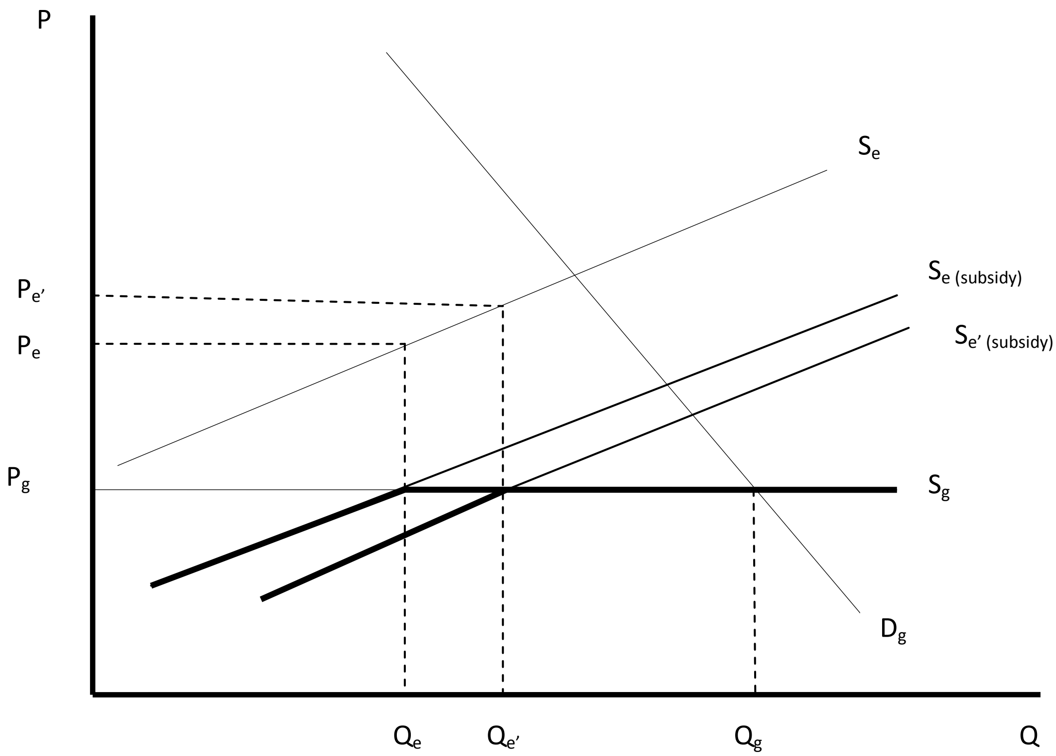
In summary therefore, the bioethanol demand at equilibrium is simply derived from that of gasoline by use of equation 3.16 above.

As noted by Tokgoz (2009) if the fuel demand is perfectly inelastic, then the mandate will have no impact on fuel consumption, but each gallon of bioethanol will exactly displace one gallon of gasoline consumption.

Figure 3-6 below shows the effect of an increase in blend mandate on the demand for bioethanol.

[13]For detailed discussion of the price gap approach use in energy markets please see Koplow (2009)

Figure 3-6: Blend mandate effect on bioethanol demand



In the above diagram, as in Figure 3-6

P_e= the market price for bioethanol without government subsidy

P_g= the price of gasoline

S_e= the ethanol supply curve

S_g= the gasoline supply curve

D_g= the gasoline demand.

Q_e= M*Q_g = ethanol market clearing quantities, where M is the blend mandate percentage.

Q_g = gasoline market clearing quantities

And at a blend mandate M'>M we therefore have;

$Q_{e'}$=M'*Q_g=ethanol market clearing quantities at a higher blend mandate M'

$S_{e'\ (subsidy)}$= the subsided supply curve for bioethanol at M'>M

$P_{e'}$ = the market price for bioethanol without government subsidy at M'>M

From Figure 3-6 above it can be seen that the effect of the increase in blend mandate is to shift the bioethanol supply curve to the right. Since this shift does not affect the gasoline market, the only effect it has is to increase bioethanol demand by an amount proportional to the increase in the blend mandate.

3.5 Gasoline and bioethanol equilibrium solution

Solving for the equilibrium in the gasoline market implies equation supply to demand. The supply curve for gasoline is flat at the price as shown in Figure 3-5. Because we are interested in finding the effect of the blend mandate on bioethanol crops commodities using the GTAP 7 model, we will use the average market equilibrium price of gasoline for year 2004, which is the base year for the database used in the GTAP 7 model. After solving for the equilibrium gasoline market, solving for the bioethanol equilibrium is quite simple. This is by the application of equation 3.16, where the equilibrium gasoline quantity is multiplied by the blend mandate. This means we will have two equilibriums for the bioethanol market i.e. at 5.75% and 10% blend mandate.

Therefore using equation 3.12, i.e.

We take P as the average price of gasoline in the EU in 2004 = € 976/1000L

GDP is also valued at its EU average in 2004 = € 16632

Therefore using these figures, we have that;

=

From the gasoline demand estimated derived before;

= 7.648

= -0.393

= 0.302

It follows therefore that;

= 7.873

Therefore;

= = 21.07 = 2625 thousand barrels per day

From this calculated fuel demand, the equivalent bioethanol demand is calculated as follows:

At 5.75% blend mandate (calculated in energy equivalence)

=M* = 226 thousand barrels per day or 0.226 million barrels a day

At 10% blend mandate

= M* = 394 thousand barrels per day or 0.394 million barrels a day

The above equilibrium results are summarized in Table 3.7 below:

Table 3.7: 2004 equilibrium gasoline and bioethanol demand

Gasoline Demand (thousands of barrels per day)	Bioethanol demand in thousands of barrels per day (and in billions of litres per year)	
	5.75% blend mandate	10% blend mandate
2625	226 (13.1)	394 (22.9)

These bioethanol quantities will subsequently be transferred into the GTAP model to determine their effect on food markets, which we undertake in chapter 6 of our study.

On the bioethanol supply side, equilibrium conditions dictate that supply equals demand. However, the supply of bioethanol in the EU region is too low to meet the calculated demand meaning that government has to subsidize its production as discussed before.

If the EU is to increase internal bioethanol production by such large amounts, this will have significant impact on EU and global food markets and our research aim is to determine this impact. This production increase will require a large increase in the prices of bioethanol, which could result in large increases in the prices of the blended fuel. To avoid such a situation therefore, government introduces a bioethanol production subsidy. As has been noted, the subsidy is set at a level at which the market clears so that just enough ethanol (the amount stipulated by the mandate) is produced. At the equilibrium bioethanol market the following equation therefore holds;

$$M^* \tag{3.17}$$

Where as before,

M= blend mandate percentage

=demand for gasoline valued at its price P

=bioethanol supply valued at gasoline price P and

= is a unit subsidy, i.e. a subsidy paid for every litre of bioethanol.

Equation 3.17 above implies that the demand for bioethanol evaluated at the market price for gasoline should be equal to the subsidised ethanol supplied in the market. The bioethanol equilibrium quantities are as shown in Table 3.7 for the 2004 reference year.

Our next task therefore is to derive the EU27 bioethanol supply curve and determine the required subsidy to bring this bioethanol supply to the calculated demand values shown in Table 3.7.

3.6 EU bioethanol supply model

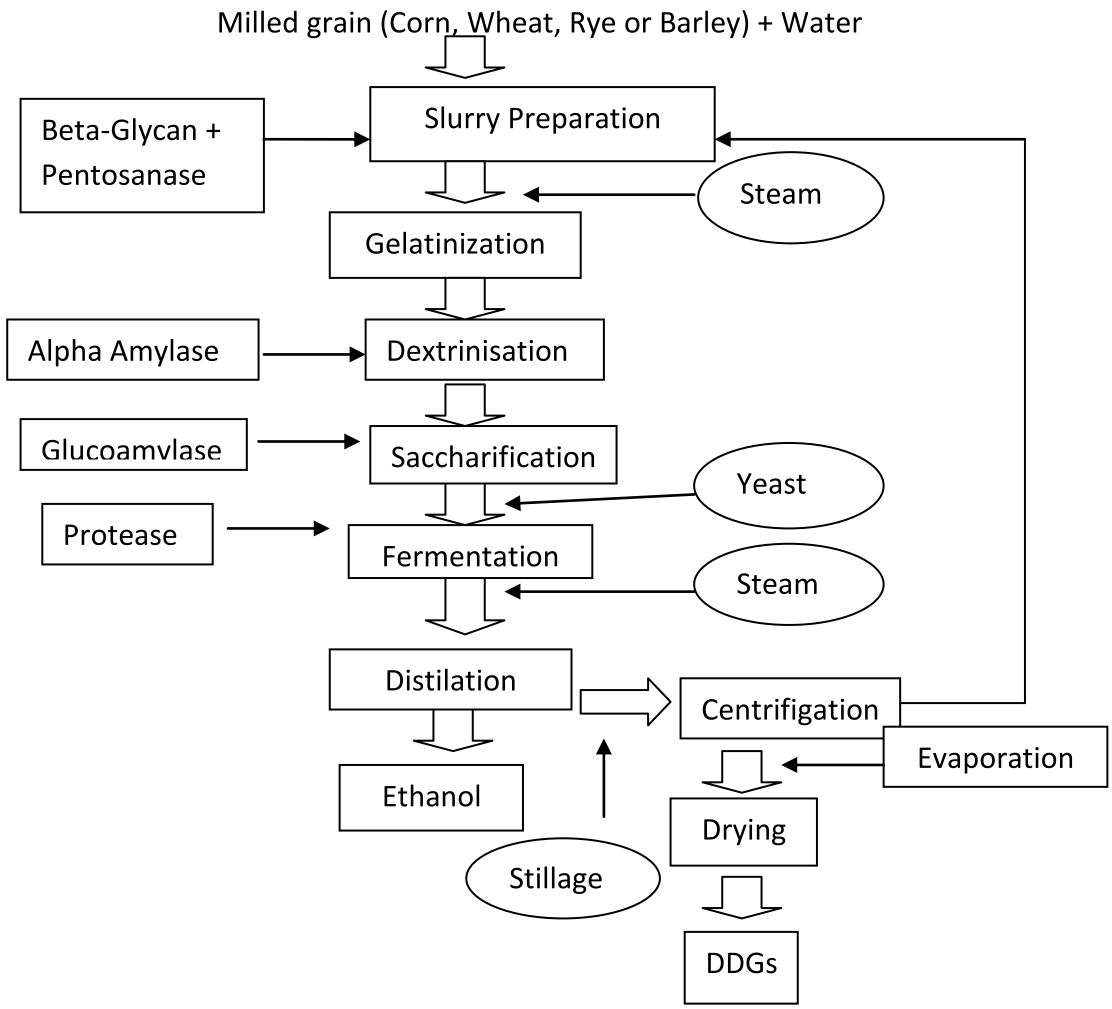
Bioethanol in the EU is produced from a number of crops each of which is expected to have different supply elasticity with different impacts on agricultural markets. It is necessary to develop the various supply models from the different bioethanol crops in the EU27 to come up with one general supply equation that will be used in the analysis of the potential effects of the blend mandate in the region.

The supply model is adapted from the profit maximization FAPRI models discussed above in section 3.2 of this chapter. These profit maximizing bioethanol supply models are driven by the prices of bioethanol and bioethanol by-products versus the prices of bioethanol crops commodities. Generally, bioethanol supply is positively related to its own price and the price of its by-products. It is negatively related to the price of bioethanol crops commodities. Our EU27 bioethanol supply model will therefore be an extension of the FAPRI USA and Brazilian bioethanol supply models by considering all the bioethanol crops used in the production of bioethanol in the region.

Bioethanol production from grain crops like wheat, barley, corn and rye follows the same process of fermentation, with the use of various enzymes and the end product is bioethanol and DDGs used as an animal feed. This means that modelling the production of bioethanol from grain crops will follow the same concept as in the production of bioethanol from corn. Production of bioethanol from sugar beet is similar to its production from sugar cane. Bioethanol production will therefore depend on the bioethanol crops area harvested and its market price versus that of the bioethanol crops commodities.

The bioethanol production efficiency of bioethanol crops vary depending on their starch content. For example, as noted by Punter et al (2004) 1 acre of good arable land (0.44 ha) can produce 3.5 tonnes of wheat grain at 16% moisture (8 t/ha) which, after drying, gives 3.03 tonnes of dried wheat grain (with about 3% moisture) and about 1.4 tonnes of straw. Hydrolysis, fermentation, distillation and dehydration will produce about 1 tone of bioethanol, giving a yield of about 2.3 tonnes per hectare. A residue of 1.14 tonnes of DDG is also produced.
The production process of bioethanol from grain crops can be represented by the Figure 3-7 below:

Figure 3-7: Bioethanol production process from grain crops (dry milling)



Source: Olsen (2007)

As shown from the production process of bioethanol from grain crops the main product of the process is the alcohol, in this case bioethanol and DDGs. This shows that bioethanol production from grain crops follow similar processes. Differences are only in the production efficiencies of the various bioethanol crops since some of the crops have higher starch or energy contents. For example, barley has low starch content (about 55%) than corn (about 70%) and as such, it produces lesser amounts of bioethanol compared to corn (USDA, 2007). In addition, the prices or market values of the crops are different which means their elasticities of supply, which are driven by their market prices, will be different. The main aim is to come up with one EU27 bioethanol supply curve that reflects all these forces.

Therefore, the supply curve for bioethanol in the EU27 is an aggregation of the various supply curves depending on the beginning crops or feedstock, with the final supply curve being the combination of all the individual supply curves. The corn bioethanol supply model is motivated by the profit maximization of the firm as follows:

The net return per kilogram of corn for a bioethanol plant can be expressed as;

(3.18)

In the above equation;

= the net return per kilogram of corn for bioethanol production at time *t*

= the price of bioethanol at time *t*

=the price of DDG at time *t*

= the price of corn at time *t*

= the price of other by-products of corn production at time *t*

= the conversion rates that are used to convert each price to Euros (€) per kilogram of corn

= the conversion rate that is used to convert each price of DDG to Euro (€) per kilogram of corn

The bioethanol production function from corn is then given by the formula below:

(3.19)

Where

= the bioethanol production function in the EU from corn at time *t*

= a constant

= the elasticity of bioethanol production to its net return from corn, which is expected to be positive

= the net return per kilogram of corn for bioethanol production at time t

The significance of equation 3.18 is that the production of bioethanol from the producer's point of view is driven by its prevailing market price compared to the market prices of the crop used. The bioethanol supply model for the other grain crops follow similar arguments and are again determined by the price of bioethanol versus the prices of the bioethanol crops commodities.

As mentioned earlier, the only difference between the bioethanol output from grain crops are the production efficiencies of the various crops used. For simplification, we assume similar conversion efficiencies for all the bioethanol crops. Due to lack of relevant data, we will also assume that the by-products of grain crops ethanol production process are zero such that the term in equation 3.18 disappears. Therefore, the supply function for bioethanol from grain crops can be summarized by equation 3.20 and 3.21 below:

(3.20)

In the above equation;

= the net return per kilogram of grain crop *i* for bioethanol production at time *t*

= the price of bioethanol in the EU at time *t*

=the price of DDG at time *t*

= the price of grain crop *i* in the EU at time *t* (per kilogram)

= the conversion rates that are used to convert each price to Euros (€) per kilogram of grain crop

= the conversion rate that is used to convert each price of DDG to Euro (€) per Kilogram of grain crop

= corn, rye, wheat, barley

The bioethanol production function from grain crops is therefore given by the formula below:

(3.21)

Where

= the bioethanol production function in the EU from grain crops at any given time *t*

= a constant

= the elasticity of bioethanol production to its net return from grain crop, which is expected to be positive

= the net return per kilogram of grain crop for bioethanol production at any given time *t.*

The same argument used to motivate the bioethanol supply functions above is adapted for from sugar beet with slight alterations because the by-products are different from those for bioethanol production from grains. In the case of sugar beet, no DDG is produced.

Again, the net return of a sugar beet bioethanol plant is shown in equation 3.22 below:

(3.22)

Where;

= net return per kilogram of sugar beet for bioethanol production at time *t*

= price of bioethanol in the EU at time *t*

= price of sugar in the EU at time t (per kilogram)

= price of other products from sugar beet production at time *t* (per kilogram)

= the conversion rates that are used to convert each price to Euros per kilogram of sugar beet.

Again, the other by-products from sugar beet are taken to be zero due to lack of data and in order to simplify the model. This means that the term in equation 3.22 disappears.

Therefore, the bioethanol production function from sugar beet is given by the following relationship;

(3.23)

Where

= the bioethanol production function in the EU from sugar beet

= a constant

= the elasticity of bioethanol production to its net return from sugar beet, which is expected to be positive

= the net return per kilogram of sugar beet for bioethanol production

Finally, to combine all the bioethanol supply curves into one it is important to calibrate them so that they produce relevant and comparable elasticities. Their calibration involves taking into account the weights or share of each bioethanol crop during the bioethanol production process. This standardization or calibration also simplifies the calculations of the equilibrium bioethanol quantities and prices using the respective crop's bioethanol conversion efficiency. The advantage of using this modelling approach is that supply is price driven and as such, the share of bioethanol production from a given crop can be viewed as determined by the prices of the various end products of the bioethanol crops compared to the price of bioethanol. For this reason, bioethanol price is viewed as a hinge in the production of the other commodities from bioethanol crops. For example, if the price of sugar goes up, the share of sugar beet used in bioethanol production will go down as producers will choose to produce more sugar. However, for a binding blend mandate the bioethanol supply will also be driven by the demand for gasoline that in turn affects the prices and therefore the production of bioethanol crops products.

Following the double log transformation as has been done for the bioethanol demand model, the final ethanol supply curve then is the combination of all the individual supply curves from the different crops weighted by the share that each crop contributes to the ethanol production function. This is shown by equation 3.24 below:

(3.24)

In equation 3.24 above;

= total bioethanol supply in the EU from the various crops at time *t*

= price of bioethanol in the EU at time *t*

= the price of DDG in the EU at time *t*

= the price of corn in the EU at time *t*

= the price of wheat in the EU at time *t*

=the price of barley in the EU at time *t*

= the price of rye in the EU at time *t*

= the price of sugar beet in the EU at time *t*

= share of bioethanol production from wheat

= share of bioethanol production from rye

= share of bioethanol production from barley

= share of bioethanol production from corn

= share of bioethanol production from sugar beet

, = coefficients on prices

With the assumption that all the bioethanol in the EU27 is produced from the above crops considered then;

= 1

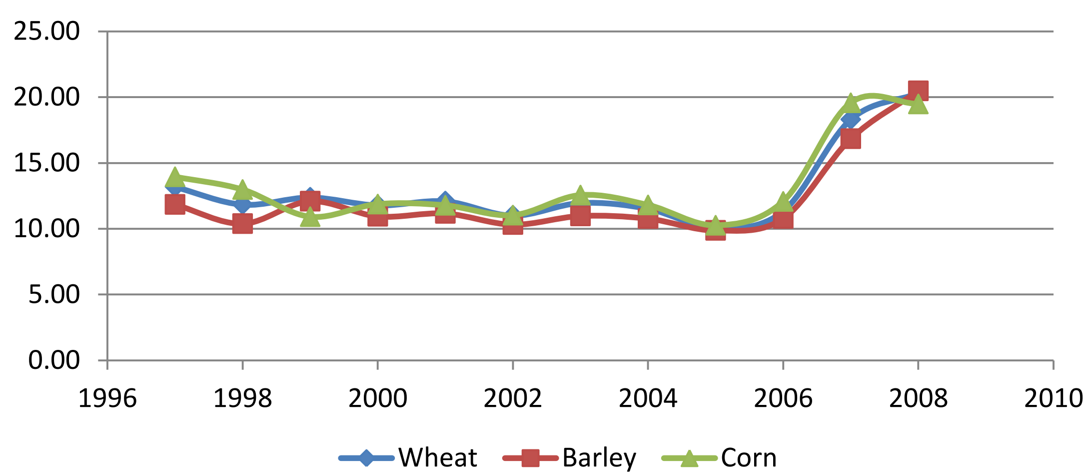
The model in equation 3.24 assumes a double log linear relationship between the bioethanol production function and prices. For the bioethanol crops commodities the coefficients are interpreted directly as cross price elasticities of bioethanol production (as opposed to their own price elasticities).

After the motivation of the bioethol supply in the EU, we now run the regression analysis of the supply model developed. Bioethanol grain crop prices are obtained from Eurostat and are avarages of the reported prices of the EU27 member states ranging from 1992 to 2009 and are expressed in €/100kg. The sugar beet prices are expressed in €/1000kg. The prices for wheat are those of soft wheat product code 1120, for rye they are product code 1150, barley is product code 1160, maize is product code 1200 and sugar beet prices are for the standard quality product code 1372.

The bioethanol supply data is from EIA and is from 1992 to 2009. There was no bioethanol production in the region according to this data source prior to 1992 meaning our regression is for annual data from 1992 to 2009 with 18 observations. The data series is too short for time series analysis but as noted before, one of the main challenges of studying biofuels is lack of data. However, this data series will provide useful insights to the aims of this research despite the fact that it is of relatively short duration. Since the production of bioethanol in the EU still does not have a significant market structure the data for the prices of DDGs are the prices of this commodity in the USA obtained from USA Economic Research Outlook (2008). These prices are converted to Euros per 1000Kg to make them comparable to the prices quoted for bioethanol crops in the EU.

As shown by the bioethanol supply model from grain, bioethanol production decisions are determined mostly by the prices of the beginning stock. The prices of bioethanol crop have been increasing in the EU in the last decade. The crop prices are related to that of bioethanol in that an increase in the price of bioethanol will increase the prices of bioethanol crops commodities, which in turn will shift production decisions away from bioethanol production. Thus, these forces act as some form of feedback loops with the prices having all the information to determine production decisions. The average price trends of the various bioethanol crops commodities in the EU during the past decade are shown in the Figure 3-8 below:

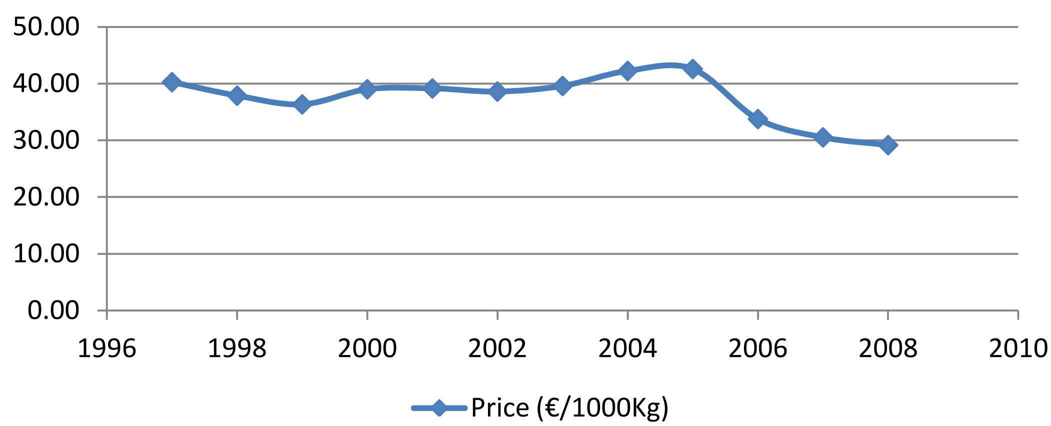
Figure 3-8: Average selling price of grain in the EU from 1997-2008 (€/100Kg)



Data source: Eurostat (2006)

As the Figure 3-8 shows, the prices of the bioethanol crops commodities are correlated signifying that they are determined by the same market forces. The graph shows that the prices of grain in the EU have generally been stable from the mid 1990's and then started to rise in the year 2007. For sugar beet, the price trend is as shown in Figure 3-9 below:

Figure 3-9: Average price of sugar beet in the EU from 1997-2008 (€/1000Kg)



Source: Eurostat (2006)

Figure 3-9 above shows that the price of sugar beet in the EU has generally been stable and has started to fall around the year 2007. It is interesting to note that the prices of grain have increased at around the same time when the prices of sugar beet started to fall.

Next, we analyse the EU bioethanol supply and demand for the EU27 region. Recent supply of bioethanol and that demanded by the EU motor industry in the past years is shown in Figure 3-10 below:

Figure 3-10: Annual demand and supply of bioethanol in the EU under different blend mandates in thousands of barrels per day

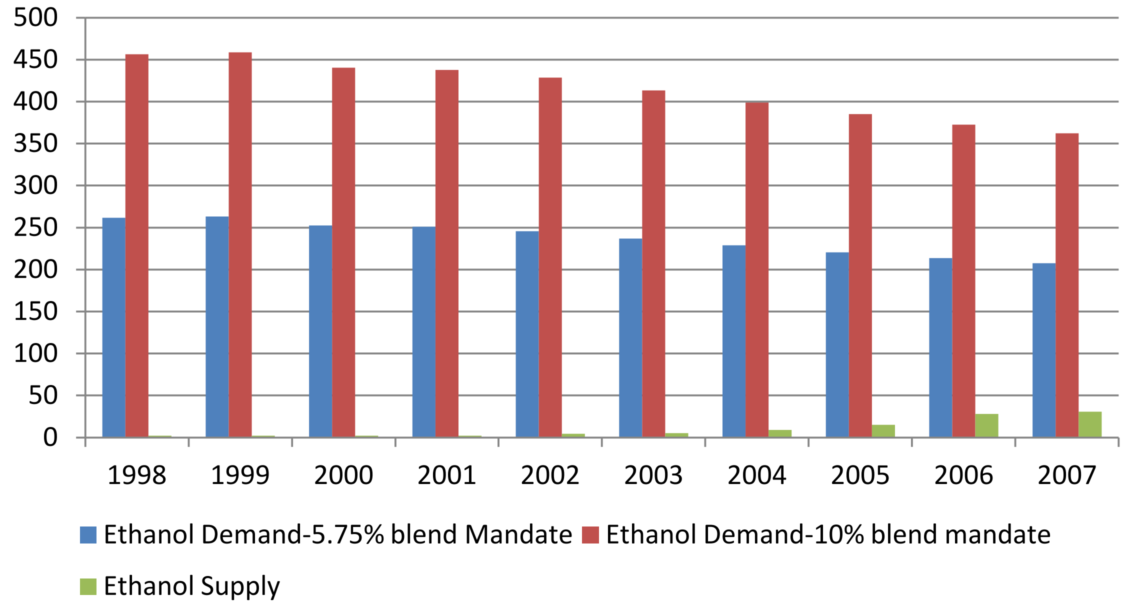


Figure 3-10 above shows that EU bioethanol supply has to increase in order to meet demand due to the blend mandate. Therefore, in order to increase bioethanol supply it is necessary to increase its price. The demand for bioethanol is determined by the demand for motor gasoline according to our model. Gasoline demand is driven by the demand for oil. As shown in Figure 3-10, gasoline demand went down around the year 2007 as expected since this was the year of record oil prices and the start of the global economic recession.

In order to determine the price elasticities for the bioethanol supply in the EU region, certain assumptions are made which are the following:

- The price of bioethanol is simply equal to the price of gasoline as in the demand motivation.
- The bioethanol crops commodities shares in the bioethanol production process is assumed constant for the duration of the period of the regression analysis. However, intuition has it that the share that each bioethanol crop

commodity contributes to the bioethanol production process should vary with price in that if the price of that bioethanol crop commodity rises relative to the others, its share in bioethanol production should fall. However, the prices of grains have been shown to be positively correlated as shown in Figure 3-9 above. This means that it is reasonable to assume constant share contribution for the duration of the period under study irrespective of the price movements. Jank et al (2009), using information from eBio and the EC calculated bioethanol crops shares up to 2012 as being the following: 32.3%, 12.8%, 12.8%, 28.2%, 5.6% and 8.3% for other sources.

- Since it is difficult to model bioethanol production from other sources we assume that all the bioethanol produced in the EU is from the bioethanol crops commodities under analysis i.e. wheat, rye, corn, barley and sugar beet. Under this assumption and using the information from Jank et al we then derive the following shares: 35.22%, 13.96%, 13.96%, 30.75% and 6.11% bringing the total to 100%.
- A report from eBio shows that sugar beet share in EU bioethanol production was 28% in 2006 as opposed to the 5.6% (and the 6.11% that can be implied from the data) as reported by Jank et al (2007). However, for our analysis we will use the 28% (which calculates to 31.1% if we assume no other sources of bioethanol except bioethanol crops) sugar beet share reported by eBio and adjust the other ethanol crops shares according to the shares reported by Jank et al (2007). The use of a higher sugar beet share is in line with the scope of our study to analyse the potential effect of the EC bioethanol blend mandate policy on ACP sugar production and trade.
- A higher sugar beet share of 100% is also used to analyse the effect of the blend mandate on global sugar markets as a sensitivity analysis. Using a higher sugar beet share for the production of bioethanol is in line with attempts to analyse the effect on the blend mandate on sugar markets.

Using sugar beet to produce bioethanol in the EU region is reasonable in that it is expected to have less adverse effects on food markets given the fact that sugar is not a vital food source. It will also have a potential of developing ACP sugar industries and their export potential. This is in line with the scope of the study that places emphasis on sugar markets because of the importance of this commodity to ACP countries. In this way, a higher sugar beet share means the blend mandate will potentially have a win-win outcome.

The period under study is too short for a time series analysis and since the demand for bioethanol outweighs its supply, it is reasonable to assume no time lag in EU bioethanol supply. Significant production of biofuel in the EU only started in earnest around the late 1990s and there is no accurate bioethanol production and consumption data prior to those years to extend the regression analysis data.

From equation 3.24 it can be seen that the cross price biethanol supply elasticities for the bioethanol crops commodities include their shares in bioethanol production (S_i). In this way, the elasticities reported will have to be divided by the bioethanol crop shares to come up with the final cross price elasticities. Changes in bioethanol crops commodities shares will result in changes in the reported elasticities. This means that, modelled this way, the supply elasticities capture the dynamic effects of changes in the bioethanol crops shares. These dynamics are also as a result of cross price elasticities between the various bioethanol crops commodities themselves.

3.6.1 Bioethanol supply model results

The results of the bioethanol supply regression of equation 3.24 are shown in Table 3.8 below:

Table 3.8: EU27 bioethanol supply elasticities

Own Price elasticity	Wheat	Rye	Barley	Sugar beet	Maize	DDG
3.22 (0.073)	-9.423 (0.082)	-1.712 (0.542)	-6.215 (0.323)	-1.452 (0.046)	-3.786 (0.035)	0.781 (0.033)
R-Squared = 0.887; N=18; *Values in brackets represent p-values						

Since our interest is on bioethanol own price supply elasticity and finding of equilibrium conditions in the bioethanol market, the various cross price elasticities of bioethanol supply for the various bioethanol crops commodities will not be pursued further.

However, these elasticities have the correct signs but their values are not very useful given the fact that the bioethanol market in the EU is still in its infancy and does not have a significant influence on the bioethanol crop commodities markets. The bioethanol cross price elasticities of supply for bioethanol crops commodities are expected to be negative in that high prices of a given bioethanol crop commodity means less of it is used in bioethanol production. Bioethanol should be positively related to the price of DDG since these are co-products as is the case in our results.

Fabiosa et al (2010) reported bioethanol supply elasticities of -0.2 and -0.12 for sugar beet and wheat respectively for the EU region. However, their study used an international FAPRI model with elasticities estimated as sample averages from year 2000 to 2004. Such studies suffer the shortfall that the data set is too short. For this reason, such data set do not produce a reliable indicator of the true effects of the bioethanol market on bioethanol crops commodities and land use in the region.

This shortfall is also complicated by the fact that the bioethanol industry in the EU is still at its infancy and is therefore not expected to have a significant impact on bioethanol crops commodities markets in its present state. This is the reason why our study has used an assumption of a binding EC blend mandate and in this way, our bioethanol market has been artificially created.

Our study show that the own price elasticity of supply for bioethanol in the EU region is 3.22. Luchansky and Monks (2009) estimated the own price elasticity of bioethanol supply in the USA market to be 0.24. Zhang et.al. (2010) estimated it to be 6.24 for a USA gasoline mixture composed of 10% to 20% bioethanol component. These estimated values are divergent and highlight the difficulty of coming up with consistent estimates in this new market distorted by subsidies, varying blend mandate levels and tax credits. As noted by Gardner (2007), supply and demand parameters for ethanol are impossible to estimate with precision because only a few years of market data exist under structural conditions favouring fuel ethanol use (i.e., technology, institutions, and regulations). Gardner (2007) further noted that the bioethanol supply elasticity is expected to be larger (ranging from 1 to 5) in the longer term as constraints imposed by fixed ethanol production capacity and capacity in the ethanol plant building industry are relaxed.

3.7 Subsidy derivation from equilibrium conditions

Using the bioethanol blend mandate market clearing conditions as calculated in the bioethanol and gasoline model for 2004, our task is to calculate the level of subsidy required to produce the equilibrium amount of bioethanol as follows;

Starting from equation 3.17, i.e.

$$M^*$$

Our aim is to solve for the market price of bioethanol, P_e in Figure 3-5 and the subsidy value following the price gap approach will be equal to:

$$(P_e - P_g)M^*Q_g$$

(3.25)

where, as before,

M=blend mandate

Q_g=gasoline demand at equilibrium

P_g= price of gasoline

P_e= price of bioethanol

For bioethanol supply, we derived equation 3.24 before as shown below;

From the above equation, we define:

(3.26)

With B again evaluated at the year 2004 variables mean. Therefore, we have:

(3.27)

The equilibrium conditions imply that;

(3.28)

From the equilibrium bioethanol quantities reported in Table 3.7 we now solve for P_e as follows;

At 5.75% blend mandate we have:

Therefore = €3740 /1000L

At 10% blend mandate we have:

Therefore = €4220/1000L

Therefore, using the price gap approach, the amount of the subsidy is determined as follows:

At 5.75% blend mandate:

$Q_e*(P_e - P_g)$ =226 x (3740-976) x 365 x 158.9 = €36.3 billion per year

At 10%, blend mandate:

$Q_e*(P_e - P_g)$ = 394 x (4220-976) x 365 x 158.99 = €74.2 billion per year

It can be seen that the higher the blend mandate, the higher the subsidy required to produce the demanded amount of bioethanol as per intuition.

Our calculated subsidies are huge but are not an abnormality in the energy and agricultural markets. For example, using the price-gap methodology, the International Energy Agency (IEA, 2010) estimated that fossil-fuel-related consumption subsidies amounted to US$ 557 billion in 2008 in OECD member countries. For agricultural markets, subsidies in OECD countries have been estimated to be almost US$ 400 billion in 2008 (OECD, 2009).

3.7.1 Discussion of equilibrium results

From the results it is seen that if the EU goes ahead or had gone ahead with the blending mandate plans as outlined in the EC directive i.e. a 5.75% blend target by 2010, the region would have had to produce about 0.226 million barrels of bioethanol per day to satisfy the requirements of the mandate using 2004 gasoline market equilibrium conditions. At the proposed blend target of 10% by 2020, about 0.394 milllion barrels of bioethanol per day will be demanded by this EC set target at equilibrium from 2004 gasoline equilibrium market conditions.

0.226 million barrels per day equates to an annual EU bioethanol demand of about 82 million barrels or 13.1 billion litres.[14]According to the United States Department of Agriculture (USDA, 2008) the EU27 produced 2.1 billion litres of bioethanol in 2008 with a forecasted increase to 3.4 billion litres by the end of 2010. This means that at 5.75% blend target, the production of bioethanol in the EU has to increase by about 523% from 2008 production levels to satisfy the equilibrium requirements of the mandate and for production to be increased by about 285% from 2010 forecast.

[14] This calculation is based on the conversion of 1 barrel (oil, petroleum)=158.99L

A total of 0.394 million barrels of bioethanol per day, which will be the equilibrium quantity at 10% blend mandate target equates to an annual EU27 bioethanol demand of 22.9 billion litres. This means that at 10% blend mandate, the production of bioethanol in the EU has to increase by about 990% from 2008 production levels to satisfy the requirements of this mandate. These increases are very large and they have a potential serious impact when one considers the pressure they will put on bioethanol crops commodities and their implications on food prices.

However, according to the USDA (2008) the production potential for bioethanol in the EU27 was calculated to be at 9 billion litres by 2010. This may seem as if the EU27 can be able to produce more than half of their bioethanol requirements at 5.75% blend mandate. However, it is not possible to fully exploit this production potential due to other external effects. For example, the USDA (2008) noted that in 2007 only about 45 % of the available EU capacity to produce bioethanol was utilized due to high grain prices, in particular wheat. This is expected since increased bioethanol production exert pressure on demand and prices for bioethanol crops commodities, land and labour thus making the full utilization of the potential not feasible.

After calculating the equilibrium bioethanol quantities (at 5.75 and 10% blend mandate), the next step is to determine their effect on EU/global bioethanol crops commodities markets and on global welfare,which is undertaken in Chapter 6.

3.8 Conclusion and extension

In this Chapter, we reviewed the relevant bioethanol models mainly for the USA and Brazil, the two countries with well developed bioethanol markets. These models were reviewed with the aim of designing the EU27 bioethanol model under certain assumptions. The EU bioethanol demand was derived from the demand for gasoline while the bioethanol supply was driven by the price of bioethanol versus the prices of bioethanol crops. Bioethanol demand was motivated under an assumption of a government subsidy. This government subsidy results in production of just enough bioethanol to meet the blend mandate demand in place. Since the production of bioethanol in the EU region is still at infant stages, there must be substantial government intervention in the form of such subsidies to increase production to meet the demand as will be created by the blend mandates. These subsidies ensure that the price of bioethanol and ultimately that of the fuel mixture remain the same as that for unblended gasoline.

The extension of this derived EU bioethanol partial equilibrium model is to analyse its implication on EU/ACP food markets in terms of welfare changes and changes in bioethanol crops commodities production and trade. For this reason, policies that support bioethanol crop production in the EU and those that support trade between the EU27 and ACP countries will be reviewed and this is the subject of the next chapter. Again, policies that promote sugar production and trade within the EU region will be given special emphasis.

Given the fact that the EC bioethanol blend mandate policy is not a policy acting in isolation, it is interesting to know how it will interact with future trade policies between the EU and ACP countries, the most important of these policies being the EPA policies. The next section therefore will also review these future policies between the EU27 and ACP countries. Our ultimate aim is to analyse their potential interaction with the EC biofuel policy again in terms of welfare, production and trade changes in bioethanol crops commodities.

Chapter 4

The EU/global sugar market: production and trade policies

4.0 Introduction

As Chapter 2 highlighted, bioethanol can be produced from a number of crops one of which is sugar. If sugar is to play an increasingly important role in helping the EU meet its self-imposed blend mandate then it is important to understand how that could affect the EU sugar regime and its relationship with African Caribbean and Pacific (ACP) countries. For this reason, it is important to understand how the policy regime for EU sugar is designed and implemented. Altering the pattern of production could require regime reform and that in turn will affect both EU and ACP countries, not simply in terms of output but also trade volumes and prices.

Thus, the aim of this chapter is to review global, EU and ACP sugar markets. In particular, emphasis will be put on policies that support EU sugar production and trade with ACP countries. Future, policies that will form trade framework between ACP countries and EU27 will also be reviewed. These future policies are mainly the Economic Partnership Agreements (EPA) between the EU and ACP countries. The review of these future policies is in line with the objectives of our research that aim to analyse their potential interaction with the EC bioethanol blend mandate policy. In this way, analysis of the policies linked to the EC bioethanol blend mandate policy will be useful in coming up with detailed and more informative conclusions on the mandate's potential effects.

The ACP/EU sugar trade and trade policy agreements between the two regions is important for the following reasons;

- Sugar trade remains one of the most important sources of revenue for many ACP countries with the EU market being an important destination for ACP sugar. For this reason, trends and developments that affect the EU sugar markets, as the EC bioethanol blend mandate policy is expected to do, are important for ACP countries.

- In general, ACP countries' sugar cannot compete with sugar from lower cost producers like Brazil. This makes bilateral trade policies that ensure and support trade between the EU and ACP important for the latter.
- The EU is a global player in sugar production and trade. As such, developments in the EU sugar market also affect the world sugar market. Such repercussions are in turn transmitted to ACP countries who export some of their sugar to the world market.
- The EU is a high cost producer of sugar. This means that the regions' sugar production and trade is supported by policies that promote its sugar sector, which in turn benefit ACP countries.

Our study scope therefore makes it important to understand the EU policies that form the framework for sugar production in the region and those that support sugar trade between the EU and ACP countries.

The chapter is therefore structured as follows; in Section 4.1 we provide an overview of the global sugar markets including that of the EU. Section 4.2 outlines the Common Agricultural Policy (CAP) and its support for agricultural productivity in the EU region while section 4.3 reviews the Common Market Organisation that specifically supports sugar production in the region. In section 4.4 we review the general trade agreements between the EU and ACP countries while section 4.5 reviews the EU and ACP policies that support specifically sugar trade between the two regions. Section 4.6 gives an overview of ACP sugar industries, section 4.7 discusses recent reforms and policies affecting the EU/ACP sugar regimes and section 4.8 is the conclusion.

4.1 The global sugar market

As the EU is an important global sugar producer and trader, we begin our analysis by reviewing the global sugar markets and the positions of EU and ACP sugar sectors in world sugar production and trade. As noted by Bureau (2008), sugar is one of the most highly protected agricultural commodities worldwide and this depresses trade opportunities and prices received by exporters without preferential market access. Further, Bureu (2008) noted that today's sugar markets are being driven by a complex array of dynamic and emerging supply, demand, and policy forces that need to be understood. The importance of policy intervention in the sugar market is seen in the case of the EU sugar industry. According to Huan-Niemi and Kerkelä (2005), the EU is a net exporter of sugar due to policies that support production and give preferential market access to developing countries. This makes the EU an important global sugar exporter and importer not because of having a competitive advantage in sugar production but because of distorting domestic policies. Such EU policies include high import duties that have the effect of artificially increasing the prices of sugar above world market prices and thus increasing output. The excess sugar produced is exported to the world market by use of export subsidies.

The degree of intervention in the sugar market makes it an ideal commodity to study if one is interested in finding out how policy reform will shape future global trade. The inter-linkage and trade implications between the biofuel policies and sugar policies therefore provide an interesting case study. Due to the potential relationship between sugar and biofuels, specifically bioethanol, sugar policies can therefore affect the climate change and renewable energy initiatives. Table 4.1 below shows the sugar production statistics of leading global sugar producers as compared to African and Carribean sugar production levels in 2004 and 2011. Production statistics close to year 2004 are useful for our research since the GTAP database that we will use in our policy analysis is based on that year's global trade data. This means that production and trade changes because of our policy simulation are with reference to year 2004 statistics.

Table 4.1: World sugar production statistics in year 2004 (2011)

Country	Production- million metric tonnes raw value	World Share %
Brazil	28. 4 (39.6)	20 (24)
European Union	19.9 (15)	15 (9)
India	15.8 (28.3)	10 (17)
China	10.5 (12)	7 (7)
United States	7.8 (7.4)	5 (4)
Mexico	5.4 (5.6)	4 (3)
[1]SADC	5.2 (5.9)	4(3)
Rest of Africa	2.9 (2.4)	6 (5)
Total Caribbeans	3.2 (1.8)	2 (1)
[2]ROW	42.2 (65.5)	30 (39)
World Production	141.7 (168.0)	100

Source:USDA (2012)
[1]SADC refers to Southern African Development Community
[2]ROW refers to Rest of the World

Sugar export is an important revenue earner for many ACP countries as noted previously. In this way, it is important to compared ACP sugar export to that of leading global sugar exporters and this is shown in Table 4.2 for the years 2004 and 2011.

Table 4.2: World sugar exports in year 2004 (2011)

Country	Exports -million metric tones raw value	World Share %
Brazil	18.02 (27.3)	38 (49)
European Union	6. 03 (1.01)	13 (2)
United States	0.2 (0.18)	0.5 (0.3)
Australia	4. 44 (2.85)	9 (5)
Thailand	3. 12 (7.30)	7 (13)
Guatemala	1. 50 (1.81)	3 (2)
SADC	2.3 (2.5)	5 (4)
Rest of Africa	1.0 (0.6)	2 (1)
Total Caribbean	2.1(0.9)	4 (2)
ROW	9.08 (11.25)	19 (20)
Total World Export	47 .75 (55.7)	100

Source: USDA (2012)

The tables 4.1 and 4.2 above shows that the EU is indeed a major sugar producer and exporter, ranking second to Brazil in sugar production with a world market share of 15% in 2004. The tables also show that global sugar production and export has increased from 2004 to 2011 with notable increases seen in Brazil, who remain a global leader. Of note however is the decrease in EU sugar production and export in recent years. For example, EU sugar production in 2011 was 30% less than its 2004 level with exports decreasing by a whopping 83% for the same years. This is likely due to the EU policy of cut in sugar intervention price, which started in 2006. This has the effect of decrease EU sugar output and exports. The policy of cut in EU intervention price will be discussed in details in section 4.7 of this chapter.

Individual ACP countries play a minor role in global sugar production and export. For example, averages over the years 2002/03 through to 2006/07 show that Africa and the Caribbean regions combined accounted for 11.3% and 7.5% of global sugar production and exports respectively (Sandrey and Vink, 2007). Table 4.1 supports this finding and shows that the African and Caribbean regions contributed 11.3% and 10.1% of global sugar production in 2004 and 2011 respectively. The same regions accounted for 5.4% and 4% of global sugar exports in 2004 and 2011 respectively. Caribbean sugar production and export has been declining due mainly to erosion of preferences in the USA and EU markets and increasing production costs (Michell, 2005).

Although the global sugar share of individual ACP countries is not very significant, sugar remains an important income generator for most of the ACP economies, meaning that policy developments in the EU/global sugar markets has important economic implications for these states. As the production of bioethanol is expected to increase demand for sugar cane or beet, a global look at the sugar consumption is necessary to predict the effect that bioethanol production might have on global sugar markets. Table 4.3 below shows the major world sugar consumers in the years 2004 and 2011.

Table 4.3: Major global sugar consumers in year 2004 (2011)

Region	Consumption (million tonnes raw sugar)
World	143.3 (162)
Brazil	10.5 (12.5)
USA	9.6 (10.3)
EU27	15 (17.5)
India	18.8 (26.5)
China	11.6 (13.6)
Africa	8.0 (13.0)
Middle East	10.8 (12.6)

Source: FAO and USDA (2012)

Table 4.3 shows that the EU27, China and India are amongst the leading consumers of sugar in the world. Figure 4-1 below summarises global sugar production and consumption from years 2004 to 2011.

Figure 4-1: Global sugar production and consumption from 2004 to 2011 (in millions of tonnes raw sugar)

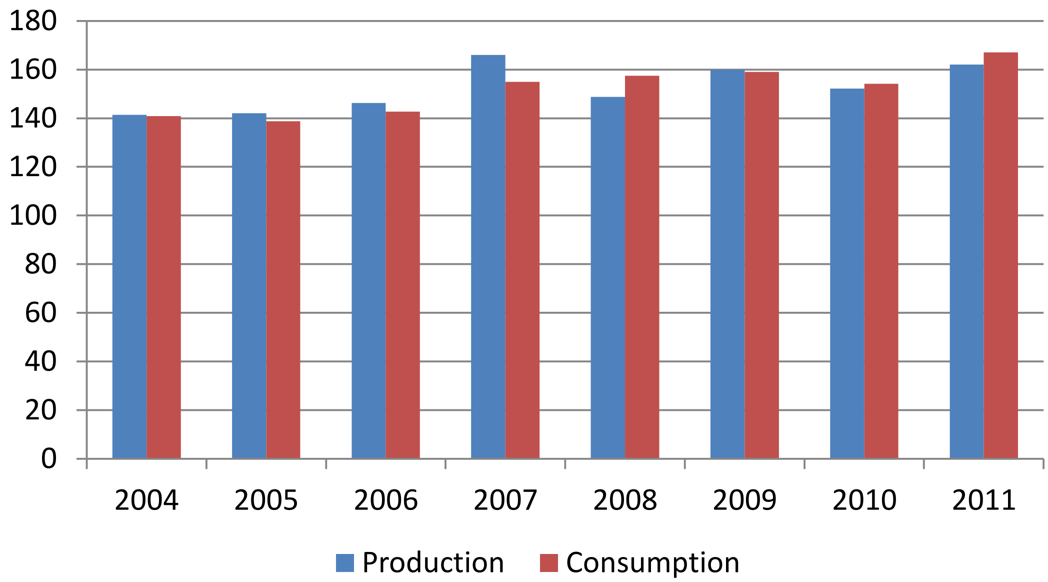


Figure 4-1 shows that global production of sugar is almost at par with consumption meaning that if bioethanol is to be produced from sugar cane or beet, global output has to be increased if demand is to be met at existing levels.

Sugar production levels and trade affect its global prices. A look at world market sugar prices show that they have been volatile in recent years, a general characteristic of agricultural products. Figure 4-2 shows the evolution of sugar prices from 2002 to 2010 in the EU, USA and world market.

Figure 4-2: EU, USA and World market sugar prices from year 2002 to 2010 (US cents per pound)

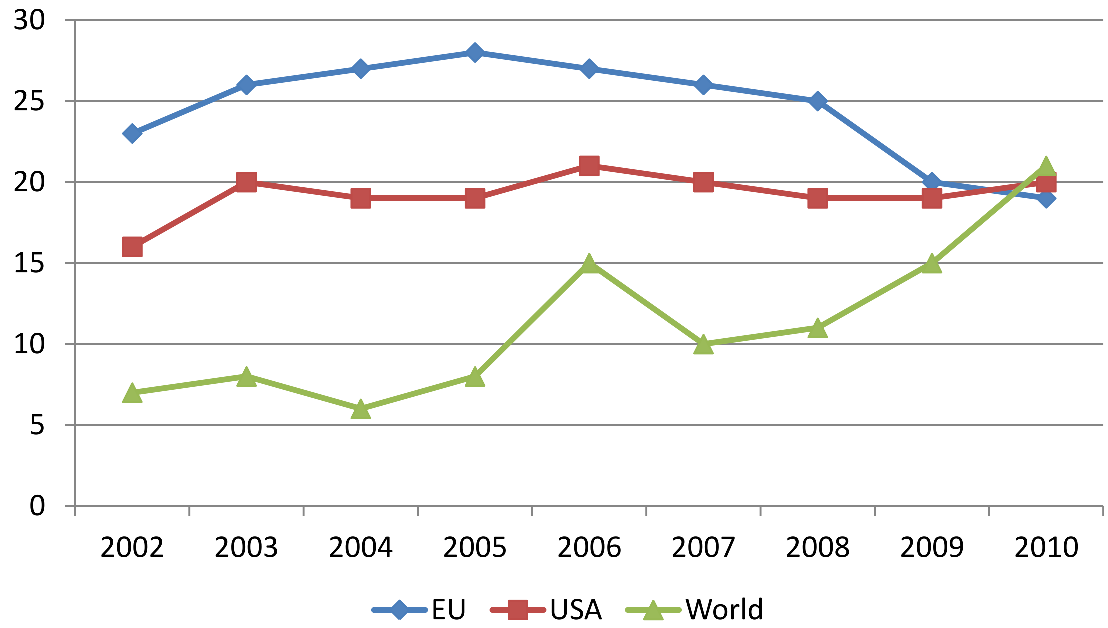
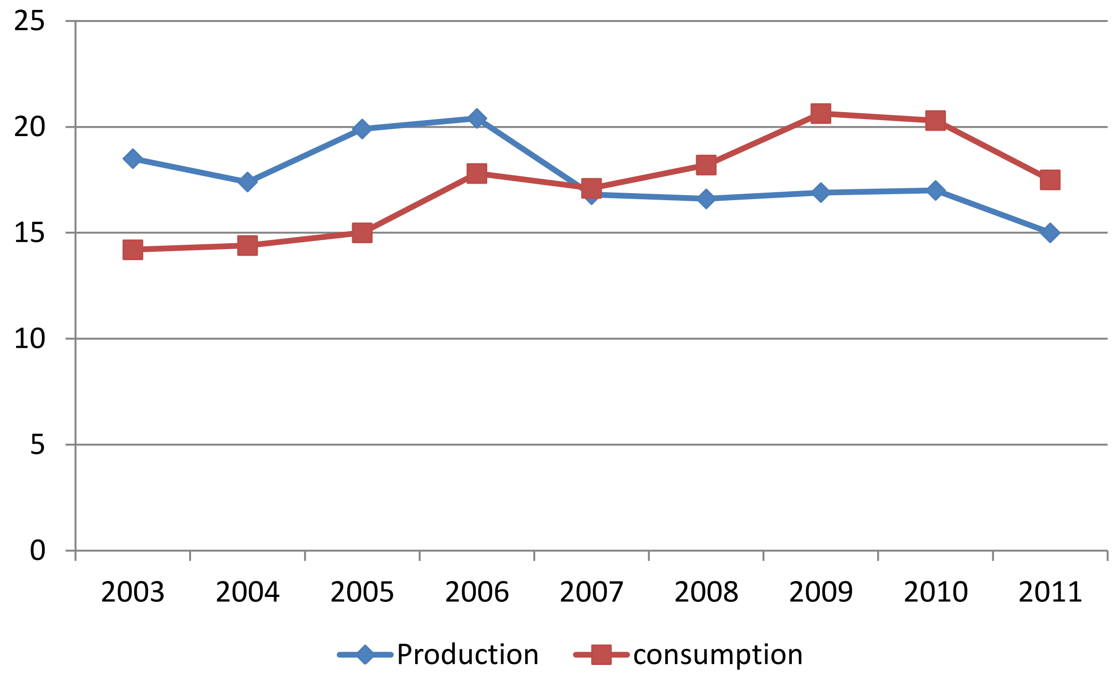


Figure 4-2 shows that the EU preferential prices for sugar have generally been above the USA and world market sugar prices. However, in 2010 the EU sugar prices dipped below those of the world and USA markets. USA sugar prices have genarally been flat at around 20 US cents per pound while those of the EU fell by almost 28% between 2008 and 2010. World market sugar prices have been on a steady increase from 2007, a factor that could be due to decreased EU output. Having reviewed the global sugar status we now analyse the sugar production, consumption and trade status specifically for the EU region.

4.1.1 The EU sugar market and trade status

Sugar in the EU region is produced from sugar beet unlike in the ACP member states where it is produced from sugar cane. Much as the EU is a high producer of sugar it is also a high consumer with production and consumption being almost at par. Figure 4-3 gives an overview of EU sugar production and consumption in recent years.

Figure 4-3: EU sugar production and consumption (million tonnes) from 2003 to 2011

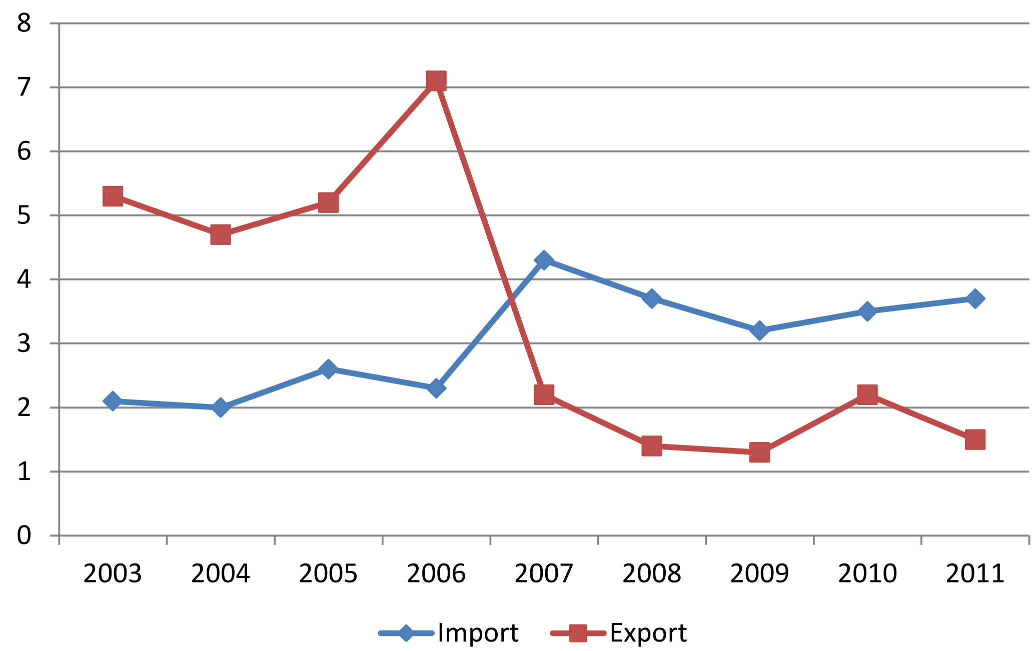


Source: USDA (2012)

Figure 4-3 shows that EU sugar consumption has been lower than production until 2006 where consumption started to be above production. Sugar production in the EU region is divided into quotas namely 'A', 'B' and 'C' quotas. Details on the EU sugar quotas will be discussed in section 4.4.1 of this chapter.

In terms of sugar trade, the EU is both an importer and exporter and these trade statistics are shown in Figure 4-4 below.

Figure 4-4: EU sugar import and export from 2003 to 2011 (million tonnes)



Source: USDA (2011)

Figure 4-4 shows that the EU has been a net exporter of sugar until after 2006 where imports started to surpass exports. This shows the effect of the 2006 sugar reform of price cut which resulted in decrease sugar production in the EU with consumption remaining elavated.

The EU sugar trade policies and international relations result in the region importing and re-exporting sugar to world markets. Most of the EU sugar imports come from ACP countries under the trade arrangements outlined in the sugar protocol and this will be discussed in more detail in Section 4.5 below. However, this EU sugar import and subsidised re-export has been challenged by other world sugar trading nations and has subsequently been ruled illegal by WTO.

Having reviewed the global sugar production and trade statistics, we now discuss policies that support sugar production in the EU region. As an agricultural commodity, sugar production is supported by the Common Agricultural Policy (CAP).

4.2 The CAP and its reforms

EU agriculture has been governed by the CAP since after the Second World War. The CAP came into existence in 1957, drafted by the European Commission from the Treaty of Rome that established the common market.[15] The objectives of the CAP as outlined in Article 39, Agriculture and Fisheries section of the Treaty of the European Union's Official Journal (2008) are the following;

(a) To increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of the factors of production, in particular labour;

(b) To ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;

(c) To stabilize markets;

(d) To assure the availability of supplies;

(e) To ensure that supplies reach consumers at reasonable prices.

Article 40 of the treaty then establishes the common organization of agriculture that takes the following forms depending on the product concerned:

(a) Common rules on competition;

(b) Compulsory coordination of the various national market organizations;

(c) A European market organization

Further, Article 40 sets out that the common organization will include measures to attain the following objectives: regulation of prices (with any common price policy based on common criteria and uniform methods of calculation), aids for the production and marketing of the various products, storage and carryover

[15]For a more detailed discussion of the establishment of CAP and its development please see *inter alia* Ackrill (2000)

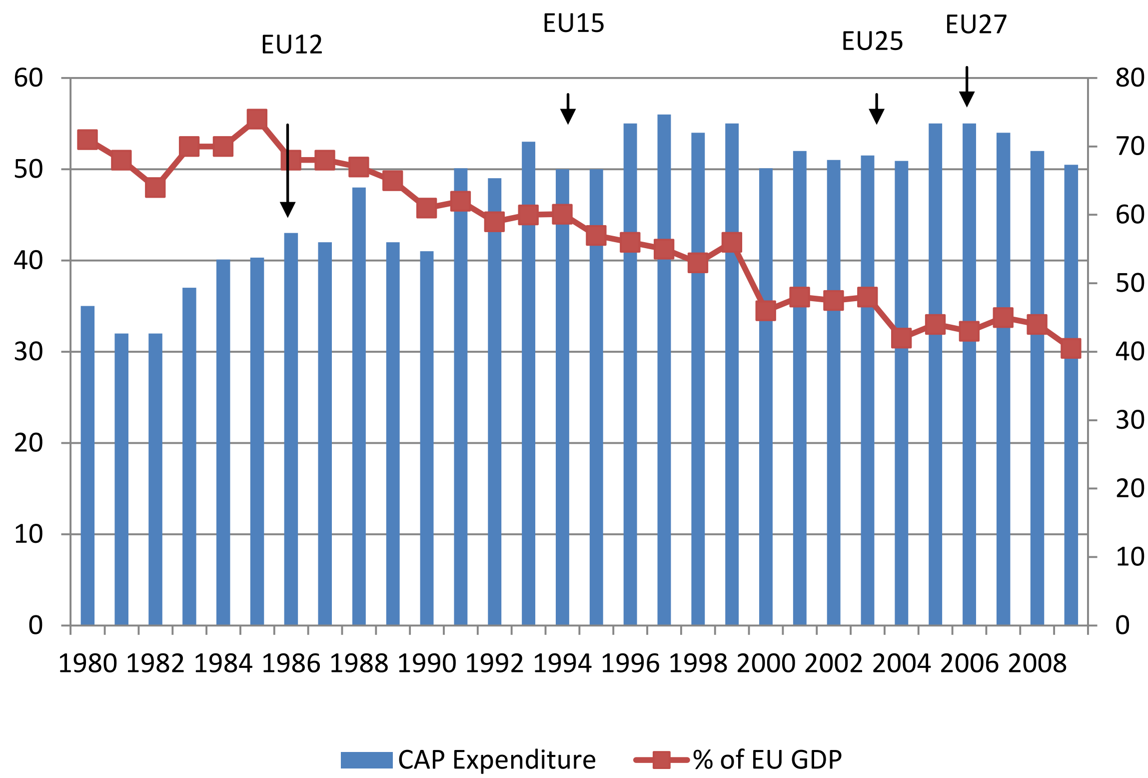
arrangements and common machinery for stabilizing imports or exports and non-discrimination between producers or consumers within the Community.

The CAP however covers mostly external products that have the potential to compete with local products within the EU. Thus, the overriding objective of the CAP is to protect the EU market from external competition. In order to achieve its mandates the CAP intervenes in markets using various means. These include application of import levies to bring world market prices to be at par with the prices that prevail in the EU, import quotas that limit the amount of goods that can be imported into the EU. However, specific exemptions enable some member states from developing countries to export certain products duty free into the EU market.

The EU also sets an internal intervention price for certain commodities and ensures that domestically, if their price falls below intervention prices, the EU will buy such commodities in order to raise their price to the intervention price level. The intervention price is set lower than the target price such that the prices of commodities in the EU vary between these two price levels. Market intervention also includes direct subsidies paid out to farmers, originally aimed at encouraging farmers to grow certain crops. There is also an arrangement for production quota and set-aside land payments to reduce overproduction of commodities such as milk, wine and grain. Currently, set aside land has been suspended following rising prices of some commodities and more interest in biofuel (Waterfield 2007).

The CAP is funded from EC buget and accounts for 40% of total EC expenduture (Overseas Development Institute –ODI, 2011). Figure 4-5 below shows the evolution of CAP expenditure and the share of this expenditure to total EU GDP.

Figure 4-5: CAP expenditure time path*



**Primary axis: CAP expenditure in billion Euros; Secondary axis: Expenditure as % of EU GDP*

Source: DG agri (2011)

Figure 4-5 shows that with continued CAP reform and the expansion of the EU, the CAP budget share as a percentage of EU GDP has been steadily declining from the 1980s to 2008.

The CAP has undergone a number of changes and reforms driven by the WTO trading rules and as a means to limit production and spending on farm subsidies[16]. One significant reform is the McSharry (named after Ray McSharry, agricultural commissioner at the time) reform of 1992 that was aimed at reducing increasing agricultural production. This reform reduced the levels of support by 29% for

[16] Please Ackril for details on these reforms

cereals and 15% for beef and introduced set aside land payments for land taken out of production and promoted forestation.

Another major reform to the CAP was the Agenda 2000 (”Agenda 2000: For a stronger and wider Union”). The Agenda 2000 was initiated in Madrid European Council at the end of 1995 following concerns of the EU financial systems in the light of the EU enlargement.[17] This EU enlargement was with the proposed addition of 12 new member states from the existing EU15 members.[18] The concerns that brought about the reform was that agriculture played a more important economic role in the new EU member states yet these states were relatively poorer that the EU15 members. This posed a problem of financing agricultural support for these new member states and the general administration of these finances. There was therefore a need to reform the CAP while maintaining production support and rural development under budgetary control. The changes in the CAP were thus aimed at achieving the following objectives (Pezaros, 1999):

- To improve EU agriculture competitiveness while lowering prices and improving the quality of agricultural products;
- To reduce agricultural output surpluses while protecting farm income;
- To give more emphasis to food safety and environmental protection;
- To make rural development part of the CAP and bring it under the agricultural budget;
- To improve the WTO negotiation power of the EU region;
- To accommodate the new comers within the existing EU budget;

[17] The Agenda 2000 was finally adopted in the Berlin Agreement of March 1999.

[18] The enlargement of the EU was with the proposed addition of 12 new member states into the EU15 and these 12 new members were namely Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Luxembourg, Malta, Poland, Romania, Slovakia and Slovenia.

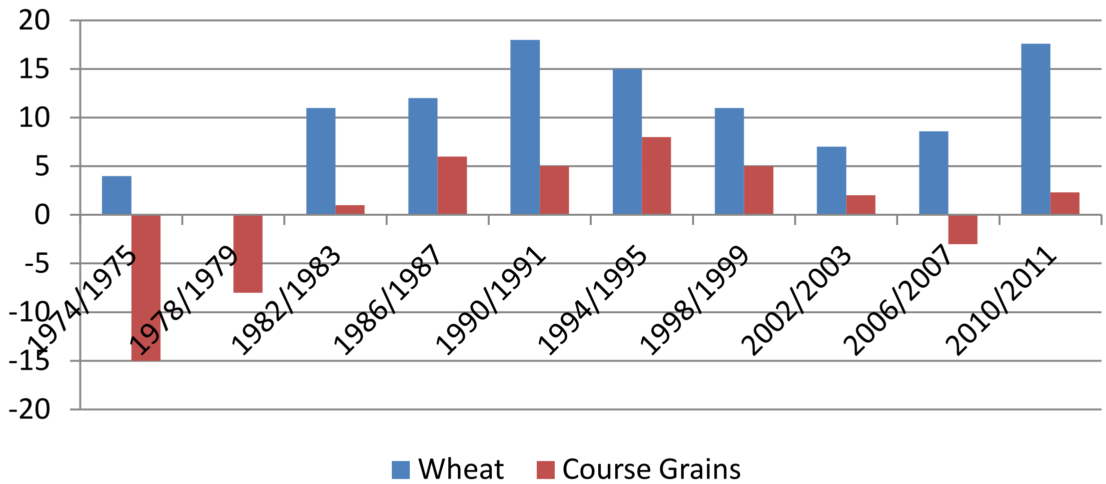
The proposed reforms of the Agenda 2000 did not therefore have a direct impact on EU sugar production and trade with ACP countries. However, it had a potential to affect cereal crops output in the EU region and thus the regions ability to produce bioethanol from bioethanol grain crops commodities.

In 2003, the CAP again underwent a major reform when the EU adopted a method of decoupling subsidies for certain crops. Such decoupled payments were subject to conditions, called cross compliance conditions related to environmental protection, food safety and animal welfare standards. Other reforms included the capping of the EU national budget for subsidies to control expenditure. The reform entered into force in 2004-2005 and member states were allowed to apply for a transitional period delaying the reform in their countries to 2007 and phasing in reforms up to 2012 (adapted from the EU website, 2012).

Continued CAP budgetary concerns also gave rise to the CAP health check of 2008. The CAP health check included changes in direct payments; phasing out of dairy quotas; and mechanisms that caused budget transfers from direct payments towards funding of rural development; and guidelines to deal with new challenges such as risk management, climate change and sustainable water management (Bureau and Mahé, 2005)

Despite its budgetary costs and subsequent reforms, the CAP has been an effective policy in supporting and promoting food production in the EU region. As has been noted by Andrews & Nelson (2001), in the late 1960s, the European Community was the largest grain-importing region in the world but by late 1970s the community had become a significant net exporter of cereals. Figure 4-6 below shows the EU cereal net trade on a four-year average from 1974 to 2011.

Figure 4-6: EU cereal net trade



Source: adapted from Andrews & Nelson (2001) and USDA database (2012)

Figure 4-6 shows that the EU has turned from being a net importer of course grains in the 1970s to being a net exporter by the 1980s. The figure also shows that net wheat export has increased from less that 10 million tonnes in the 1970s to almost 20 million tonnes in 1990s and has stayed elavated up to 2010. However, a binding EC bioethanol blend mandate policy is expected to increase demand for bioethanol crops meaning that the CAP need to be reformed further to take into account the need to produce biofuel crops in the region. In the next section we discuss in details the EU policies that has made the region a global leader in sugar production and trade.

4.3 The Common Market Organization[19]

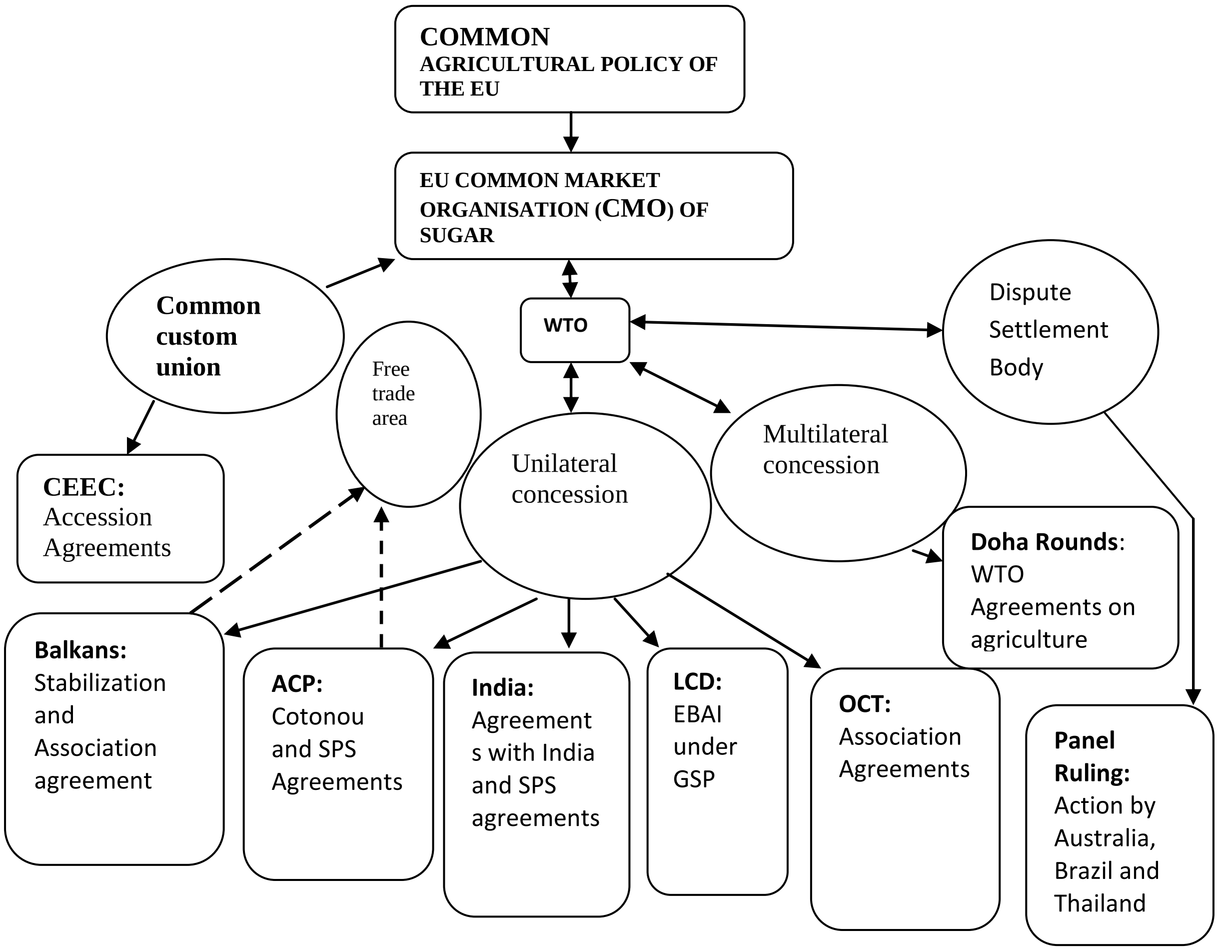
The sugar market in the EU is under the auspices of the Common Market Organization (CMO). The CMO was set up in 1968 as an integral part of the CAP and its main purpose was to guarantee sugar producers a fair income, to provide self-

[19]The initial discussion of the EU sugar regime covers the period up to June 2006 with most of the discussion sourced from the EC treaty on the Common Market Organization of 2004 report *AGRI/63362/*2004 where details on CMO can also be found. Reform to the policy that took place in the light of the WTO disputes after this date will be considered later.

sufficiency in sugar and to ensure that supplies reach consumers throughout the Community (OECD, 2007).

The goals of the CMO have pursued through the establishment of an intervention price which sugar producers in the EU receive but which also include internal production quotas and import controls. The EU intervention price is generally higher than the world market price and creates a floor price for EU sugar. The higher price of sugar in the community above the world price means that it is consumers that subsidize sugar producers since they pay prices above production costs. As with other agricultural trade policies, the CMO do not act in isolation but is linked to other policies. Figure 4-7 is a summary of the relationship between the CMO policy and other policies that support agriculture and trade in the EU region.

Figure 4-7: The CMO and related policies



Source: Huan-Niemi and Kerkelä (2005)

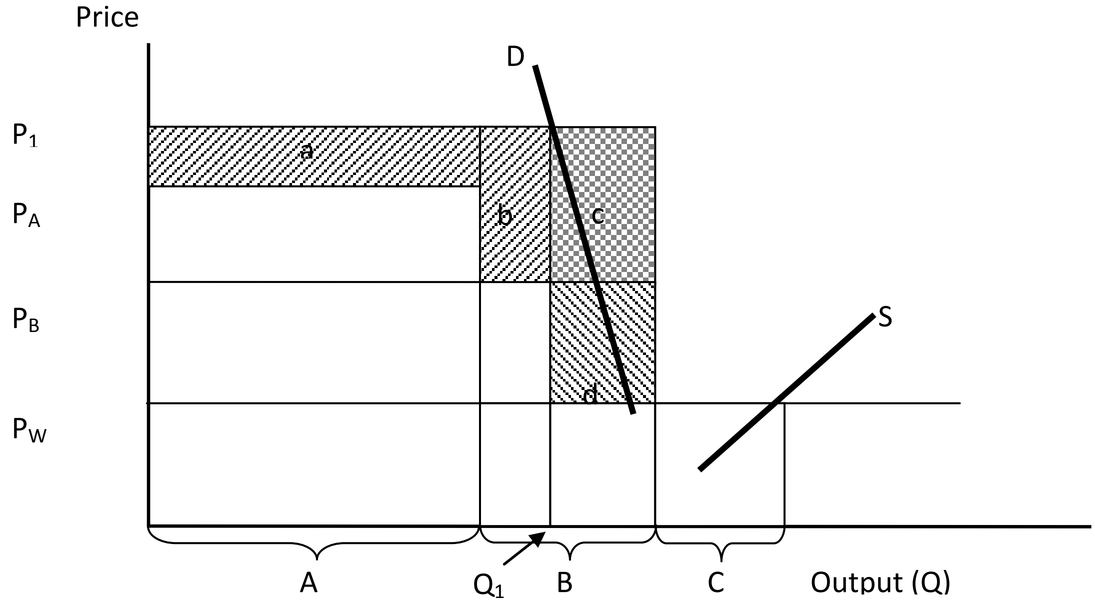
Figure 4-7 shows that the EU sugar policy as set out by the CMO is subject to other global policy interactions, with the main influence coming from the WTO concessions. As such, the EU sugar policies are expected to be aligned to WTO trade agreements. For example, the EPAs between the EU and ACP countries are attempts by the EU to comply with WTO trade protocols. Sugar production in the EU region, as promoted by the CMO is controlled through quota restrictions which we discuss next.

4.3.1 Production quotas

Sugar production in the EU region is subject to quota restrictions and three quotas are identified, namely the 'A', 'B' and 'C' quota. The 'A' quota was initially set for individual EU countries at the level of consumption while the 'B' quota allowed for cases of overproduction. The 'B' quota is allocated according to comparative advantage in sugar thereby allowing some specialisation by certain countries (Chaplin and Matthews, 2005). Production above the allocated 'A' and 'B' quotas forms the 'C' quota which is exported into the world market. 'A' quota sugar attracts a fixed levy of 2% of the intervention price, 'B' quota sugar face a variable levy of up to 37.5% of intervention price (dependent upon the cost of export refunds) while 'C' quota sugar is not eligible for intervention buying and is sold to the world market without subsidy (Milner, Morgan and Zgovu; 2003).

The different levies charged on the sugar quotas means that the sugar quota prices differ but are all related to the set intervention price. The EU sugar quotas price dynamics can be explained by Figure 4-8 below:

Figure 4-8: EU sugar quota mechanisms



Source : Milner, Morgan and Zgovu; 2003

In Figure 4-8, P_1 is the EU intervention price and P_A and P_B are the prices of 'A' and 'B' sugar quota output respectively. The price of 'A' sugar is higher than that for 'B' sugar because of the lower levy charged for 'A' sugar. 'C' sugar price is the same as the world market price P_W. If EU sugar consumption is at Q_1, which corresponds to the intersection of the EU sugar demand curve D and the intervention price P_1 it then follows that ($A+B-Q_1$) represents excess supply of 'A' and 'B' sugar output. Since excess supply of 'A' and 'B' quota is sold at the world market price, the revenue loss from this excess sugar production is shown by areas c+d in the diagram. This revenue loss must the covered by the revenue gain from the levies charged on 'A' and 'B' sugar production which is shown by the shaded areas a+b+c. Thus, if well balanced, the levies charged for 'A' and 'B' sugar production could be enough to cover excess production that is sold at the lower world market price.

With the integration of the ACP countries and India into the trading regimes, the 'A' sugar quota was calculated as the total consumption demand in the EU less projected imports from these countries. The ‘C’ sugar then, together with the exportable ‘A’ and ‘B’ quota from the EU and the preferential ACP and Indian imports makes the EU one of the leading global exporter of sugar.

Table 4.4 is a summary of the sugar quota distribution in the EU25

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Table 4.4: The quota distribution of sugar in the EU25 (2004)

Region (tonnes of white sugar)	A Quota	B Quota	Total
Czech Republic	441 209,0	13 653,0	454 862,0
Denmark	325 000,0	95 745,5	420 745,5
Germany	2 612 913,3	803 982,2	3 416 895,5
Greece	288 638,0	28 863,8	317 501,8
Spain	957 082,4	39 878,5	996 960,9
France (continental)	2 536 487,4	752 259,5	3 288 746,9
France Overseas Department	433 872,0	46 372,5	480 244,5
Ireland	181 145,2	18 114,5	199 259,7
Italy	1 310 903,9	246 539,3	1 557 443,2
Lativia	66 400,0	105,0	66 505,0
Lithuania	103 010,0	0,0	103 010,0
Hungary	400 454,0	1 230,0	401 684,0
Netherlands	684 112,4	180 447,1	864 559,5
Austria	314 028,9	73 297,5	387 326,4
Poland	1 580 000,0	91 926,0	1 671 926,0
Portugal	63 380,2	6 338,0	69 718,2
Autonomic regions of Azores	9 048,2	904,8	9 953,0
Slovakia	189 760,0	17 672,0	207 432,0
Slovenia	48 157,0	4 816,0	52 973,0
Finland	132 806,3	13 280,4	146 086,7
Sweden	334 784,2	33 478,0	368 262,2
*BLEU	674 905,5	144 906,1	819 811,6
United Kingdom	1 035 115,4	103 511,5	1 138 626,9
Total EU 25	14 723 213,3	2 717 321,2	17 440 534,5

Source: EC, 2004

*The Belgium Luxemburg Economic Union

Various other sweeteners compete with sugar in the EU region. Such sweeteners may be natural or artificial. Since these sweeteners compete with sugar, they affect the sugar market and trade. Examples of these sweeteners include iso-glucose that is an isomer of glucose. Since this sweetener became a strong competitor to sugar, the CMO in 1977 limited its production to 300 000 tones (EC, 2004). The point of interest here is the potential to increase the production of these alternative sweeteners that can have the effect of displacing sugar from the market and thus liberate the raw material for sugar production to the production of bioethanol.

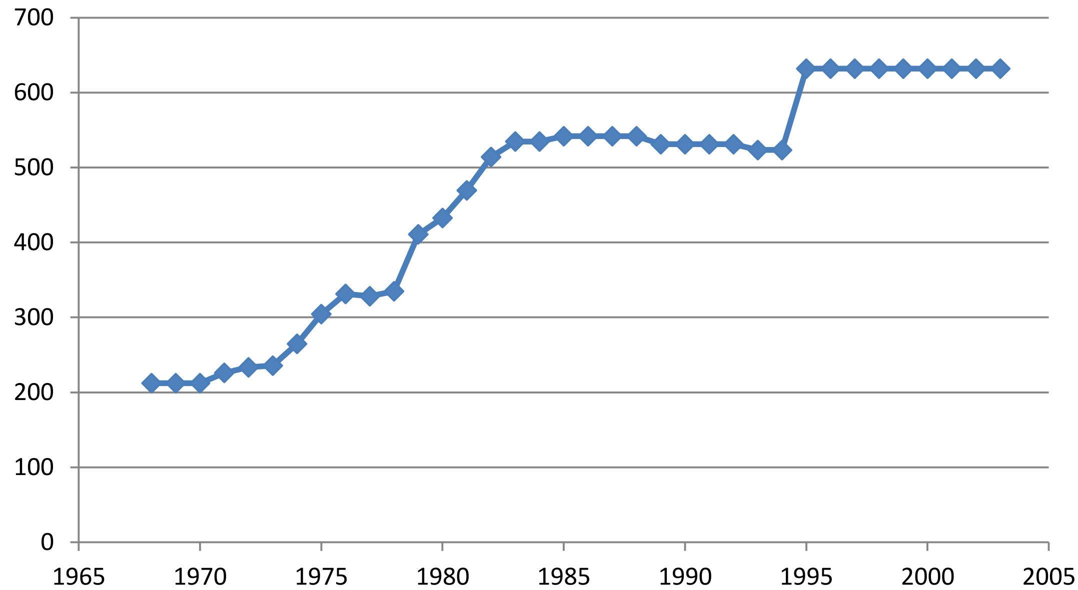
Sugar production also produces by-products of economic importance e.g. molasses. Molasses has high energy value and is used mainly for production of alcohol (e.g. bioethanol) and as an animal feed. Import duties also support the production of molasses in the EU. It is reported by the EC, 2004 that the community produces 4-5 million tonnes of molasses per year and imports about 3 million tonnes of cane molasses for animal feed. This means that converting molasses into bioethanol could directly affect the animal feed market and thus it can be expected to have an effect on the prices of food of animal origin. As production of bioethanol from grain crops produces Dried Distillers Grains (DDGs) which are used as an animal feed, this means that DDGs can potentially have an impact on molasses use as an animal feed in the EU region.

In the next section we discuss the EU sugar price structure that has made the region a global sugar producer and trader.

4.3.2 Sugar prices and levies

Price support for EU sugar involves an intervention price at which agencies in the region are required to buy eligible sugar delivered to them. Since 1993 it has been frozen at €631.90 per tonne for white sugar and €523.70 per tonne for raw sugar. Figure 4-9 below show the changes in the intervention prices of white sugar in the EU from 1968 to 2003 at constant exchange rate.

Figure 4-9: EU Intervention price for white sugar from 1968 to 2003 in €/tonne



Source: EC report, 2006

Figure 4-9 shows that the EU sugar intervention prices has steadily been increasing up to the early 1980s where it stabilized at around €533/ tonne. It was then increased in 1993 to €631.90/tonne where it has remained until 2006. This EU intervention price is at most times higher than the world market price for sugar as we have seen earlier in section 4.1 of this chapter. According to the EC (2004), the world market/intervention sugar price ratio, has been increasing from around 1:2 in the opening years of the organization 1:3 by 2004. This high EU artificial price of sugar is also benefiting the trading countries of the ACP. However, the proposed cut in the intervention price after 2006 has resulted in the EU sugar price dropping below the world price as we saw in Figure 4-2.

As we have seen in the previous section, sugar production in the EU region is subject to various levies that depend on the production quota. These levies become part of the Community budget after the Member States have withheld 25% in collection charges (EC, 2004). The calculation of the levies from the sugar quota allocation and consumption in the EU region has been discussed in section 4.4.1. The precise levy rates are determined each year by the Commission using production and consumption statistics and the average rate of the various Community refunds on sugar.

At the start of the CMO in 1968, sugar levies applied only to 'B' quota sugar, which represented the sugar that could be exported with refunds. However, the levies charged on 'B' sugar quota could no longer cover the cost of surplus sugar production with increase sugar output in the EU region and this therefore meant extending the levies to 'A' quota sugar.

The levies on the sugar quotas are applied as follows;

- A basic levy on all 'A' quota production at a fixed rate of 2% of the intervention price;
- A 'B' quota levy at a maximum rate of 37.5% of the intervention price;
- An additional levy that is imposed if the amount generated is still insufficient to cover the cost of surplus sugar. This levy is charged as a flat-rate percentage with no maximum being set so as to achieve the sum required.

Table 4.5 summarises the average levy arrangement in the EU sugar industry for the years 1990 to 2002.

Table 4.5: The average levy regime for the EU sugar industry from 1990 to 2002

LEVIES (€ per TONNE OF SUGAR)			SHARE (€ per TONNE OF SUGAR)	
A	B	AVERAGE A-B	MANUFACTURERS	PRODUCERS
13	238	53	22	31

Source: EC report, 2006

On levies applicable to international trade, the EU sugar market is protected by import duties that artificially increase the internal market price of sugar above that which prevail in the world market. The import duties started in 1968 and have been applied in accordance with the price of sugar in the world market.

These import duties are important to understand since they can potentially be used to protect the EU bioethanol market. However, these import duties have less significance when considering switching from trade in preferential sugar to bioethanol since preferential sugar is shielded from these import duties. Trade liberilisation policies in as far as sugar trade between EU and ACP countries abolish the quotas that is allocated to ACP countries. This means ACP countries can export sugar to the EU market without the restriction of quota. In theory therefore ACP sugar industries have a potential to expand according to how competitive they are and according to the sugar demand dynamics in the EU region. Policies that increase sugar demand in the EU region and those that abolish trade restrictions will be favourable to the development of ACP sugar industries.

The average price of raw cane sugar imports into the Community is stable at about €530 per tonne (Comext/Eurostat, 2006). This price is higher than the world market price for sugar and favours countries that export sugar to the EU market. Preferential sugar from ACP countries in particular benefits from this high priced EU sugar market. As Community production is in surplus, the raw cane sugar imported at a high price must be re-exported to the lower priced world market with an export refund to sugar traders to ensure profitability of the sector. This export refund mechanism makes the EU the second largest global exporter of sugar after Brazil. In cases where sugar prices in the EU region is less than that of the world market, the export refund becomes an export levy to ensure adequate amount of sugar in the region. In order for the refunds to reflect the true world sugar market prices, they are offered to traders after they bid for them in a tendering system.

In the next section we discuss the trade arrangements between EU and ACP countries. Some of these trade arrangements have helped made the EU a global sugar trader.

4.4 General trade agreements between the EU and ACP countries

There have been various trade protocols dating from the 1970s between the EU and ACP countries most of which are former colonies of various EU countries.[20] These ACP countries are former British, Dutch, Belgian and French colonies. Such trade protocols between the EU and ACP countries are therefore a form of aid for development in these former European colonies. These agreements basically offer duty free access to the EU market for certain ACP products in a quota arrangement at a guaranteed price known or preferential price for an indefinite period of time. Sugar produced by ACP countries has been one of the commodities entering the EU under these arrangements and which therefore had to be incooperated into Europe's CMO sugar. This guaranteed price is often above the world market price and as such, these trade agreements are an important source of foreign revenue for most ACP countries that could otherwise not break even if they were exporting at world market price. It is for this reason that sugar entering the EU under the preferential trade agreements has been the mainstay of many ACP economies. The two most significant trade agreements between the EU and the ACP member states had been the Lomé convention (together with its amendments) and the Cotonou Agreements.

[20] For details discussion on the developments of the trade agreements between the EU and ACP countries please see Morgan (2008).

The Lomé convention I was started in 1975 and included 46 ACP countries.[21] Its main aim was to enable preferential access for most of ACP agricultural and mineral exports to the EC free of duty. This preferential access was on an agreed quota system on selected products like beef and sugar. Besides this preferential access, the agreements also involved aid and investments in ACP member states.

The Lomé convention I was followed by the Lomé convention II of 1979 which included 58 ACP countries; the Lomé Convention III included 65 ACP countries and lastly the Lomé convention IV of 1989 which included 68 ACP countries and these were increased to 70 by 1995. In June 2000, the EU and 78 ACP countries entered into the Cotonou Agreement that included 48 African states. The Cotonou Agreement of June 2000 expired in 2008 and was a waiver given to ACP countries by WTO to replace the Lomé scheme.[22]

The Cotonou Agreement between the EU and ACP countries trade in Agricultural products stipulates, in article 1 of the General Trade Agreements: annex v, that; Products originating in the ACP States shall be imported into the Community free of customs duties and charges having equivalent effect;

(a) For products originating in the ACP States: listed in Annex I to the Treaty where they come under a Common Organization of the market within the meaning of Article 34 of the Treaty, or subject, on import into the Community, to specific rules introduced as a result of the implementation of the Common Agricultural Policy, the Community shall take the necessary measures to ensure more favorable treatment than that granted to third countries benefiting from the most-favored-nation clause for the same products.

[21] The Lomé Convention was the first trade and aid agreement signed between the EU and 71 ACP countries. It was signed in February 1975 in Lomé, Togo and is thus named after the capitial city of the host country.

[22] There have been other trade agreements between the EC and former African colonies like the Younde Convention of 1963 between EC and 18 African ex colonies and the Arusha convention of 1969 between the EC and the East African countries of Kenya, Uganda and Tanzania.

(Article 1 of the General Trade Agreements, annex v-The Cotonou)

The Cotonou agreement as mentioned has been signed by 78 ACP countries but only 19 of these are involved in the ACP/EU Sugar Protocol and these are namely: Barbados, Belize, Congo, Cote d'Ivore, Fiji, Guyana, Jamaica, Kenya, Madagascar, Malawi, Mauritius, St. Kitts and Nevis, Surinam, Swaziland, Tanzania, Trinidad, Uganda, Zambia and Zimbabwe.

The hallmark of all these trade agreements is their non-reciprocity and violation of the Most Favored Nations (MFN) clause of the WTO and as such they were only temporarily covered by a WTO waiver (specifically the Cotonou Agreement) provided by the Generalized System of Preference (GSP) which was previously known as the General Agreements on Tariff and Trade (GATT) which expired in December 2007 (Vollmer, 2009). The GSP or previously the GATT is a formal system that excludes certain member countries from the WTO MFN rules. The EPAs between the EU and ACP countries are as a result of the expiration of this WTO waiver. The next section discusses the EU and ACP trade agreements specific to sugar.

4.5 The ACP/EU trade agreements specific to sugar

Sugar trade between the EU and ACP countries has been guided by the sugar protocol agreements and agreements on special preference sugar. First, we review the ACP/EU sugar protocol arrangements.

4.5.1 The ACP/EU sugar protocol

Sugar trade between the EU and ACP countries has been guided by the ACP/EU Sugar Protocol, an agreement signed in 1975 and which allows a fixed quantity of sugar from ACP countries to enter the EU market at preferential prices for an indefinite period of time. The preferential price or guaranteed price is basically the same price as that received by the EU Community sugar producers. The EU sugar policy to support EU farmers therefore has also benefited ACP countries because of this sugar protocol agreement as the sugar price received by EU community sugar producers has been generally above the world market price. This ACP/EU sugar protocol is likely to have supported high cost ACP countries sugar producers who would not have survived if they exported at world market sugar prices. Thus for some high cost ACP sugar producers the EU market has more economic importance to them than low cost producers. In addition, as mentioned before, ACP sugar cannot compete with sugar from lower cost producers like Brazil. This makes bilateral trade policies that ensure and support trade between the EU and ACP important for these countries.

Table 4.6 below shows the ACP countries involved in this agreement and the quantities they are allowed to export to the EU at various periods.

Table 4.6: Sugar quotas of ACP Protocol countries

ACP Country	1975	2003/2004
Belize*	39 400	40 349
Congo	10 000	10 186
Ivory Coast	-	10 186
Fiji	163 600	165 348
Guyana	157 700	159 410
Jamaica	118 300	118 696
Kenya	5 000	0
Barbados	49 300	50 312
Madagascar*	10 000	10 760
Malawi*	20 000	20 824
Mauritius	487 200	491 031
Uganda	5 000	0
St. Kitts and Nevis	14 800	15 591
Surinam	4 000	0
Swaziland	116 000	117 845
Tanzania*	10 000	10 186
Trinidad and Tobago*	69 000	43 751
Zambia*	-	0
Zimbabwe	-	30 225
Total	1 279 300	1 294 700

Source: EC, 2004
* refers to LDC and ACP

Table 4.6 above shows that the allocated sugar quota of various SPS ACP countries has not changed by much from 1975 to 2004.

The Sugar Protocol between the EU and ACP countries states that;

'the [European] Community undertakes for an indefinite period to purchase and import, at guaranteed prices, specific quantities of cane sugar, raw or white, which originate in the ACP states and which these States undertake to deliver to it'
(Article 1 of the ACP/EU Sugar Protocol)

The EU regulation on the common organization of the markets in the sugar sector (No. 2038/1999) ensures that the Protocol quantities are irreducible even in cases where the Community has to reduce 'A' and 'B' production quotas on account of its Uruguay Round commitments.

Further, Article 1 of ACP/EU Sugar Protocol is reflected in Cotonou Agreement which states that;

'In accordance with Article 25 of the ACP-EEC Convention of Lomé signed on 28 February 1975 and with Protocol 3 annexed thereto, the Community has undertaken for an indefinite period … to purchase and import, at guaranteed prices, specific quantities of cane sugar, raw or white, which originates in the ACP States producing and exporting cane sugar and which those States have undertaken to deliver to it.'

(Article 13 of Annex V: Trade Regime Applicable During the Preparatory Period)

ACP guaranteed prices are negotiated annually between the EU and the ACP states signatory to the Sugar Protocol, 'within the price range obtaining in the Community, taking into account all relevant economic factors' (Article 5(4) of the ACP/EU Sugar Protocol).

Generally, the ACP states receive the same price as Community sugar producers. This is because the Community has always linked the guaranteed price for ACP raw cane sugar to the intervention price for EU produced raw sugar, and the guaranteed price of white sugar to the derived intervention price in the UK. The level of the guaranteed price is that at which, 'the Community undertakes to purchase, within the agreed quantities, preferential sugar which cannot be marketed in the Community at a price equivalent to or in excess of the guaranteed price.' (Article 5(3) of the ACP/EU Sugar Protocol).

'Indefinite duration' in the Protocol gives legal guarantee to ACP sugar supplying states and reflects the commitments of the EC to these trade arrangements.

However, the sugar protocol, though related to the traditional trade agreement between the EU and ACP countries (Lomé and Cotonou) was made independent of them. This means that the sugar protocol could be amended independently without violation of the broader trade agreements.

All the guarantees contained in the Sugar Protocol are also enshrined in the IVth Lomé Convention which, in its Article 213, reiterates the commitments undertaken in terms of the Protocol, notably the indefinite duration of the Protocol, the non-applicability of the safeguard clause under Article 177 of the Convention, and the fact that should the Convention be terminated, measures must be taken to secure the continued application of the Sugar Protocol.

The above provisions, both under the Sugar Protocol and reinforced under the Lomé Convention guarantees that the application of the Protocol is for an indefinite period. However, the sugar protocol between the EU and ACP countries was updated to include the Agreement on Special Preferential Sugar, which we now discuss.

4.5.2 The agreement on Special Preferential Sugar (SPS)

Sugar import into the EU from ACP countries is also subject to the SPS protocol, which we discuss next. Most of the information is adapted from the ACP sugar group website (http://www.acpsugar.org/SPS.html). The SPS agreement came into existence with the aim of supplying raw sugar deficit of Portugal and Spain. Entry of these two countries into the EU in 1986 therefore resulted in the need to refine existing sugar protocols with the introduction of a Maximum Supply Need (MSN) aimed at setting a ceiling to the amount of sugar that could be imported to the EU.

The SPS agreement with ACP states was reached on 1 June 1995, and, like the ACP/EU Sugar Protocol, it is a government-to-government agreement, but unlike the Protocol, it is of a fixed duration and the ACP states are liable to supply the quantities of sugar covered by the SPS agreement. The SPS agreement was for an initial period of six years and is as outlined below:

'the European Community undertakes to open annually a special tariff quota for the import of raw cane sugar for refining which originates in ACP states, on the basis of the needs determined by the Commission in accordance with paragraph 3 ("bilan"), and the ACP states undertake to supply the said quantities under conditions fixed by this agreement and by the measures taken by the Commission for the application of this agreement within the framework of the management of the common organization of the markets in the sugar sector.'
(http://www.acpsugar.org/SPS.html)

According to a report by Berkum et al (2005), the SPS amount is the difference between the MSN and sugar imports from French Overseas Departments (DOM), those under the ACP/Indian quotas, the MFN sugar quotas and, more recently, the Everything But Arms Initiative (EBAI) sugar import quota. No import duty is paid on the SPS sugar, which receives €496.8 per tonne (EU support price for raw sugar minus a refining aid of €26.9 per ton). Further, Berkum et al (2005) noted that following the EBAI, the volume of SPS sugar has been reduced to about 217,000 tonnes in 2002-03 with further reductions in the volume of SPS sugar expected due to increases in EBAI quotas and possible cuts in the MSN.

The possible effects of a binding EC bioethanol blend mandate policy therefore is to act against reduction in the MSN sugar. This is possible due to the likely increase in demand for sugar in the EU27 region as more sugar beet is diverted to bioethanol production. Gotor (2009) noted that nearly 60 percent of all SPS sugar supplies came from the SADC countries, with Swaziland, Zimbabwe and Malawi being priority suppliers. Table 4.7 shows the ACP Sugar Protocol (SP) and ACP SPS sugar quota allocations for the years 2002-2004 and the respective ACP country sugar production average.

Table 4.7: ACP SP and SPS sugar quotas and average production levels (in tonnes white sugar equivalent)

Countries	**SP quota allocation (2003/04)**	**SPS quota allocation (2002/03)**	**Production, average (2001/03)**
Barbados	32,097	0	40,000
Belize	40,349	5,527	105,000
Congo	10,186	2,249	41,000
Cote d'Ivoire	10,186	9,704	144,000
Fiji	165,348	21,060	304,000
Guyana	159,410	17,111	282,000
Jamaica	118,696	18,894	164,000
Kenya	5,000	10,908	418,000
Madagascar	10,760	0	36,000
Malawi	20,824	9,897	222,000
Mauritius	491.031	21,266	545,000
Mozambique	6,000	0	140,000
St. Kitts	15,591	0	19,000
Swaziland	117,845	45,030	569,000
Tanzania	10,186	2,183	159,000
Trinidad	43,751	5,658	82,000
Zambia	7,215	12,863	203,000
Zimbabwe	30,225	29,948	489,000
Total	*1,294,700*	*217,298*	*3,962,000*

(Berkum et al 2005)

Table 4.7 above shows that the SP sugar quota is generally higher that the SPS sugar quota for most of the ACP member states. It is also seen that the importance of the EU sugar market differs for the different ACP sugar protocol countries in that their

EU export as a percentage of total sugar production vary as we will see in section 4.7.

In summary therefore, prior to 2006, sugar from ACP countries entered the EU market under three trading agreements, which are the EBAI for LDCs, the ACP/EU Sugar Protocol, and the SPS agreement. The complete classification of countries into whether they are ACP members, ACP/LDCs, ACP/EU SPS or ACP/EU SPS/LDCs is shown in Table 4.8 below:

Table 4.8: Summary Classification of ACP countries and trade arrangement with the EU

ACP Country	**ACP/LDCs**	**ACP/EU SPS**	**ACP/EU SPS/LDC**
Angola	Angola	Barbados	Madagascar
Antigua and Barbuda	Benin	Belize	Malawi
Bahamas, The	Burkina Faso	Congo	Mauritania
Barbados	Burundi	Cote d'Ivore	Tanzania
Belize	Cape Verde	Fiji	Uganda
Benin	Central African	Guyana	Zambia
Botswana	Chad	Jamaica	
Burkina Faso	Comoros Islands	Kenya	
Burundi	Congo, Democratic	Madagascar	
Cameroon	Djibouti	Malawi	
Cape Verde	Equatorial Guinea	Mauritius	
Central African Republic	Eritrea	St Kitts and	
Chad	Ethiopia	Surinam	
Comoros	Gambia	Swaziland	
Dem. Rep. of Congo	Guinea	Tanzania	
Congo	Guinea-Bissau	Trinidad	
Cook Islands	Haiti	Uganda	
Cote d'Ivoire	Kiribati	Zambia	
Djibouti	Laos	Zimbabwe	
Dominica	Lesotho		
Dominican Republic	Liberia		
Equatorial Guinea	Madagascar		
Eritrea	Malawi		
Ethiopia	Mali		
Fiji	Mauritania		
Gabon	Mozambique		

Gambia	Niger		
Ghana	Rwanda		
Grenada	Samoa		
Guinea	São Tomé & Principe		
Guinea-Bissau	Senegal		
Guyana	Sierra Leone		
Haiti	Solomon Islands		
Jamaica	Somalia		
Kenya	Sudan		
Kiribati	Tanzania		
Lesotho	Togo		
Liberia	Uganda		
Madagascar	Vanuatu		
Malawi	Zambia		
Mali			
Marshall Islands			
Mauritania			
Mauritius			
Micronesia, Federated			
Mozambique			
Namibia			
Nauru			
Niger			
Nigeria			
Niue			
Palau			
Papua New Guinea			
Rwanda			
Saint Kitts and Nevis			
Saint Lucia			
Saint Vincent and the			
Samoa			
Sao Tome and Principe			
Senegal			
Seychelles			
Sierra Leone			
Solomon Islands			
Somalia			
Sudan			
Suriname			
Swaziland			

Tanzania			
Timor Leste			
Togo			
Tonga			
Trinidad and Tobago			
Tuvalu			
Uganda			
Vanuatu			
Zambia			
Zimbabwe			

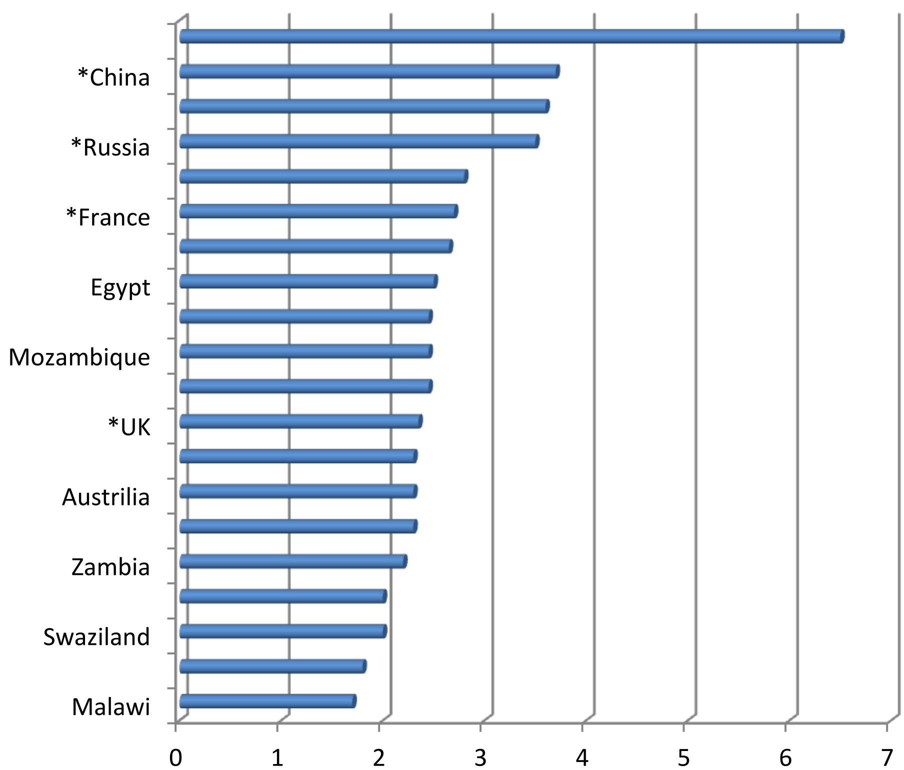
In a nutshell therefore, these various trade agreements and the internal EU sugar policies have been important determinants of the price that ACP countries receive for their sugar and the quantities they are eligible to export to the EU sugar market. As such, these policies and trade arrangements have historically affected sugar production decisions in ACP countries and have played an important role in the economic development of these states. This again highlights the importance of the EU sugar policies and possible developments on EU sugar markets for ACP countries. This means that for ACP countries, future production decisions and trade potential hinges on understanding EU policy developments and trade protocols in that region. In this light, we next discuss the ACP sugar markets with the aim of understanding the potential impact on ACP sugar sector of policies that affect international sugar markets especially the EU sugar regime.

4.6 ACP sugar industries

Since our thesis focus is on the effect of the EC bioethanol blend mandate policy with special emphasis on ACP sugar production and trade, we will discuss in details the sugar sectors of ACP countries that had a traditional sugar trade arrangement with the EU. Only 18 ACP members are beneficiaries of the ACP/EU sugar protocols. These include six member states of the Caribbean, which are Barbados, Belize, Guyana, Jamaica, St. Kitts-Nevis, and Trinidad & Tobago. The African beneficiaries are namely Congo, Cote d'Ivore, Kenya, Madagascar, Malawi, Mauritius, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe while Fiji is the only Pacific member.

Sugar production in the ACP region dates back to the first human settlements thanks to the favourable climatic conditions for growing sugar cane. The favourable climatic conditions mean most of the ACP regions have a competitive advantage in sugar production as seen in Figure 4-10 below.

Figure 4-10: Relative sugar production cost for period 2006-2010



Source: Illovo (2010)
*refers to sugar beet production, rest is sugar cane.

According to Figure 4-10 Malawi, in Southern African is the lowest cost sugar cane producer ahead of Brazil. Many countries in Southern Africa and which are part of the ACP sugar protocol are also low cost sugar producers and these countries include Swaziland, South Africa, Zambia and to a lesser extent Zimbabwe and Mozambique.

Generally, the Southern African region is more competitive in sugar production that the Caribbean and the Pacific. This observation is supported by an Oxford Policy Management study (2003) which analysed the impact of erosion preferences on ACP sugar viability based on production costs. Their study outcomes divided ACP sugar producers into three distinct groups when comparing sugar industry profitability pre and post reform as follows;

- Countries where sugar production will still be viable under pre-reform industry structure or restructuring plans: Congo, Malawi, Swaziland, Tanzania, Zambia and Zimbabwe;
- Countries where sugar production is potentially viable if restructuring beyond pre-reform plans is undertaken: Fiji, Guyana, Mauritius; and,
- Countries where sugar production will be no longer be viable under any circumstances: Barbados, Belize, Cote d'Ivoire, Jamaica, Madagascar, St Kitts, and Trinidad and Tobago.

It is apparent therefore that most Caribbean countries are less efficient in sugar production compared to the rest of ACP countries. However, this observation notwithstanding, most ACP countries are also endowed with cheap labour and land such that their sugar production potential is still high should favourable policies that increase sugar demand in global markets come into force. Sugar production in the ACP region has also been encouraged by increased trade in international markets, mostly under the preferential trade agreements with the EU region as we have discussed in section 4.6.

International trade in sugar has made it an important commodity for most of ACP member states as seen by its contribution their GDP (please see Table 1.1 of the introduction chapter). As an example, in 2003 sugar generated over 17% of GDP in

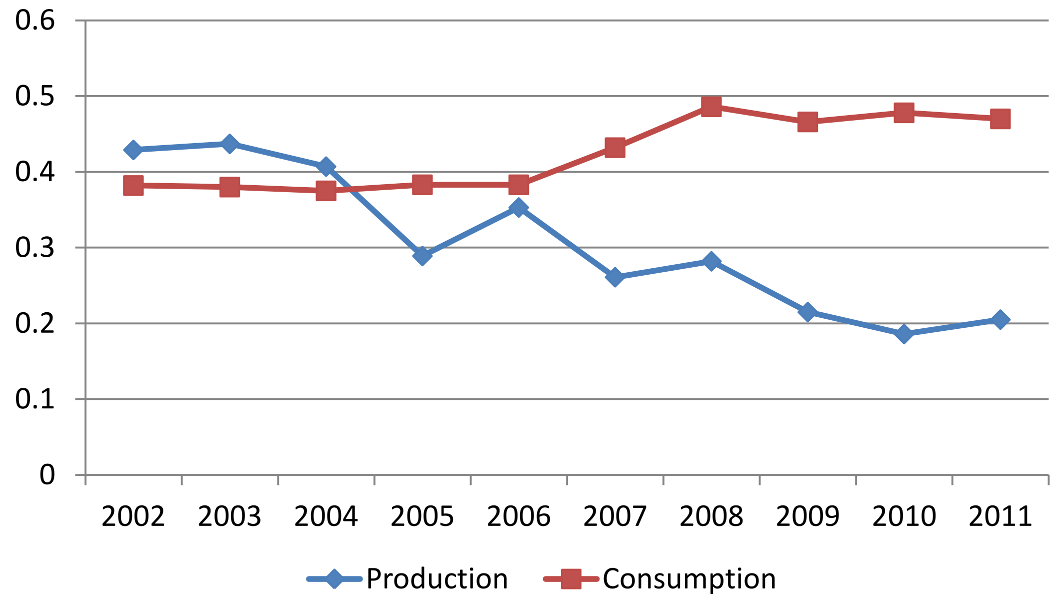
Guyana and 24% in Swaziland, while in Fiji sugar production was responsible for over 90% of agricultural output (ACP sugar group, 2005). ACP trade in sugar dates back to the 16th and 17th centuries with an increase in cane production in European colonies firstly in the Caribbean, South American and later in the Southern Africa region for export to Europe. However, repeated rebellions in the colonies during the late 1700s and early 1800s and disruption in supplies encouraged European countries to establish their own sugar industries and through subsidised sugar beet production (Mitchell, 2004).

However, bilateral trade between the EU and ACP countries is still in existence as we have seen. As has been alluded to, ACP sugar industries remain key to sustaining many ACP economies. Developments and policies that have the potential to affect global sugar markets are therefore of direct interest to most ACP member states. To give an overview of the ACP sugar industries we start with the Caribbean region.

4.6.1 The Caribbean sugar industries

The Caribbean sugar industry, as in other ACP regions, is an important foreign revenue earner and employer of skilled and non-skilled labour. According to Ahmed (2001), the Caribbean industry employed approximately 150,000 workers in 2000. However, Ahmend (2001) noted that the deregulated foreign exchange market resulting in increased prices of imported inputs like fertilizers, pesticide and irrigation material makes sugar production in the Caribbeans expensive. Sugar production in the Caribbeans forms a small portion of world production and has been on the decline in recent years as shown in Figure 4-11 below.

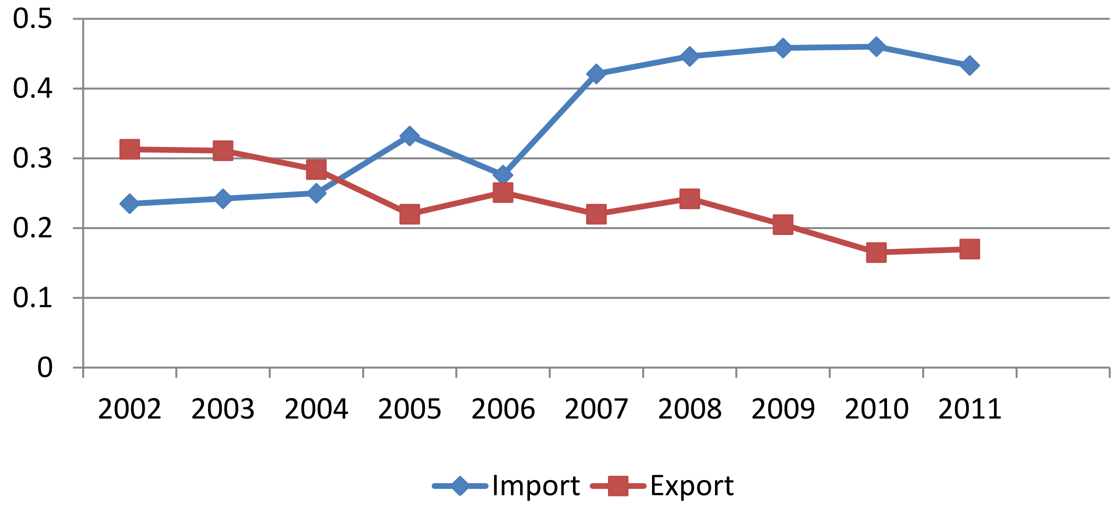
Figure 4-11: Caribbean Sugar production and consumption (millions of tonnes raw sugar equivalent)



Source: USDA database (2011)

As can be seen in Figure 4-11 above, sugar production in the Caribbean started to decline from 2006 while consumption stayed elevated and above production. Annual sugar production in the Caribbean averaged 0.2 million metric tonnes in 2011, which was only 0.1% of global sugar production. The decline in production corresponded with increase in imports and decrease in exports as seen in Figure 4-12 below.

Figure 4-12: Caribbean sugar import and export (million of tonnes raw sugar equivalent)



Source: USDA database (2011)

The recent developments in the Caribbean sugar industry therefore shows the effect of the EU sugar reform of 2006 that negatively affected sugar production in the region and increased imports. Such sugar reform has resulted in St. Kitts and the Nevis going out of sugar production completely. The EU market affects ACP countries differently depending on how much of their sugar production is exported to that market. Generally, Caribbean countries, besides being relatively higher cost producers, exported a higher percentage of their sugar to the EU markets. Figure 4-13 below shows the sugar production and export to the EU market of the various sugar protocol countries in 2003, before the sugar reform.

Figure 4-13: Sugar production and export to EU for ACP sugar protocol countries in 2003

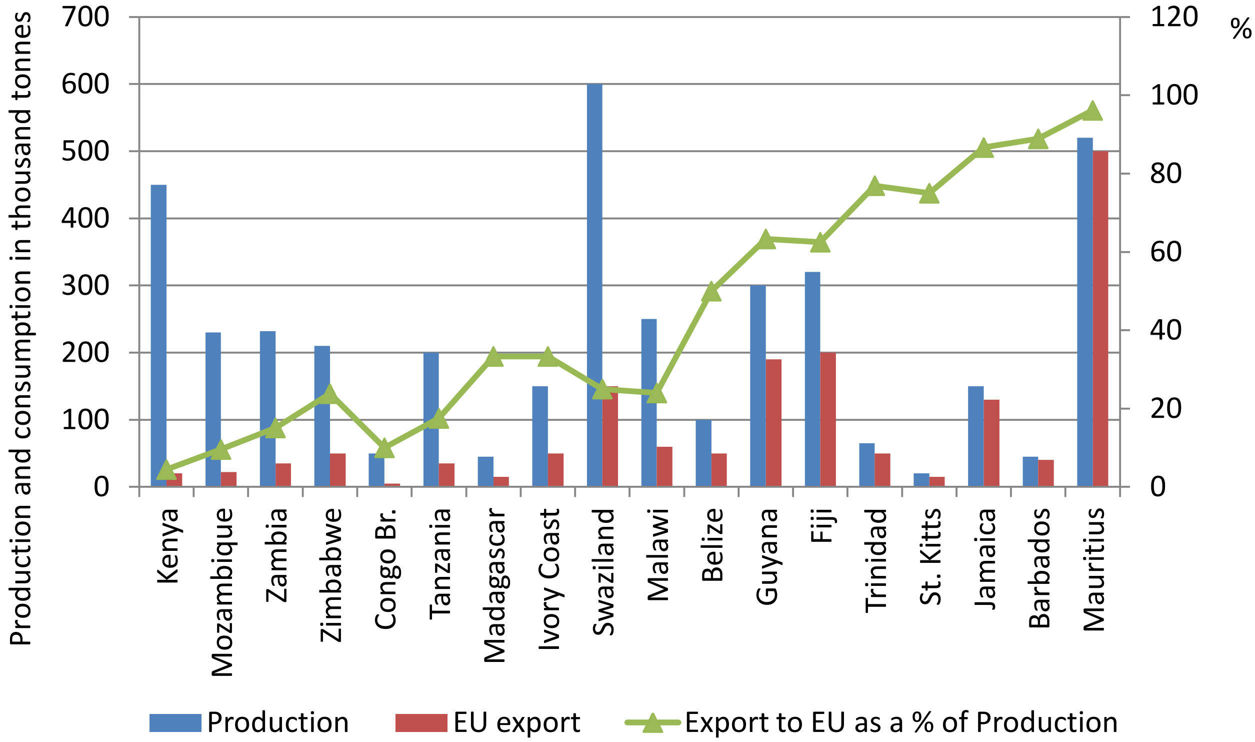


Figure 4-13 above also shows that most members of the Southern African Development Community (SADC) countries export a lower share of their sugar output to the EU market.[23] This means that, besides being relatively lower cost sugar producers, they are expected to be less affected by the EU sugar reform compared to the Caribbean countries and Fiji in the Pacific. As such, policies that affect the EU sugar market will have different effect on the various ACP sugar industries. The heterogeneity in the ACP sugar sector therefore makes it important to disaggregate the ACP regions into various trading blocs when analysing policies

[23]The SADC region is made up of 15 member states which are: Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

that affect their industries. The EC bioethanol blend mandate policy, which will increase sugar demand in the EU region, is also expected to affect the production and export profile of these countries' sugar sectors differently depending on the importance of the EU market to their sugar industries. It is the aim of this research to determine how this export profile will change at regional level and specifically for the SADC region as compared to the rest of the ACP region.

Next, we analyse the sugar industries of the African member states. Our emphasis will be on the SADC countries that form part of the ACP/EU sugar protocol for two reasons. Firstly, as we have seen, most of the SADC countries have a competitive advantage in sugar production. In this way, sugar will most likely remain an important commodity for this region. Secondly, the SADC region has an agenda to liberate trade amongst themselves and ultimately form a common market. In this way, policy outcomes that are likely to affect their important industries are informative as a way of guiding their future developmental plans. Despite the fact that the EU sugar market is not as important to SADC region as it is for the Caribbean member states, SADC countries will likely continue trading with the EU given their relative competitive advantage in sugar production.

Further, the EU is a global player is sugar trade and changes in its sugar market will be transmitted to the world market where SADC countries also trade. As such, the EC bioethanol blend mandate policy is expected to affect SADC sugar industries (directly and indirectly) and it is important to analyse such possible effects. Our interest therefore is on the sugar industries of the SADC trading block, most of which are also signatories of the SPS sugar arrangement with the EU.

4.6.2 The African/SADC sugar industries

The SADC region's sugar production originated in the latter part of the eighteenth century on the physically and politically distant Indian Ocean island of Mauritius (Lincoln, 2006). International trade and the favourable conditions for sugar cane production in most of the region have seen the SADC sugar industry grow to play a crucial economic role. Table 4.9 below show sugar cane production and area harvested in 2010 for selected SADC sugar cane producing countries.

Table 4.9: Sugar cane production in SADC region in 2010

SADC country	Production (x 1000 tonnes)	Area Harvested (Ha)	Tonnes/Ha
Angola	360	95000	3.8
DRC	1827	40000	45.7
Madagascar	3000	95000	31.6
Malawi	2500	23000	108.7
Mauritius	4366	58709	74.4
Mozambique	2800	215000	13.0
South Africa	16016	267000	60.0
Swaziland	5000	52000	96.2
Zambia	4050	38500	105.2
Zimbabwe	3100	39000	79.5

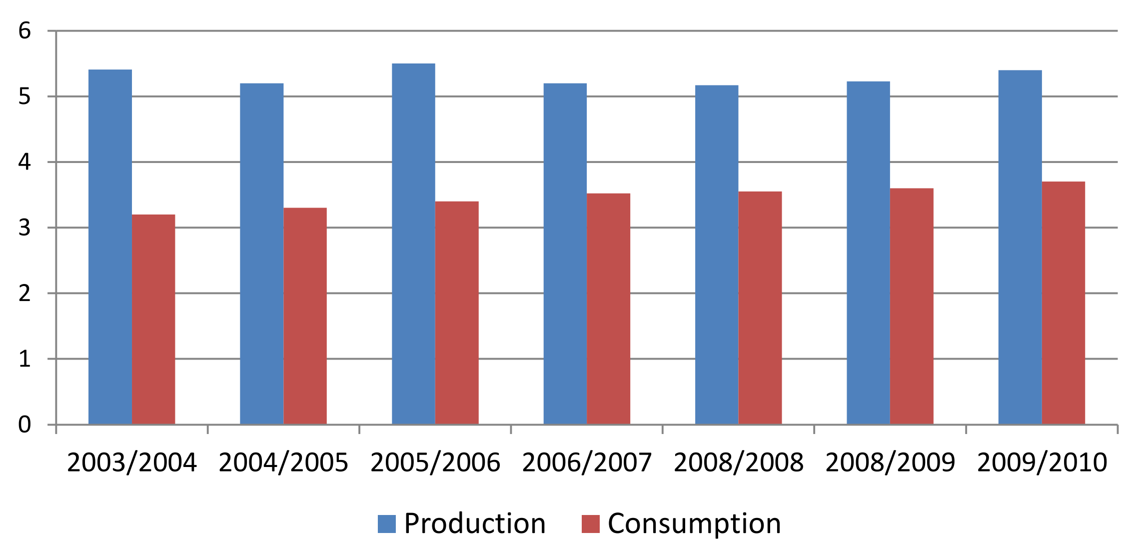
Source: FAO (2012) and author calculation

With reference to Table 4.8, Angola and Mozambique are not part of the EU/ACP SPS but are included because they are part of SADC. Likewise, South Africa is not part of the SPS *per se* but has a free trade agreement with the EU under the Trade and Development Cooperation Agenda (TDCA), which for sugar has similar effect as the duty free SPS sugar from ACP countries. Being members of a trading block, it is reasonable therefore to class South Africa as part of the SPS SADC countries. However, with the coming into force of the EPAs, the SPS sugar arrangement of ACP countries with the EU becomes invalid but the sake of simplify our analysis we will concentrate on analysis of countries that had a previous SPS arrangement with the EU and which are part of a regional trading bloc.

Table 4.9 shows that individual SADC countries have different sugar cane production efficiency and this highlights a within region heterogeneity. It can be seen that Malawi, Swaziland and Zambia are the three most efficient sugar cane producers in the region as they produce more sugar cane per hectare while Angola, because of its dry weather conditions, is the least efficient sugar cane producer. Efficient sugar cane producers are relatively more likely to expand their industries should policies that increase global sugar demand come into existence.

Total SADC sugar production and consumption from selected members of SADC (which are South Africa, Zimbabwe, Malawi, Swaziland, Zambia, Tanzania, Mauritius and Mozambique) are summarised in Figure 4-14 below for the years 2003/2004 to 2009/2010.

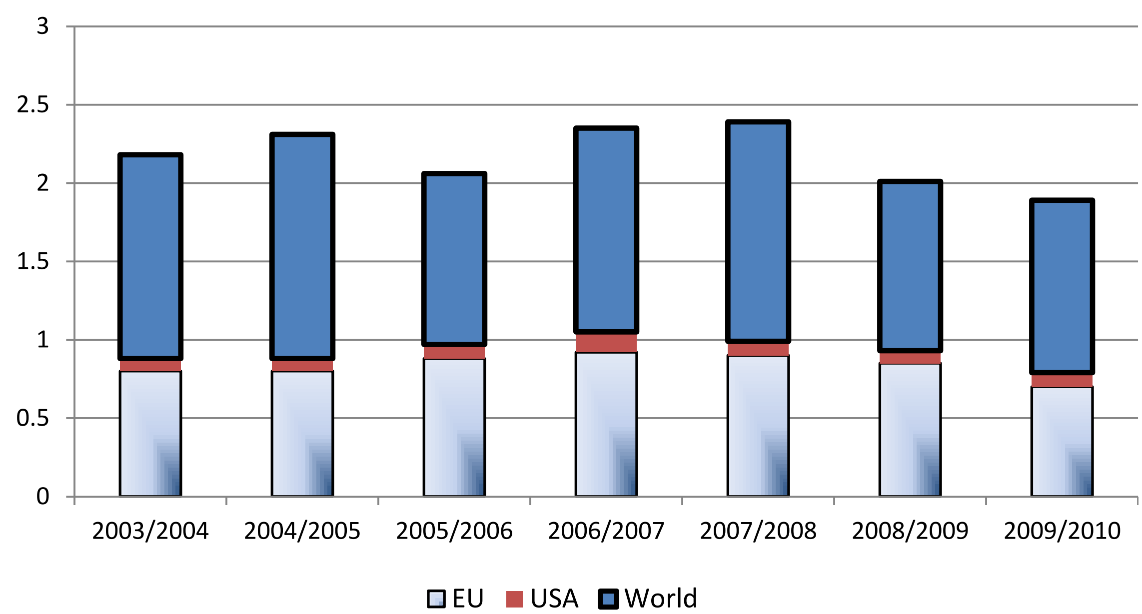
Figure 4-14: SADC sugar production and consumption (million tonnes raw sugar equivalent)



Source: Illovo annual report, 2010

Figure 4-14 above shows that SADC sugar production has been almost stable with an average annual output of 5.3 million tonnes for the years 2003 to 2010. Consumption has shown a slight but steady increase with an annual average of 3.4 million tonnes raw sugar equivalence for the same years. Since production has persistently outstripped consumption, the region remains a net exporter of sugar. Figure 4-15 shows the export destinations of SADC sugar.

Figure 4-15: SADC sugar export markets destinations (millions tonnes raw sugar equivalent)



Source: Illovo annual report (2010)

Figure 4-15 above shows that most SADC sugar is exported into the world market. However, the EU market remain an import market for these countries sugar given the fact that almost 40% of annual SADC sugar is exported to this market.

The relative competitive advantage of the SADC sugar industries in general means that they are likely to expand should policies that increase global sugar demand and world prices come into existence. However, whether the industries of smaller countries like Swaziland and Madagascar can competitive with absolute advantage low cost producers like Brazil and Australia for example is contentious. Much as the SADC region is suitable for production of sugar cane, challenges still persist in the expansion of the sugar sector. These include increased need for irrigation water, more investment into skilled labour, infrastructure and research. The importance of water in particular is seen by the fact that Botswana, a SADC country, does not produce any sugar cane because of its dry weather conditions. Huge investment in irrigation would make it a high cost sugar cane grower.

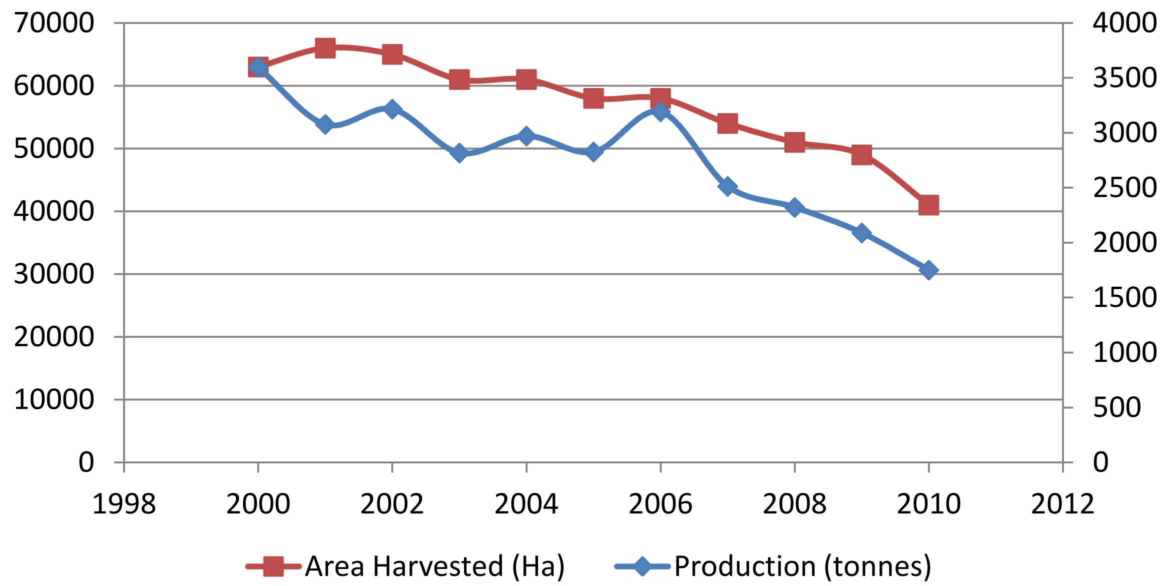
In summary therefore, for the SADC sugar industry to remain viable especially after the derogation of preferences there should be;

- Major restructuring of the industries to reduce production cost
- More investment in infrastructure and skilled personnel
- Existence of global policies that will have the effect of increasing global sugar demand and prices
- Diversification of the industries into for example bioethanol production

The EC bioethanol blend mandate is one policy that is expected to increase global sugar demand and therefore support sugar production and export in the SADC region and ACP countries in general.

In the pacific region, only Fiji had a special sugar trade agreement with the EU region. Figure 4-16 below show sugar cane production in Fiji in recent years.

Figure 4-16: Fiji Sugar cane production and area harvested*



**Primary axis: Hactares; Secondary axis: Tonnes*
Source: FAO Statistics

Like is the case in most SADC ACP member states the sugar industry has historical economic importance to Fiji economy. For example, in 2005 the most recent period for which published data is available, sugar accounted for 6% of GDP and some 26 % of total merchandise exports (The Fiji Sugar Corporation ltd, 2012). However, Fiji sugar production has been on a steady decline from the year 2000 as seen in Figure 4-16. Since most of the Pacific region has not had a special sugar trade arrangement with the EU, that region's sugar sector will not be discussed in details.

Having reviewed the ACP sugar industries, specifically those that had special trade arrangements with the EU, we now discuss recent policies and reforms affecting EU sugar regime. These policies and reforms are expected to have an effect on the ACP sugar industries that benefited from preferential trade arrangements with the EU as we have alluded to.

4.7 Recent EU/ACP sugar trade regime reforms

The EU sugar regime has undergone some major reforms mostly in an attempt to comply with WTO trading rules. In discussing the reforms and policies that are expected to affect the EU sugar regime, we start with the EU sugar reform of 2006.

4.7.1 The EU sugar reform of 2006

As of 21 February 2006, the EU decided to reduce the guaranteed price of sugar by 36% over four years, starting in 2006. According to the EC (2006) this was the first serious reform of sugar under the CAP for 40 years. This EU sugar reforms followed the developments in 2003 in which the most efficient sugar producers that do not have access to the highly protected EU market, namely Brazil, Australia, and Thailand, filed a complaint against EU subsidized sugar exports. The complainants claimed that the subsidized re-export of EU sugar was above the levels agreed to in Uruguay Round world trade negotiations and these included the subsidization of the export of 1.6 million tonnes of sugar from ACP and Indian. A WTO panel and the Appellate Body ruled in favor of the complainants, finding that the EU exceeded its export subsidy commitment level by the exported quantity of 2.8 million tonnes. Therefore, the EU was obliged to bring its domestic market regulation into conformity with its WTO obligations (Analytical Note Report, 2007). This price cut then is an attempt to reduce the amount of sugar produced and imported into the EU.

The major features of the reform as outlined by Gudoshnikov (2010) are the following:[24]

- Reduction in sugar reference prices by 36% over four years starting from 2006/07. The 2006/07 white sugar support price of €631.9 per tonne would

[24] For details of the EU sugar reform, please see House of Commons, Environment, Food and Rural Affairs Committee report, Volume 1.

be reduced to €404.4 per tonne by the end of the transition period in 2009/10

- Intervention after the four-year transition would be abolished and replaced with a system of private storage with producers taking advantage of the scheme being paid a private storage aid. Intervention during the transition period will be limited to 600 thousand tonnes per marketing year and the buying-in will take place at 80% of the reference price of the following marketing year;
- To compensate farmers leaving the sector direct payments would cover 64.2% of the income loss;
- A restructuring fund would pay a basic €730 per tonne in the first two years for producers, renouncing their quotas and quitting the industry with at least €73 per tonne going to ex-growers. To qualify for the restructuring money, which falls to €625 per tonne in 2008/09 and €520 per tonne in 2009/10, sugar companies had to give up their rights to the quota, stop production altogether in at least one factory, close the factory and restore good environmental conditions of the site and help the redeployment of factory staff; and
- The quota system was simplified. The “A” and “B” quotas were merged into a single quota. The previous basic maximum (A+B) quotas applicable would apply for the first four years as there will be no compulsory quota reduction applicable during that time.

The EU measures of price cut in particular affects EU sugar production and incomes in the 19 ACP countries that benefit from the preferential price from the Special and Preferential sugar. The evolution of the price cuts is shown in Table 4.10 below.

Table 4.10: EU support prices from 2005-2010

	2005/06	2006/07	2007/08	2008/09	2009/10
Reference price for producers (€/tonne)	631.9	505.5	458.1	410.7	404.4
% reduction in reference price	0	20.0	27.5	35.0	36.0
Reference price for consumers (€/tonne)	631.9	631.9	631.9	541.5	404.4
% reduction in consumer prices	0	0	0	14.3	36.0
Restructuring levy (€/tonne)	0	126.4	173.8	113.3	0
Reference price (ACP raw sugar-€/tonne)	523.7	496.8	496.8	448.8	335.2
% reduction in raw sugar price	0	5.1	5.1	14.3	36.0
Minimum sugar beet price (€/tonne)	43.63	32.9	29.8	27.8	26.3
% reduction in minimum sugar beet price	0	24.7	31.7	36.2	39.7

Source: International sugar organisation (ISO), 2010

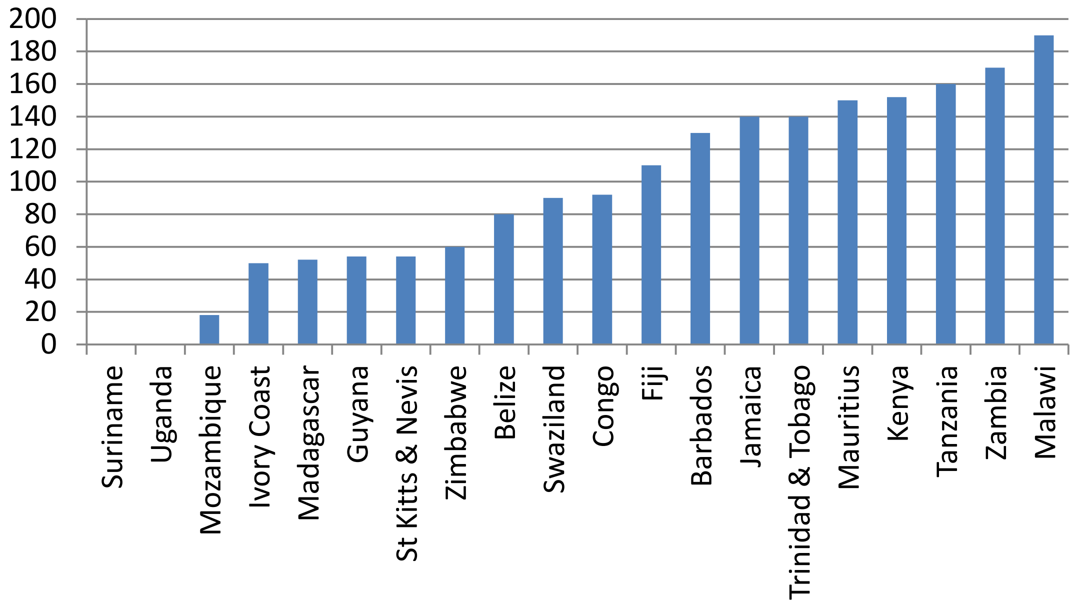
Table 4.10 above show that the guaranteed prices that ACP countries receive for sugar export to the EU has gradually eroded from 2006 to reach the target 36% in 2010. This reduction in guaranteed price is expected to affect the production of sugar both in the EU and in ACP countries. A study by Elbehri et al (2008) concluded that the combined effect of cuts in the intervention prices and production quotas would lead to lower EU sugar production, lower prices for consumers and increase consumption. The study further concluded that the EU sugar exports would decline because of a combination of lower production, lower export subsidies, and restrictions on exports of non-quota sugar and consequently, EU sugar imports will have to rise to bring the market into balance. These findings have interesting implications for the EC bioethanol blend mandate policy, whose application will lead to further increase in demand for sugar in the region with significant impact to the EU and global sugar markets.

A study by the Organization of Economic Co-operation and Development (OECD, 2007) concluded that a 36% cut in EU intervention price will result in 7.7% reduction in EU sugar imports, 86.6% reduction in EU sugar export and increase in world market price for white sugar of 1.2% by 2015. The study further noted that efficient sugar producers will benefit from this intervention price cut with sugar exports rising by 3.1% for South Africa, 0.9% for Brazil, 1.3% for Cuba, 0.2% for Australia and 1.5% for Thailand. Moyo and Spreen (2011) found that the EU cut in intervention price for sugar will result in a decrease in EU annual sugar production of 3.82% between 2000/2001 and 2010/2011 agricultural marketing years.

The intervention price cut has adversely affected a majority of ACP countries that were benefitting from the high priced EU sugar market. This is a direct result of revenue loss due to the lower prices. For example, the cut in intervention price has seen exports from the Caribbean regions to the EU drop significantly as has been seen in Figure 4-12 with some of these countries moving away from sugar production to tourism. The Ramphal centre for international trade law, policy & services of the University of the West Indies (2010) noted that with the exception of Guyana and Belize, the Caribbean sugar industry's economic importance has largely been replaced by the tourism industry. It further noted that according to the Bureau of Statistics of Guyana, the sugar industry contributed 4.7% to the Guyanese economy in 2009 as compared to 15.8% contribution in 2003.

Figure 4-17 below is an estimate of the loss of revenue to various ACP countries as a result of the reform in EU sugar regime.

Figure 4-17: ACP estimated revenue loss due to EU sugar reform (US$/tonne)



Source: USDA (2011)

Figure 4-17 above shows that ACP countries are affected differently because of their differences in dependencies on the EU sugar market and the speed of diversification to other industries. This further highlights the significance of country or regional heterogeneity in response to a policy change.

Since one of the aims of this research is to model the potential effects of a binding EC bioethanol policy on ACP sugar trade with the EU, the preferential price agreements become important. This is because the EC bioethanol blend mandate policy is envisaged to increase demand and therefore the price of sugar in the region. These dynamics will potentially have an opposite effect to the proposed intervention price cut by the EC.

As well as the specific reform of the EU sugar regime arising from the WTO ruling in 2006, there are various other policies that are expected to affect the EU sugar regime with direct and indirect spillover effects to ACP sugar industries. The most important ones are discussed next.

4.7.2 The EU biofuel policy

The EU biofuel policy and its link to the EU sugar market has been extensively reviewed earlier. For completion, the biofuel blend mandate directive is as follows:

*Directive 2003/30/EC of the European Parliament and of the Council, OJ L 123, 17/052003. The Directive on Biofuels set a reference value for the national indicative targets at 2%, calculated on the *basis of energy content*, of all fuels for transport purposes placed on their markets by 2005, while the market share of biofuels is set at 5.75% for 2010. In 2007 the European Commission recommends a minimum share of 10% for biofuels by 2020 in its schedule regarding renewable energy (Hingyi H, 2007).*

Our interest in this derective is on bioethanol production in the EU region as a result of its application. Since bioethanol in the EU is also produced from sugar beet, it is expected that this blend mandate will affect the EU sugar market by increasing demand for sugar. This will have implications on sugar production and trade between the EU and ACP countries.
However, analysis of the potential effect of this directive on the EU sugar market cannot be done in isolation without a study of its possible interactions with the other policies that affect the EU/ACP sugar trade protocols. The most important trade policies between the EU and ACP countries are the EPA policies which we discuss next.

4.7.3 The EPAs

The EPAs aim to replace the Lomé and the Cotonou Agreements between the EU and ACP countries. The Cotonou Agreement of June 2000 expired in 2008 and was a waiver given to ACP countries by WTO to replace the Lomé scheme. Both agreements were not in line with the WTO MFN clause, thus resulting in the EU/ACP EPA trade negotiations which aim to comply with this WTO clause.[25]

The Sugar Protocol preferences generally violate the nondiscrimination obligations contained in the GATT 1994 clause of the WTO. In order to deal with preferential arrangement between the EU and ACP countries, the EU had received a special waiver with regard to this WTO clause which allowed it to grant trade preferences under the Cotonou Agreement, which also embraces the Sugar Protocol . The WTO waiver expired at the end of 2007 meaning such preferences became highly vulnerable to legal challenge from other WTO members. The denunciation of the Sugar Protocol remedied this vulnerability with effect from October 2009 by the creation of the EPAs between the EU and ACP member states which were beneficiaries to the preferential trade agreements (Analytical Note Report, 2007).

The first vulnerability of the legal status of the EU and ACP trade protocols was first exposed by the USA in 1995. The USA at the time filed an application to the WTO requesting an investigation on whether the Lomé IV convention was not a violation of the WTO trade rules. After investigation the WTO ruled that the trade arrangement between the EU and ACP countries was indeed in violation of its rules. Hence, for continued existence of these trade arrangements between the EU and ACP, a special waiver was required.

Therefore, in an attempt to comply with the WTO trade rules the EU, as mentioned before has proposed the EPAs which will see the end of preferential trade arrangements between the EU and ACP countries and will introduce reciprocity and

[25] GATT Article I: provides for WTO Members to accord Most-Favoured-Nation treatment to like products of other WTO Members regarding tariffs, regulations on exports and imports, internal taxes and charges, and internal regulations. In other words, "like" products from all WTO Members must be given the same treatment as the most advantageous treatment accorded the products of any state.

non discrimination trade arrangements between the two regions. There has however been a lot of speculation about the outcome of EPAs between the EU and ACP countries on whether they will promote regional integration or subject ACP countries to unfair competition from subsidized EU exports.

For example, Stevens (2005) noted that such uncertainties arise due to questions like: how much liberalization would each ACP country have to undertake to meet the definition of 'substantially' all trade in the EPAs clause, how difficult is it likely to be to forge common regional positions under EPAs that do not result in future problems and what effect will EPA liberalization have on ACP government revenues. Some of these questions arise from the EPA clause that says 'substantial trade liberalization' without a clear definition of the meaning of 'substantial' in the clause

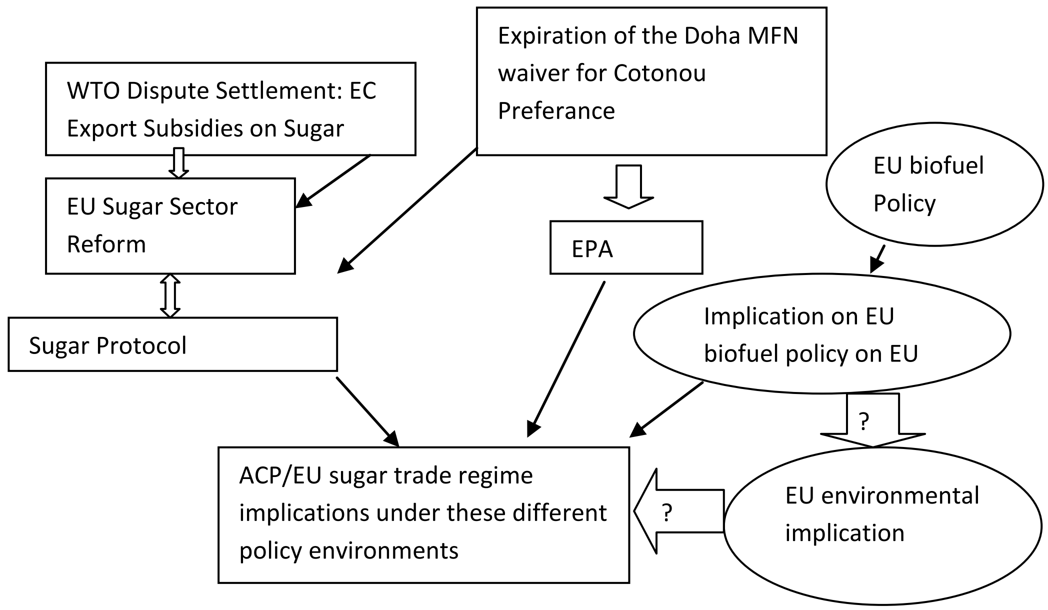
Other important contentious issues in the EPAs as far as trade liberalization and reciprocity arrangement with the EU is concerned is the heterogeneity of the ACP countries in their trade and tariff lines, their production efficiencies, speed of adjustment to policies changes and therefore on their classification of sensitive products. These issues makes the arguments proposed by the EU that the EPAs will promote regional integration look over ambitious and not easy to model and support empirically. The review of the ACP sugar industries has highlighted such heterogeneity amongst ACP countries.

The first step to the EPAs negotiations was for the ACP countries to form themselves into regional groups, some of which are actually more advanced in regional integration than others, and six groups have emerged namely; The Caribbean, Central Africa, West Africa, Southern Africa (SADC), East and Southern Africa (ESA) and the East and African Community (EAC). Some African countries have yet to decide which group they are in and some are members of more than one group, e.g., Zambia is in ESA and SADC; Tanzania is in ESA, SADC and EAC. One of the problems faced by these regional groups, as noted by Lyakurwa et al (1997) is that existing regional integration arrangements (RIAs) are at best weak, have proved politically difficult to sustain and have unclear economic benefits generated.

These are some of the difficulties the EPAs are likely to encounter and the sugar trade protocol is expected to be at the centre stage of these trade developments. This is because it is expected that these EPAs will affect sugar exporting ACP countries differently due to among other things, their different production and transport cost, differences in the contributions of the sugar trade arrangements to their GDP, speed of production adjustments and reforms and the interlinkages of sugar to other commodities in the classification of sensitive products which are therefore subject to tariff protection as we have already seen. The potential complexities of the EPAs therefore means that in order to analyse their likely effects on the sugar protocol between the EU/ACP countries, assumptions have to be made about the EPA arrangement in place in as far as tariff lines and trade liberation arrangement between the various ACP countries and EU is concerned.

Figure 4-18 is the summary of recent EU policy development that will have impacts on the EU/global sugar market and therefore have impacts, directly or indirectly on the sugar trade regime between the EU and ACP countries.

Figure 4-18: EU sugar policy developments



Source: expanded from Analytical Note, 2007

4.8 Conclusion

This chapter has reviewed the policies that sustain agricultural markets in the EU with special attention given to the EU sugar market, one which will potentially be affected by the EC biofuel policy. It has thus reviewed the EU sugar regime and its linkages to the Common Agricultural Policy (CAP) in details. The CAP policy, due to its protectionist mechanism has helped increased agricultural productivity in the EU region. The intricate CMO policies that are linked to the CAP have helped made the EU a global sugar producer and trader despite the fact that the region is a high cost producer of this commodity. EU sugar imports from ACP countries have been important in shaping the EU sugar regime. In this way, historical policies that have sustained trade between the EU and ACP countries were also been discussed. These include the Lomé and the Cotonou trade Agreements which have since expired to give way to the EPAs which are more in line with WTO trade expectations.

These policies have sustained sugar industries and ACP countries. In this way, the ACP sugar industries have also been reviewed to point out their heterogeneity in as far as their dependence on the EU sugar market and sugar production efficiencies are concerned. In this way, this highlights their potential different reactions from policies that affect the EU sugar markets. Recent policy developments in the EU sugar regime as an attempt to comply with WTO rules have also been discussed more especially the 2006 reform of 36% price cut in sugar intervention prices which has already had an impact on EU and ACP sugar sectors.

A binding EC bioethanol policy will have the effect of increasing demand for sugar in the EU region as more sugar beet is diverted into the production of bioethanol as discussed in Chapter 3. In this way, such a policy is expected to have an impact on EU and global bioethanol crops commodities markets including sugar markets. The challenge is to be able to model the global impact of this policy together with its interaction with other future trade policies between the EU and ACP countries in order to come up with meaningful conclusions.

In the next chapter, we review and motivate the GTAP model, a global CGE model that is ideal to analyse international trade policies.

Chapter 5

A review of the GTAP model

5.0 Introduction

In Chapter 3, we set up an EU27 bioethanol supply and demand model under an assumption of a binding EC bioethanol blend mandate policy. The EU bioethanol supply and demand was then used to determine the equilibrium bioethanol conditions for the region. These bioethanol equilibrium conditions are expected to affect EU/global bioethanol crop commodities' markets.

It is the aim of this study to analyse these EU bioethanol market equilibrium effects on bioethanol crops commodities markets especially those of ACP countries. It is also interesting to analyse how the EC bioethanol blend mandate will interact with other future trade policies between the EU and ACP countries. Analysis of the global effect of the EC bioethanol blend mandate policy and its interaction with other trade policies therefore requires a global Computable General Equilibrium (CGE) model. In this dissertation, the Global Trade Analysis Project (GTAP) model is the CGE model that will be used to analyse these policies. In the next section, we discuss this model so as to show its relevance and suitability for our study. We also motivate the theoretical foundations of the trade and welfare effects of the policies that we aim to simulate.

This chapter is therefore structured as follows; section 5.1 offers an introduction to CGE and the GTAP modelling techniques. With reference to our study objectives, the theoretical foundations underpinning the GTAP model are discussed in section 5.2 and section 5.3 motivates the model closure and linearisation of accounting equations. Section 5.4 discusses the application of the GTAP model in our study and the basis for our policy simulation results while section 5.5 is the conclusion.

5.1 CGE and GTAP modelling

Partial equilibrium models are informative, detailed and easy to model for a small-scale market simulation of a policy change but they are generally not convenient to study spillover effects, especially at a global or international level. Partial equilibrium models are also not suitable to analyse multi-policy interaction, as is one of the objectives for this study. As such, an alternative means of capturing global spillovers of policies and their interaction, our study is going to utilise CGE modelling techniques.

CGE modelling, as first conceptualised by Walras (1834-1910), has its underpinnings on a system of equations based on the assumption of an economy in perfect competition where firms maximise profits subject to their production function and consumers maximise their utility subject to a budget constraint. In this case then there are various economic agents and the sum of excess demand across markets must be equal to zero. CGE models are therefore based on a general equilibrium approach where economic agents are represented by a set of equations that describe their optimisation behaviour. The modeler specifies the equations that describe the agent behaviour and how these various economic agents are related to each other. The key to these equations, however is that they are interdependent in a given economy through accounting mechanisms. For example, economic agents could be households, government and firms. With reference to income, households use their factors of production to obtain wages that they spend on private consumption, government taxes and savings. There is thus a circular flow of income through all these economic agents and this flow must balance.

CGE modelling, as its name suggests, therefore aims to determine a point in a market where supply equals demand i.e. Walrasian equilibrium. At this equilibrium point markets clear, households maximise utility under a budget constraint and firms maximise profits, which are driven down to zero. The aim of CGE modelling then is to solve for prices and quantities that will prevail at the equilibrium point. In the Walrasian equilibrium model the flexible price vector determines the equilibrium while in the Keynesian equilibrium model in the short-run the quantities vary while the prices remain fixed (Khan, 2007). CGE models are calibrated against data at a given point in time. The database and its size depend on the economy under analysis. Experiments are designed by manipulating certain key variables in a balanced dataset and analysing the resulting changes in variables specified as endogenous.

Such models have been used in a wide range of studies and in various fields of economic and environmental policy analysis. For example, CGE modelling techniques have been used to analyse taxes and international trade (Shoven and Whalley ,1984), in the study of developing economies (Decaluwé and Martens, 1988), to analyse energy and the environment (Bhattacharyya, 1996) and in analysis of benefits and losses resulting from free trade agreements (Lloyd and MacLafren, 2004).

The advantage of CGE models is that they take a holistic view of the entire economy under analysis and consider the interrelationships between the various economic agents across a given economy. In this way, they offer useful insights on possible economic impacts of changes in key variables and this makes them informative. They also integrate many aspects of economic theory and the basic assumption of agent behaviour can be manipulated by the modeler to suite the economy under analysis.

Their major drawback is that they are static and cannot predict outcome in a time-series manner. This makes them unsuitable for forecasting. Another disadvantage is that the assumptions made by the model are sometimes not realistic and can affect simulation outcomes. They also generally need a lot of data from various sources and some of the data may not be accurate, which may result in misleading experimental outcomes. Further, CGE models tend to be large and as such they cannot relate results or outcomes accurately to a specific cause or shock in the database. As noted by Wing (2004) CGE models are viewed with suspicion in the economics and policy analysis communities as a "black box", whose results cannot be meaningfully traced to any particular features of their data base or input parameters, algebraic structure or method of solution. However, for empirical studies of policies with global spillovers they remain the methods of choice.

The GTAP model, which is an example of a CGE model, was developed by Hertel in 1997. It is a static, multi sector, multi region model that has been widely used to simulate international trade policies. It is based on a detailed database with a broad coverage of trade and explicit statistics on transport margins. Firms use constant-returns-to-scale technologies and import demand is modelled through the Armington assumption[26] of imperfect substitutability between domestic and imported goods. Since the GTAP model is multiregional and multimarket, it is able to analyse local and international multi commodity markets' changes in production and trade profiles due to a local or regional policy. This makes the model ideal to analyse the EC bioethanol blend mandate policy.

[26] Armington (1969) made the assumption that internationally traded products are separable by their country of origin. In this way, the assumption also differentiate between domestic and imported products. This has made internationally traded products (both for consumption and production) heterogenous and separable by use of CES. This assumption is widely used in CGE models and differs from the Heckscher-Ohlin models of homegenous products. This Armington assumption does not allow relocation of firms but since this is a static model this assumptioin is therefore not strong.

5.2 Theoretical foundations of the GTAP model

The GTAP model is an example of a CGE model and its basis is a Social Accounting Matrix (SAM). A SAM is a square matrix of economic transactions (in monetary terms) in a macroeconomic entity. The SAM, being a square matrix, is designed such that rows (which represent income) are equal to columns (which represent expenditure) in the accounting flow of commodities. The database for a SAM is from Input-Output Tables, national accounts, government fiscal accounts and trade data.

A typical structure of a SAM is shown in Table 5.1 below:

Table 5.1: A typical structure of a Social Accounting Matrix

Expenditure /Income	**Commodities**	**Activities**	**Factor Payments**	**Households**	**Government**	**Capital Account**	**Rest of World**	**Total Incomes**
Commodities		Intermediate Consumption		Household Consumption expenditure	Government consumption expenditure	Investment and inventory expenditure	Export revenue	Commodity demand
Activities	Marketed Production							Domestic Production
Factors		Value Added		Domestic Employment	Government Employment		Factor income from abroad	Factor incomes
Institutions: Households			Labour incomes and distributed profits	Inter-household transfers	Government transfers to households		Remittances to households from abroad	Household incomes
Institutions: Government	Tariff Revenue	Indirect tax revenue less subsidies plus tariff revenue	Taxes on labour and profits	Tax revenue from households		Tax revenue from capital account	Government income from world	Government revenue
Capital Account				Household saving	Government saving		Current account BoP	Total Savings
Rest of world	Competitive commodity Imports	Non Competitive commodity imports	Factor payments abroad	Households transfer to world	Government transfer to world			**Total imports**
Total Expenditures	Commodity supply	Production	Factor outlay	Household expenditure	Government expenditure	Capital expenditure	**Total exports**	

Source : Lange et al (2002)

As seen in the Table 5.1, the structure of the SAM describes a circular flow of commodities in a given economy. The accounts must balance, with income from a given activity being equal to expenditure for that activity. However, a SAM is not an economic model although its structure has a Keynesian flavour, reflecting its origins in Leontief's input-output schema and Keynesian macroeconomics (McDonald et. al, 1997). The database of the SAM is therefore used with CGE modelling techniques to offer a powerful but user-friendly tool to analyze regional and international policies affecting the representative economic entity.

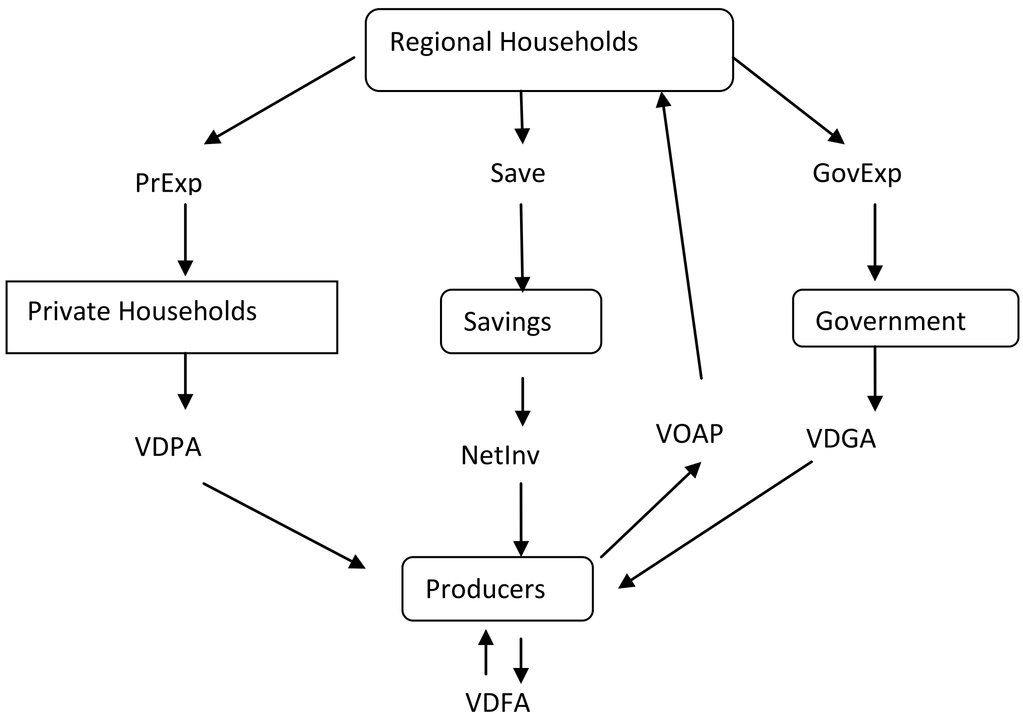
In the flow of commodities in a typical SAM, households are the owners of means of production (capital and labour). Households rent out these factors of production to firms who produce the commodities that are in turn used up by the households. In the SAM flow of commodities a third party is added in this scenario, the government that acts to harmonize the flow of commodities between the firms and households by taxes and other policies that smooth this flow (Wing, 2003). Thus using 'the closed loop' flow of commodities of the SAM, the CGE is a zero-sum game, which enables it to have a unique solution in prices, allocation of goods and factors of production.

Adapted from the concept of the SAM and CGE modelling, the overview of the GTAP model is then motivate following a paper by Brockmeier (2001)[27]. Figure 5-1 below shows the basic structure of the GTAP depicting a one region closed economy without government intervention in the form of taxes and subsidies. This is the simplest form of the model showing the various economic agents and their linkages to each other via production, consumption and savings flow. The main

[27] Full exposition of the theoretical underpinnings of the model including behavoural equations can be found in Hertel and Tsigas (1997). The discussion here is with reference to our study objectives but we will maintain the variable notations as in the original GTAP model for ease of motivation of the adaptation of the model. For ease of decription and adaptation of the model, most of our discussion will therefore follow closely the paper by Hertel and Tsigas (1997)

economic agent in the model is the regional household, which is made up of government, private household and a saving agent as Figure 5-1 shows.

Figure 5-1: GTAP model - closed economy



Source: Hertel and Tsigas (1997)

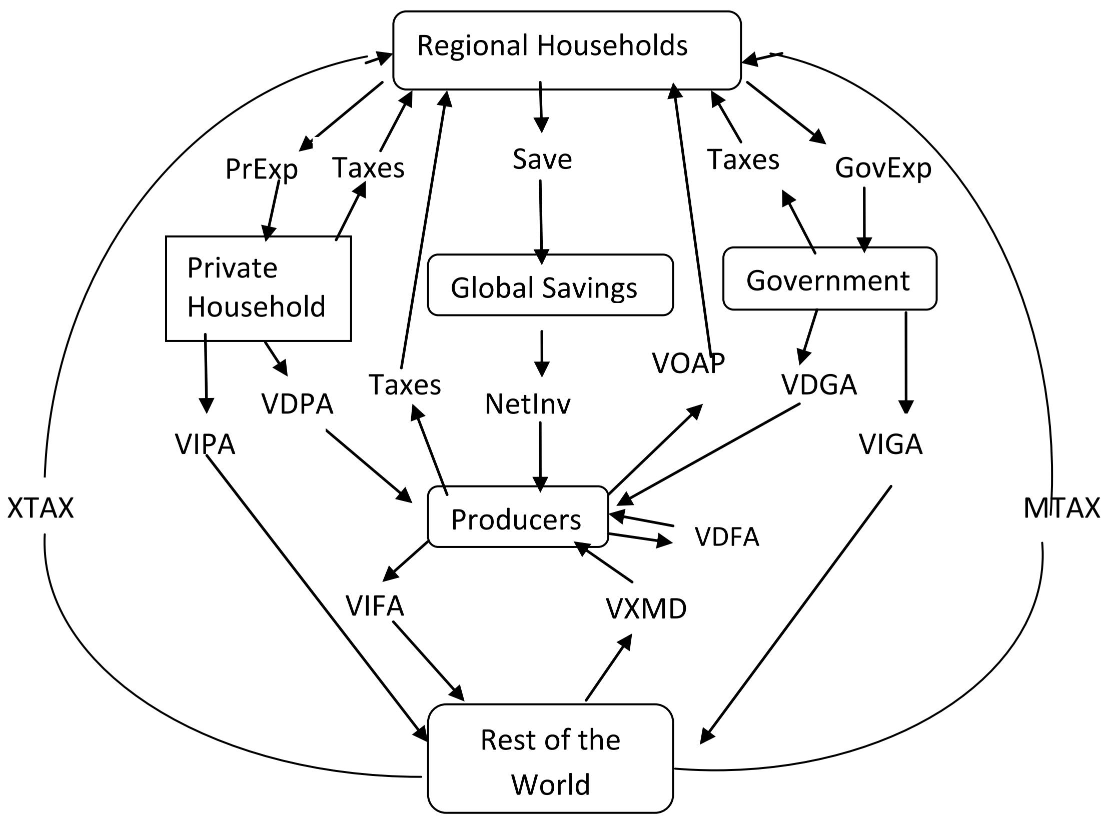
In such an economy, all income accumulates to regional households who are owners of the factors of production. The source of this income is therefore producers who pay the regional households for use of factor endowments, namely labour, land and capital to produce commodities. These payments from producers to regional households are shown as Value of Output at Agents Price or VOAP in the diagram.

The regional households use their incomes as Private Households Expenditure (PrExp), Savings (Save) and Government Expenditure (GovExp). These regional incomes are assumed to be distributed into these three components according to a

Cobb-Douglas per capita utility function. These fixed expenditures can be viewed as representing households budget constraints in which case exogenous shocks can be analysed by the way the households adjust given their budget expenditure. The household budget constraint is also the sources of welfare changes from policies that affect commodity prices and therefore household incomes. In the above exposition the firm's behaviour, besides the purchase of factors of production, VOAP, also purchase intermediate products, which are denoted as Value of Domestic Purchase by firms at Agent's Price (VDFA). Since the firms themselves produce these intermediate goods, they enter into this economy in a cyclical manner within producers meaning that their net effect is zero.

Government expenditure must therefore be equal to the Value of their Domestic purchases at Agents prices (VDGA), Private household expenditure must be equal to the Value of their Domestic purchases at Agents prices (VDPA) and households invest their savings as Net Investments (NetInv). The motivation above does not involve trade flows since it is a closed economy scenario as already mentioned. This simplified one region scenario also does not involve policy intervention such as the introduction of taxes and subsidies in the flow of commodities. Involvement of taxes, subsidies and international trade result in the open economy scenarios as shown in Figure 5-2.

Figure 5-2: GTAP model – open economy



Source: Hertel and Tsigas (1997).

In Figure 5-2, the openness of the economy is seen by the introduction of another region namely the Rest Of the World (ROW). This region is an aggregation of all the trading partners of the reference economy. In this open economy, producers in the reference region also gain additional revenue from exporting goods to the rest of the world and these are denoted by VXMD. The producers also import intermediate products from the rest of the world and these are shown as VIFA.

The savings component has been modified in this open economy to GLOBAL savings, which is the collection of all saving in the global economy. Since households and governments are on their budget constraint and because firm profits are driven to zero, these global savings are equivalent to global investments as per the dictates of Walras' Law. In this extended economy, government and private households also import commodities, besides the use of domestic commodities to satisfy their demand. These imported commodities are denoted as VIGA and VIPA for government and household imports respectively. In this way, producers combine domestic intermediate inputs and imported intermediate inputs to maximise their profit while government and private households combine local commodities and imported commodities to maximise their utility subject to a budget constraint.

Value of exports (i.e export price multiplied by the exported quantity) from the reference economy to the rest of the world are denoted by VXMD . Taxes have also been included in this extended scenario, where MTAX refer to import taxes paid by regional households to the rest of the world while export taxes, paid by the rest of the world to regional households are denoted by XTAX. Taxes here mean ‘taxes and subsidies’ where subsidies are negative taxes. For example, an import tax result in the price of the domestic commodity being higher than the rest of the world price and an import subsidy has the opposite effect. Likewise, an export tax results in the rest of the world price for the exported commodity being higher that the domestic price, with an export subsidy having an opposite effect.

The effect of an export subsidy in an open economy can be explained by Figure 5-3 below;

Figure 5-3: Effect of an export subsidy in region *r*

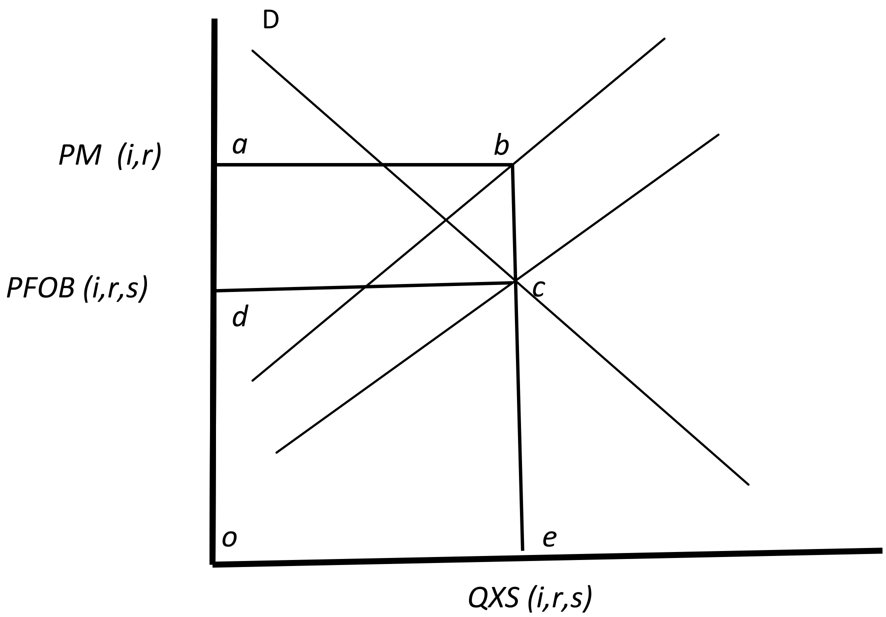


Figure 5-3 above shows that the imposition of an export subsidy results in the Free on Board price of commodity *i* from region *r* to region *s* i.e. *PFOB (i,r,s),* being lower than its domestic price shown as *PM (i,r).* In the above diagram, *QXS (i,r,s)* represent the quantity of exports of commodity *i* from region *r* to region *s.* S_1 and S_0 are the subsidized and pre-subsidized export supply respectively of commodity *i* from region *r* to region *s. D* represent the demand for commodity *i* supplied from region *r* to region *s*.

With reference to Figure 5-3 the following variables are defined;

VXMD (i,r,s) = Value of exports of commodity *i* from region *r* to region *s* at exporter's domestic price. This is shown by the area *aboe*.

VXWD (i,r,s) = Value of export of commodity *i* from region *r* to region s at FOB price. This is shown by the area *cdoe*

XTAX (i,r,s) = Value of expenditure on subsidy, which is equivalent to a negative tax. This is shown by the area *abcd.*

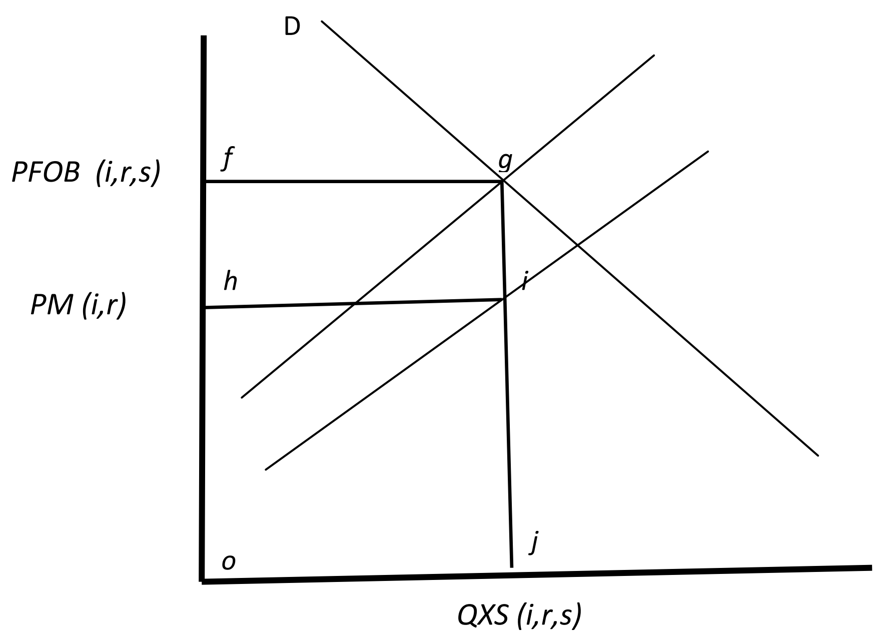
It therefore follows that;

$$VXWD\ (i,r,s) = VXMD\ (i,r,s) - XTAX\ (i,r,s) \tag{5.1}$$

The effect of the export subsidy shows that region *r* is worse off since it has to pay the subsidy which is equivalent to *XTAX (i,r,s),* which represents a negative tax to the economy.

The effect of an export tax is opposite to that of an export subsidy and is shown in Figure 5-4.

Figure 5-4: Effect of an export tax in region *r*



As Figure 5-4 above shows, the effect of the export tax is to raise the market price of the exported commodity *i* from region *r* i.e. *PM (i,r,)* to the free on board price *PFOB (i,r,s)* by an amount of the tax. This means that government in the exporting country *r* gains revenue equivalent to XTAX (*i,r,s).*

In the case of the export tax with reference to Figure 5-4 therefore;

VXMD (i,r,s), which is the value of exports of commodity *i* from region *r* to region s at exporter's domestic price is now shown by the area *hijo*.

VXWD (i,r,s), which is the value of export of commodity *i* from region *r* to region s at FOB price is now shown by the area *fgjo*.

XTAX (i,r,s), which is the value of the export tax imposed by region *r* on commodity *i* being exported to region *s* is now shown by the area *fghi* and represent a positive tax or revenue to the economy of region *r*.

Again it follows that:

$$VXWD\ (i,r,s) = VXMD\ (i,r,s) + XTAX\ (i,r,s) \tag{5.2}$$

The effects of import taxes (subsidies) work in an opposite manner to the effects of exports taxes (subsidies) and their effects are summarised by the Figures 5-5 and 5-6 below:

Figure 5-5: Effect of an import subsidy in region *s*

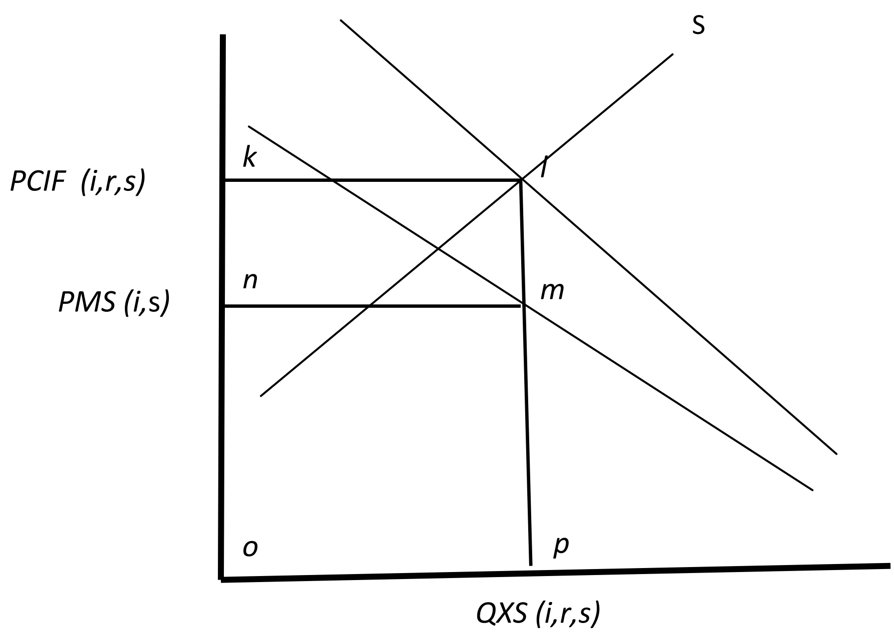


Figure 5-5 shows that the imposition of an import subsidy results in the domestic price of the imported commodity *i* from region *r* to regions *s* shown as *PMS (i,s)* being lower that its cost insurance and freight price *PCIF (i,r,s)* price. In the diagram D_0 is the pre-subsidized net demand of commodity *i* supplied from region *r* to region *s*. D_1 is the subsidized net demand of commodity *i* supplied from region *r* to region *s*. Region *s* therefore pay for the import subsidy equivalent to *MTAX (i,r,s),* which is equivalent to a negative tax to the economy.

With reference to Figure 5-5 we again define the following variables;

VIMS (i,r,s) = Value of imports of commodity *i* from region *r* to region *s* at importer's domestic price. This is shown by the area *mnop*.

VIWS (i,r,s) = Value of imports of commodity *i* from region *r* to region s at CIF price. This is shown by the area *klop*.

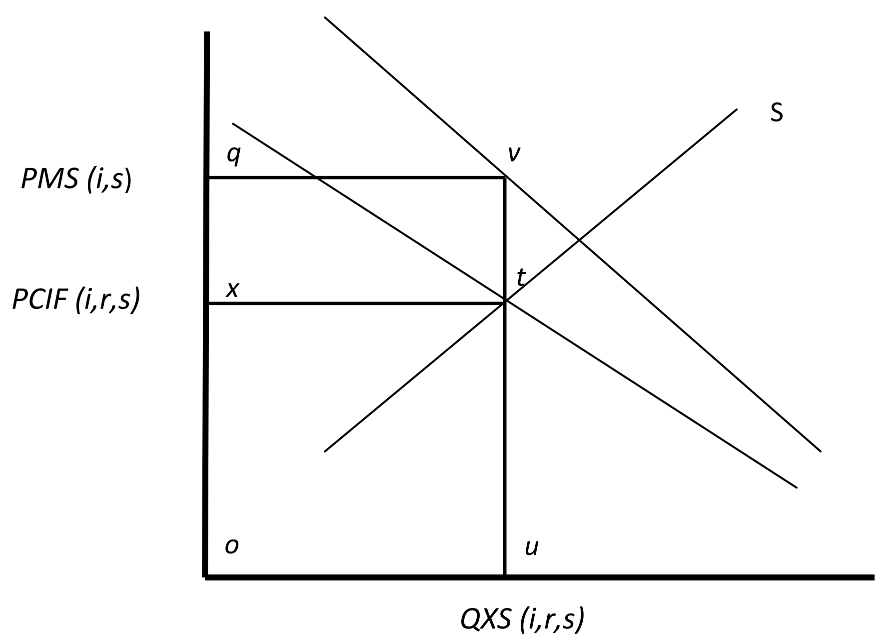
MTAX (i,r,s) = Value of expenditure on import subsidy of commodity *i* supplied from region *r* to region *s*. This is shown by the area *klmn*.

In the above case then it follows that:

$$VIMS\ (i,r,s) = VIWS\ (i,r,s) - MTAX\ (i,r,s) \tag{5.3}$$

And finally the effect of an import tax is shown below:

Figure 5-6: Effects of an import tax in region *s*



From Figure 5-6 above, the effect of the import tax is to raise the domestic price of commodity *i* supplied from region *r* to region *s* shown as *PMS (i,s)* to be above the cost insurance and freight price *PCFI (i,r,s)* by the amount of the import tax. In this case therefore, it is clearly apparent that policies that have the tendency of reducing the import tax will be welfare enhancing in that they will reduce the domestic price that households face and in this way result in positive equivalent variation outcomes.

In this case therefore;

VIMS (i,r,s), which is the value of imports of commodity *i* from region *r* to region *s* at importer's domestic price in now shown by the area *qvou*.
VIWS (i,r,s), which is the value of imports of commodity *i* from region *r* to region s at CIF price is now shown by the area *xtou*.
MTAX (i,r,s), which is the value of gain on import tax of commodity *i* supplied from region *r* to region *s* is now shown by the area *qvxt*.
Again, the identity below holds

$$VIMS\ (i,r,s) = VIWS\ (i,r,s) + MTAX\ (i,r,s) \tag{5.4}$$

When the market price exceeds the world price, i.e. *PMS (i,r,s) > PCIF (i,r,s)* then *MTAX (i,r,s)> 0* and this contributes to regional income. In this case, therefore the equation below holds;

$$VIMS\ (i,r,s) - VIWS\ (i,r,s) = \tau_{imp}(i,r,s)\ PCIF\ (i,r,s) QXS\ (i,r,s) > 0 \tag{5.5}$$

With *VIMS (i,r,s) and VIWS (i,r,s)* defined as before and $\tau_{imp}(i,r,s)$ is the import tax on commodity *i* imported from region *r* to region *s*. *PCIF (i,r,s)* is the world (*cif*) price

of tradeable commodity *i* imported from source *r* to destination *s*. The manipulation of the tax rate on imports in the GTAP model is key to simulating trade liberalisation agreements like the EPA policies between the EU and ACP countries.
The effects of the taxes on domestic prices can be shown by equation 5.6 below:

$$PS\ (i,r)\ [1 + \tau\ (i,r)] = PM\ (i,r) \tag{5.6}$$

Where PS *(i,r)* is the supply price of nonsaving commodity *i* in region *r* and *PM (i,r)* is the market price of nonsaving commodity *i* in region *r*. In this case, *τ (i,r)* represents the *ad valorem* tax rate. This then means that;

$$VOM\ (i,r) - VOA\ (i,r) = \tau\ (i,r) PM\ (i,r) QO\ (i,r) \tag{5.7}$$

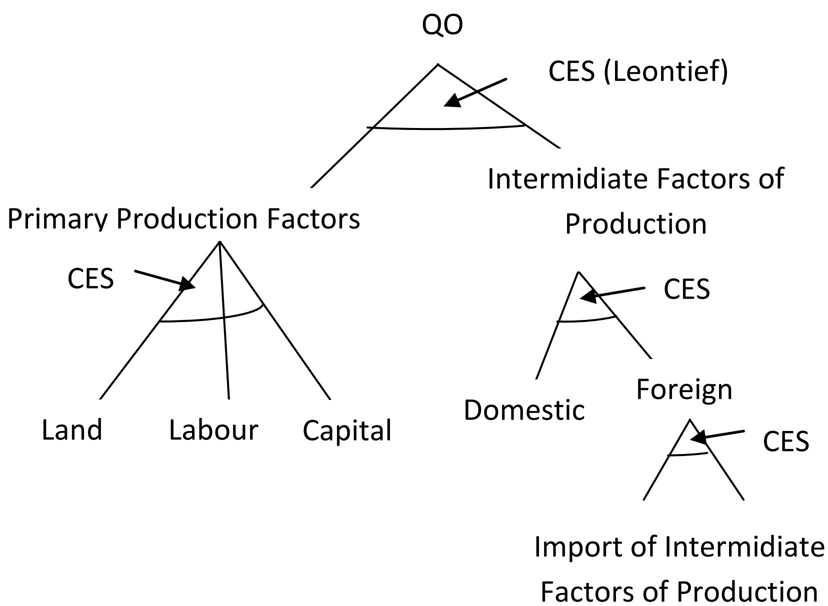
Where *VOM (i,r)* and *VOA (i,r)* are the values of nonsaving commodity *i* produced in region *r* evaluated at market price and agent price respectively. Equation 5.7 will allow us to simulate the effect of the EC bioethanol blend mandate policy by artificially depressing EU bioethanol crops commodities output through increasing their output tax as we will see later.

In the next section, we discuss the equations that characterise the behaviour of various economic agents in the model. Behavioural equations are based on the assumptions made about economic variables like consumer spending and production functions and they represent the decision characterising the choices made by such economic agents in a model.

5.2.1 Behavioural equations

Firms' behaviour: The behavior of firms like those of households follows a constant return to scale with a constant elasticity of substitution (CES). The elasticity of substitution for the combination of primary and intermediate inputs is Leontief meaning these are combined in fixed proportions. The CES assumption in the GTAP model allows for separability of the factors of production. The exposition of firm's behaviour is summarised by a production tree as shown in Figure 5-7 below.

Figure 5-7: Production tree for output (QO) in the GTAP model



Source: Adapted from Bryant and Campiche, 2009

The production tree in Figure 5-7 shows that to produce output QO firms use primary factors of production, which are mainly labour, capital and land combined with intermediate factors of production. The primary factors of production are assumed immobile across regions. However, factors are fully mobile across production sectors, and the equilibria generated by the model are therefore long run (Bryant and Campiche, 2009). On the other hand, regions adjust immediately to an external shock so as to remain in continuous equilibrium. The lack of a clear time path response to policy changes in standard CGE models is their major shortfall that hinders their usefulness for policy makers. However, they do offer useful policy simulation outcomes albeit of a static nature.

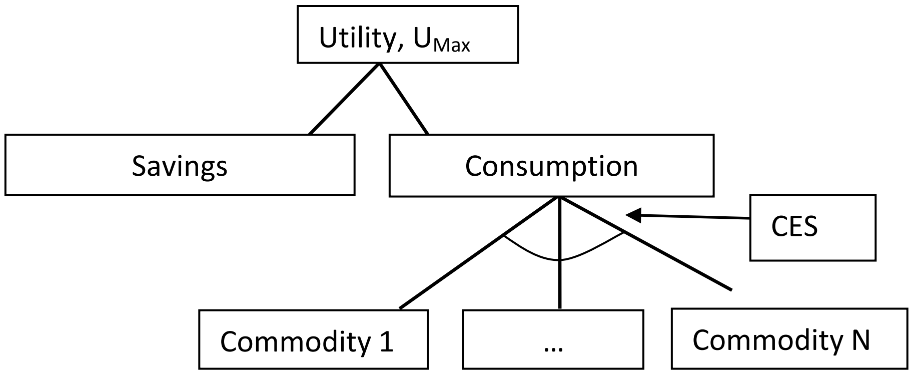
Household behaviour: Regional household behaviour is driven by an aggregate utility function, specified over composite private consumption, composite government purchases, and savings.

Households dispose total regional income according to a Cobb-Douglas per capita utility function specified over the three forms of final demand which are household expenditures, government expenditures and savings. Thus in the standard closure, the claims of each of these areas represent a constant share of total income.

> ***Government Expenditure***: Government collects taxes from households levied on factor incomes, on factor use and against production sectors. Taxes are also levied on import and export of commodities. These taxes form total government income that is in turn exhausted on income payment for households and on the purchase of composite goods in a Cobb-Douglas expenditure of the budget.
>
> ***Private Expenditure***: Households, as owners of the factors of production receive income from the production sector and transfer payments from government. This income is used as savings and for consumption, with the consumption of differentiated goods specified on a CES assumption. Households aim to maximise their utility under a budget constraint. Factors that improve household utility are welfare improving while those that reduce household utility result in welfare loss. For example, policies that have an effect of reducing domestic prices for commodities are welfare improving since households can now afford larger bundles of goods and services and therefore reach a higher utility curve.

In the GTAP model, the computation of the utility of private household consumption takes into account the population growth rate meaning that it is expressed on a per capita basis. Private household behaviour is summarised in Figure 5-8 below:

Figure 5-8: Private household behavioural tree

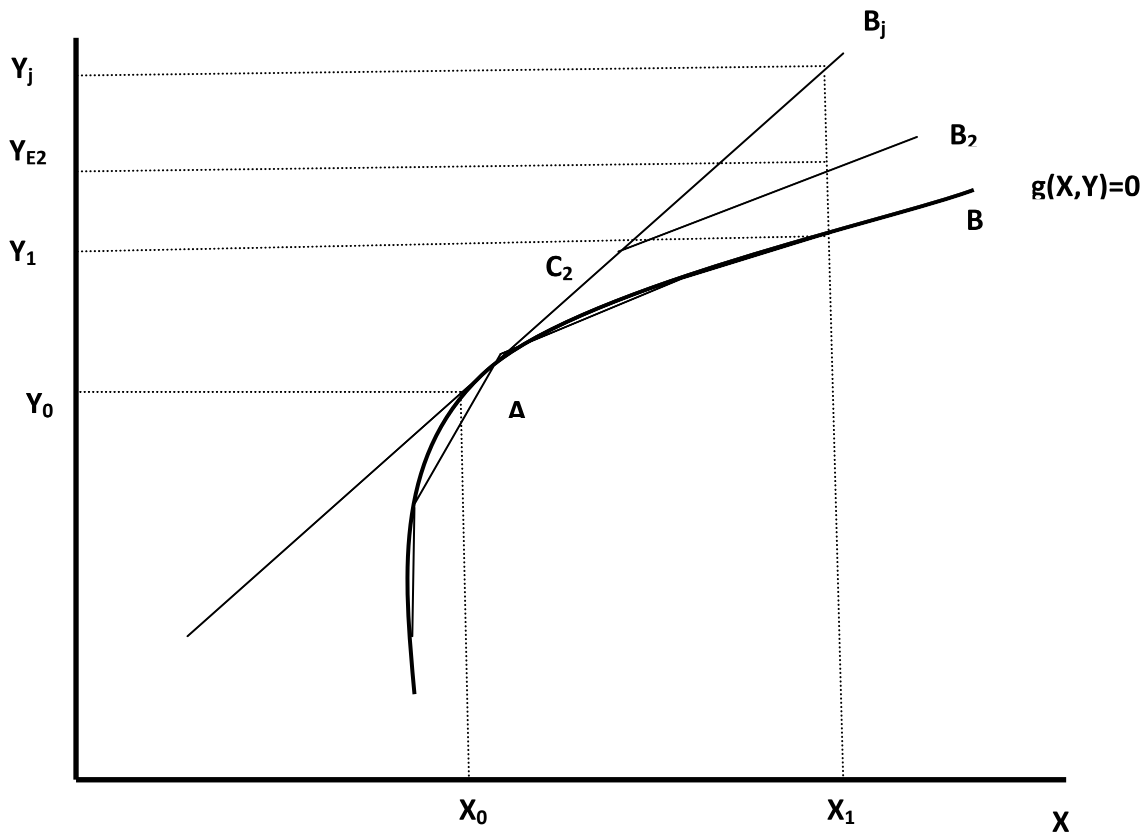


Source: Adapted from Bryant and Campiche, 2009

5.2.2 Model closure and linearization

Closure of the model implies the specification of variables as being endogenous or exogenous. For the model to have a unique solution, the number of endogenous variables must be equal to the number of equations. In the standard GTAP model closure prices and quantities of all endowment commodities and regional incomes are set to be endogenous. Policy variables, technical change variables and population are all exogenous. In the standard model closure, and as a model consistency check, global saving must be equal to global investments. Simulations in the model are performed by manipulation of exogenous variables. However, exogenous variables can be swapped for endogenous variables but in all cases of model closure, Walras Law must hold. For this study, it is not necessary to change the standard GTAP closure since the exogenous variables specified in this closure can be manipulated appropriately to simulate all our experiments. The linearisation problem in the equilibrium solution of CGE models following a policy change is best explained by Figure 5-9 below with its discussion as adapted from Hertel and Tsigas (1997).

Figure 5-9: A graphical exposition of linearization



Source: adapted from Hertel and Tsigas (1997).

The linearisation in the GTAP model is motivated by first considering a model given by a single equation g(X,Y) = 0 (with X being exogenous and *Y* being endogenous) and an initial equilibrium at point (X_0, Y_0). These points and the model are shown in Figure 5-9 above. Policy simulation involves 'shocking' the exogenous variable to say X_1, and computing the resulting endogenous outcome Y_1. Evaluating the linearized representation of the model at (X_0, Y_0) means the equations would predict the outcome B_J = (X_1, Y_J). This is the Johansen approach and is not accurate in that $Y_J > Y_1$. This type of error has led to criticism of the individuals using linearized CGE models. However, the accuracy of the linearized model can be considerably improved by dividing the shock to *X* into two parts and updating the equilibrium sequentially. This approach means moving from point *A* to C_2 to B_2 and evaluating the Y outcome at Y_{E2}, which has a lower error compared to Y_j. This method is termed Euler's method of solution via linearized representation. By increasing the number of steps, one obtains an increasingly accurate solution of the nonlinear model, which will eventually converge to the true values i.e. (X_1, Y_1). The default method used for solving the GTAP model is Gragg's method in which case the model is solved as a stepwise approach.

In summary therefore, the GTAP model has three solution methods for simulation experiments, which are the Johansen, Gragg, and Euler's method. For all our policy simulation experiments, we will assume a linear solution outcome and apply the Johansen approach. The reason is that the Johansen approach is the one that is used in many simulation studies that use the GTAP model. Further, the exogenous variables that we manipulate to simulate our policy experiments have a linear relationship with the endogenous variables as seen in equations 5.5 and 5.7 above.

5.3 Study application of the GTAP model

Policy simulation in the GTAP model is done by manipulating the variables that are set as exogenous in the GTAP closure. In setting up the EU bioethanol market model, one of the key assumptions we made was that the region produces its entire bioethanol requirements locally as will be demanded by the mandate, by diverting some of the bioethanol crops from food production to bioethanol production. In this way, modelling the effects of the EC bioethanol blend mandate policy on bioethanol crops commodities market in the EU region can be done through artificially depressing bioethanol crops commodities amount marketed in the region by an amount equivalent to that which will be demanded by a binding blend mandate.

Artificially depressing bioethanol crops commodities output or production in the EU to simulate the EC bioethanol blend mandate effects is not straight forward in the

GTAP model given the fact that prices and quantities of all commodities are set to be endogenous in a standard GTAP closure. However, policy variables like taxes or subsidies are all exogenous in the model. In this way to simulate the artificial reduction in bioethanol crops commodities output in the EU region we will use the exogenously defined tax rates i.e. τ (i,r).

The manipulation of the tax rates is the standard procedure used in the GTAP model to obtain regional elasticities of various commodities. This is done by altering the tax by enough to raise the market price, *pm (i,r),* by 1%, one commodity and one region at a time. The percentage reduction in output {qo (i,r)} is then recorded and the own price elasticity of demand is then simply define as; {*ϵ (i,r) = qo(i,r)/pm(i,r)}*.

In our analysis *qo (i,r)* will represent the artificial percentage decrease in bioethanol crops commodities output in the EU due to bioethanol production. In this way, the model is able to simulate the effects of the EU bioethanol partial equilibrium conditions as derived in chapter 3. The idea is that bioethanol production will divert some bioethanol crops commodities to bioethanol production. Therefore, we will simulate this 'diversion' as an artificial decrease in bioethanol crops commodities output in the EU region. The amount of bioethanol crops commodities diverted to be bioethanol production will be determined from the bioethanol market clearing quantities as derived in chapter 3. Therefore, using bioethanol crops commodities own price elasticities and manipulating the variable *pm (i,r)* via the exogenously defined tax variable we are able to manipulate the variable *qo (i,r)* which is the percentage change in quantity of non saving commodity *i* ouput in region *r*.

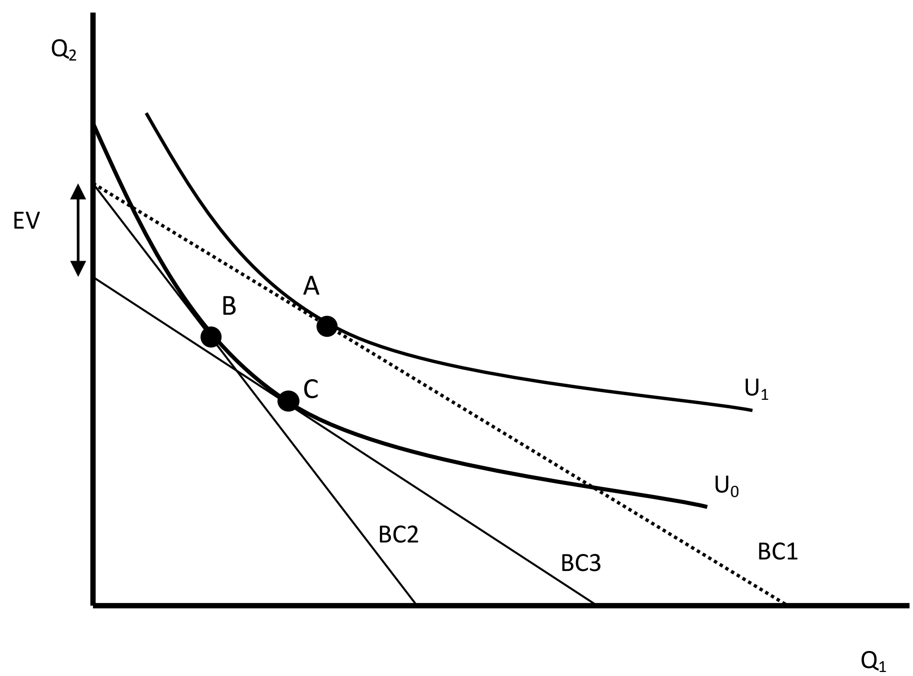
The simulation of the EPA policies is also via the exogenously defined tax on imports of tradeable commodity *i* from region *r* to destination s and levied in region *s*. To simulate a full EPA, the import tax is reduced to zero percent between the EU27 and ACP countries and vice versa because of reciprocity. Reducing import tax to zero percent is the extreme case in that it does not consider sensitive products that are not liberalised and thus it takes the EPA clause of 'substantial' liberalization of tradeable commodities as 'full' liberalization. However, it is a reasonable scenario in the analysis of the possible effects of the EPAs on the ACP member states as an upper bound outcome.

The economic effect of a policy change is usually measured in its welfare outcomes on consumers or households. Therefore, welfare changes, industry output changes and changes in trade balances as a result of the EC bioethanol blend mandate policy, EPA policies and their interactions are the outcomes of interest to be analysed.

In a perfectly working global economy prices for the same commodity will be equal due to arbitrage tendencies. However, taxes in the form of tariffs and non-tariff barriers are market distorting. Import tariffs for example result in welfare loss since they have a tendency of increasing domestic prices for households above those that prevail in the world market. In theory therefore, it is envisaged that cuts in import tariffs will benefit domestic consumers in that they will be able to obtain products from lowest cost producers elsewhere. In this case, abolition of trade barriers should result in an efficient global economy. The simulation of the EPA policies therefore aims to quantify the welfare gain from the abolition of import duties. On the other hand, the EC bioethanol blend mandate policy is expected to result in welfare loss as a direct result of increase in the prices of bioethanol crops commodities in the EU region.

One measure of welfare outcome of a policy is the equivalent variation (EV) which is defined as the amount of money paid to a consumer so as to leave them as well off as they would be after a policy change. Equivalently, equivalent variation can be defined as a change in nominal income that is equivalent in its effect on utility to a change in the price of a commodity. To motivate the idea of equivalent variation we use the exposition shown in Figure 5-10 below;

Figure 5-10: Graphical exposition of equivalent variation



First, consider an economy with two goods Q_1 and Q2. In the above diagram, BC refers to the budget constraint line. Suppose we begin with BC1 and optimal consumption at A on indifference curve U_1. There is then a policy change e.g. an increase in import tax that results in the price of good Q1 to rise. This causes the budget constraint line to pivot inwards to become BC2 such that the new point of optimality is at B on indifference curve U_0. The price increase therefore has the same effect as a fall in the consumer's real income and as such, the consumer is worse off as he/she is now at a lower indifference curve. The equivalent variation in monetary terms as a result of this price increase is determined by moving the old budget line BC1 in a parallel fashion until it targents at the lower indifference curve

U_0 (i.e. point C). This results in a new bugdet line BC3 and the equivalent variation is then measured on the vertical axis in monetary units as the difference between BC1 and BC3.

Taxes and subsidies, because they result in changes in prices of goods, have welfare implications. Generally, policies that decrease (increase) the prices of goods, like import subsidies (taxes) result in welfare gain (loss). The welfare effect of an international trade policy like an import tax can also be explained by its effects on production and trade following Pant et al (2000). Let us assume that a country has imposed a prohibitive import tariff that makes it remain at autarky. Let P represent the relative price of importable goods in terms of exportable goods, Q is the output for the given country and X is a vector of demand. The autarky equilibrium is given by the function (P^o, Q^o, X^o). The effect of the tax on price P^0 is given by;

$$P^o = P^* (1+T^o)$$

where P* is the world price of the importable and T^o is the *ad valorem* tariff rate. Therefore we have ($Q^o = X^o$) which represent the autarky equilibrium. If the country removes the tariff fully so that the change in domestic price ratio is equal to the international terms of trade i.e. $P^1 = P^*$ holds and letting (P^1, Q^1, X^1) = the new equilibrium after tariff removal, then;

$$EV = P^oX^1 - P^oX^o$$

$$= P^o(E^1 + Q^1 - P^oQ^o)$$

$$= P^*(1+T^o)E^1 + P^o(Q^1 - Q^o)$$

Where E^1 is a vector of excess demand, which is equal to (X-Q).

Noting that the aggregate value of excess demand disappears at world prices, the expression becomes;

$$EV = P^*T^oE^1 + P^o (Q^1-Q^0)$$

EV depends on changes in quantity of net imports E^1 and changes in output.

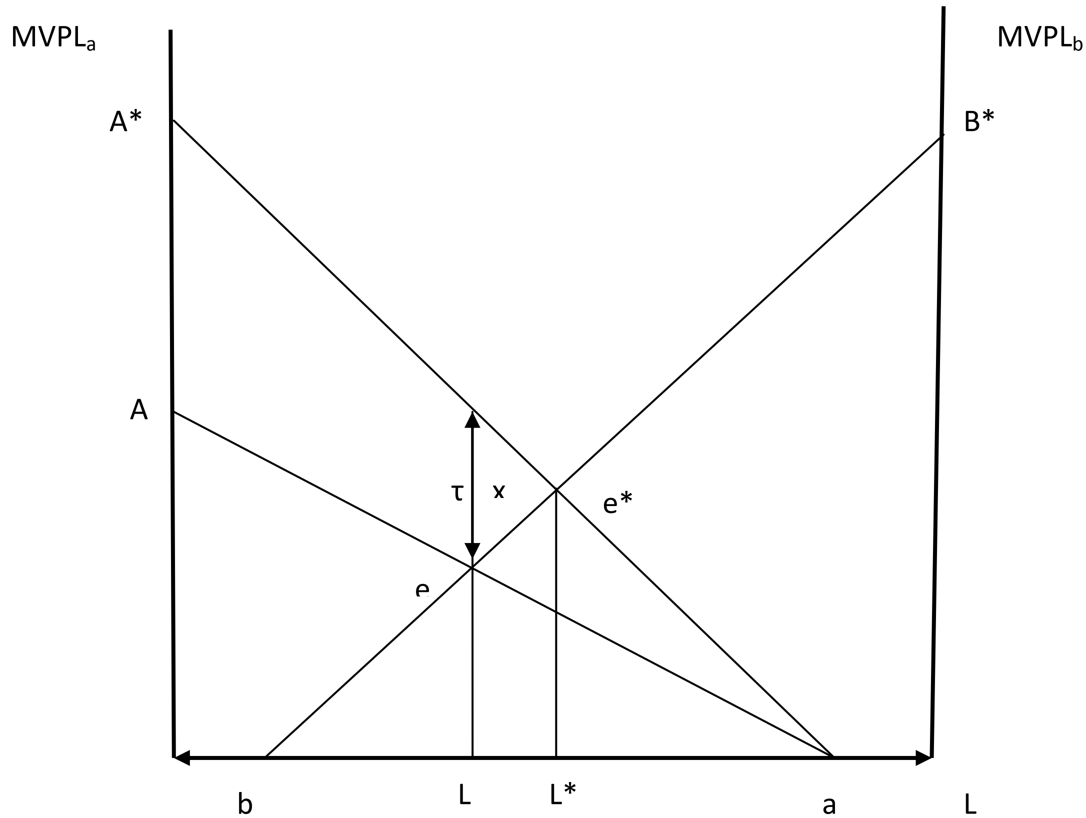
The first term is positive if imports increase due to removal of tariff. For the second term, if the economy was operating at full efficiency at autarky then $P^oQ^o > P^oQ^1$. However, if trade liberalisation improves efficiency and promotes competitive firms, then the second term will be positive. Therefore, the removal of tax on imports will be welfare improving if it will increase imports and promote efficiency among domestic firms. As noted by McCulloch, Winters and Cirera (2001), import restrictions creates an anti-export bias by raising the price of importable goods relative to exportable goods. The removal of this bias through trade liberalization therefore results in re-allocation of resources from the production of import substitutes to the production of export-oriented goods. This in turn stimulates growth in the short to medium term as the country adjusts to the new allocation of resources to sectors that have a relative competitive advantage.

In the GTAP model, welfare effects are composed of endowment contribution, technical efficiency, allocative efficiency, investment/savings effects and terms of trade changes. Endownment contribution arises from changes in the availability of primary factors of production while technical efficiency arises from changes in the use of factors of production. Allocative efficiency is a result of changes in the allocation of resources in response to relative price changes. Terms of trade effects are due to the difference between the value of the initial and new vector of net exports prices and if this difference is positive, the country experiences a welfare gain (Pant et al, 2000). Terms of trade welfare gains may also be due to a policy change that result in cheaper imports or an increase in prices of exports. Both these outcomes has the effect of increasing the income of a given country or region thus resulting in welfare gain. A terms of trade (TOT) welfare gain can also occur therefore when there is an incomplete pass-through of a newly imposed tariff to domestic prices (Chong and Hur, 2007).

Allocative and technical efficiency contribution to welfare is explained by the diagrams below as adapted from Huff and Hertel (2000). The diagram shows a two-sector economy A and B with labour input L. MVPL refers to the Marginal Value Product of labour in the two sectors. In the production of the two commodities, the efficient labour input equilibrium is at point e*. If sector A labour is taxed by amount τ it makes it more expensive and therefore less efficient. This shifts the labour equilibrium allocation of the two sectors to point e. In this case, labour supply also shifts from the less efficient sector A to the more efficient sector B by an amount (L*-L). The triangle X therefore shows the allocative efficiency welfare loss because of the tax. The argument for the outcomes of improvement in technology will be similar to that due to the effect of the tax on production inputs. In such a case, an improvement in technology in one sector will improve production efficiency of that sector and shift of production inputs from the less to the more productive sector.

There is no reason why the argument of endowment of factors of production cannot be viewed as having similar effect to technological progress. This is because better-endowed sectors are more efficient in production. This means they produce at a lower cost and have overall welfare gain to society. Indeed, opening up to trade has the effect of allocation of resources to better endowed and technologically advanced sectors. This results in more efficient production, lower prices and an overall welfare gain.

Figure 5-11: Allocative and technical efficiency contribution to welfare



Source: adapted from Huff and Hertel (2000)

High consumer demand results in high commodity prices and therefore shifting of resources from other sectors to the sector with high commodity demand. Shifting of resources means the sectors that lose such production resources become less endowed. This result in them being less efficient in production, which increases their production costs and thus resulting in welfare loss.

High prices of bioethanol crops commodities as a result of the EC bioethanol blend mandate policy result in households being less able to invest and save. If households are not investing, the endowment of factors of production goes down. Lower household income also results in less investment in technology, less technical efficiency and therefore walfare loss. Increase in the local prices of bioethanol crops commodities means that imports become relatively cheaper. This results in an increase of imports of these commodities from external markets thus negatively affecting the terms of trade welfare gain in the affected region.

The structure of the GTAP model therefore is suitable for the simulation of the EC bioethanol blend mandate/EPA policies and to explain the reasons behind the expected welfare outcomes.

5.4 Conclusion

The chapter has explained the GTAP model and has motivated the theory behind it. It has also justified the reasons why the GTAP model is suitable for our study objectives as well as the method to be used to simulate the policy changes under study. One of the major shortfalls of the GTAP model, and indeed most CGE models, is its static nature, which limits its use for policy makers. However, the GTAP is important in shedding some light on the potential effects of regional and international policies that have an impact on commodities production and trade.

The chapter has also shown that welfare outcomes of a policy hinge on changes in prices of commodities and therefore on household incomes. The policies under our analysis all have an impact on prices of commodities. In this way, these policies will have important welfare outcomes which we are interested in analysing. For this reason, the theory behind welfare outcomes because of a policy change has also been discussed. This chapter has therefore laid down the framework for the simulation of our policy experiments and the discussion of the results based on theoretical foundations.

The next chapters are the empirical simulation of the experiments, starting with the simulation of the EC bioethanol blend mandate policy, which we undertake in Chapter 6.

Chapter 6

Simulating the EC bioethanol blend mandate policy on ACP countries

6.1 Introduction

The aim of this chapter is to simulate the effects of the EC bioethanol blend mandate policy on EU and ACP member states bioethanol crops commodities markets using the GTAP 7 model and database. The GTAP model has been discussed in Chapter 5.

In the simulation of the EC bioethanol blend mandate policy, the equilibrium bioethanol quantities derived in Chapter 3 will first be converted to EU bioethanol crops commodities quantities in tonnes. This conversion is done by use of the various bioethanol crop commodities' bioethanol production efficiencies and their shares in EU bioethanol production.

These derived quantities will then be transferred into the GTAP model. The simulation of the EC bioethanol blend mandate policy therefore will be through an artificial decrease in bioethanol crops commodities production in the EU region. This artificial decrease in production is due to diversion of some of these bioethanol crops commodities to production of bioethanol. Since bioethanol uptake in the EU region will also affect gasoline use, the EU bioethanol equilibrium effects on petrol is also simulated. This simulation is through an artificial decrease in EU gasoline use, as some of it is displaced by bioethanol due to the blend mandate percentage requirements.

The GTAP7 database used in this study has a base year of 2004. The simulation results therefore show changes from the 2004 baseline equilibrium after the policy simulations under study. The results given therefore in our study do not have a time path because of the static nature of the model. The process of time adjustment to the new equilibrium is therefore not explicitly represented in such CGE models. This is one of the major shortfalls of such models as mentioned before since their usefulness as projection tools is limited.

The EC bioethanol blend mandate policy outcome analysis mainly focuses on welfare effects and bioethanol crops commodities production and trade changes in the EU27 and ACP regions as a result of this policy.

The Chapter is therefore structured as follows: Section 6.1 undertakes conversion of the EU bioethanol equilibrium quantities in litres as derived in Chapter 3 into bioethanol crop commodities quantities in tonnes. Section 6.2 motivates the transfer of these bioethanol crops commodities quantities derived in section 6.1 into the GTAP model. The effect of the EU bioethanol equilibrium quantities on EU transport fuel sector is discussed in section 6.3 and section 6.4 is the GTAP experimental simulation of the EC bioethanol blend mandate policy. Section 6.5 presents and discusses the results of the simulation and section 6.6 is the conclusion.

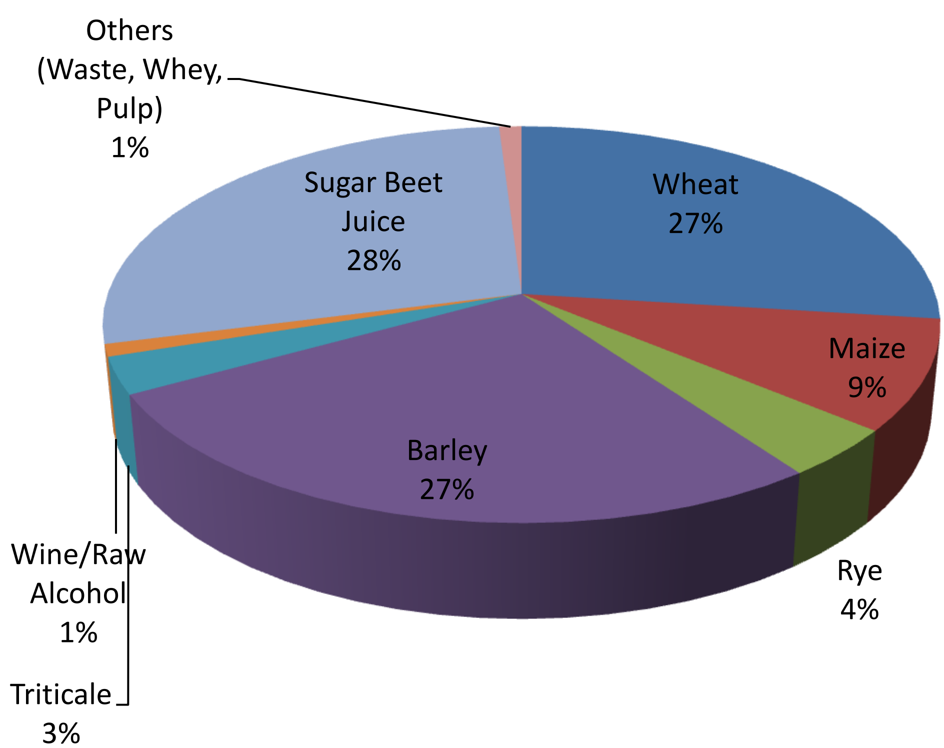
6.1 Conversion of bioethanol to bioethanol crops commodities equivalent

The conversion of the EU bioethanol equilibrium quantities in litres into the various EU bioethanol crops commodities quantities equivalent in tonnes uses the share of that given bioethanol crop commodity in EU bioethanol production programme as mentioned. The shares of the bioethanol crops commodities used in the EU bioethanol production programme are derived from literature.

As discussed in Chapter 3, using information from eBio and the Economic Commission (EC), Jank et al (2007) calculated the share for bioethanol production up to 2012 as being the following: 32.3%, 12.8%, 12.8%, 28.2%, 5.6%, with other sources making the remaining 8.3%. Again, is the wheat share, is the rye share, is the corn share, is the barley share and is the sugar beet share. Since it is difficult to model bioethanol production from other sources we assume that all the bioethanol produced in the EU is from the bioethanol crops under analysis i.e. wheat, rye, corn, barley and sugar beet. Under this assumption therefore, the adjusted bioethanol crops shares are as follows: 35.22%, 13.96%, 13.96%, 30.75% and 6.11%, thus bringing the total to 100%.

The shares reported by Jank et al (2007) are considered more accurate than annual shares because they are averages for the years 2004-2012. For example, eBio (2008) reported the EU bioethanol crop commodities shares for EU bioethanol production in 2006 as shown in Figure 6-1.

Figure 6-1: EU bioethanol production by crop type in 2006



Source: eBio (2008)

The report from eBio shows that sugar beet share in EU bioethanol production was 28% in 2006 as opposed to the 5.6% (and the 6.11% that can be implied from the data) as reported by Jank et al (2007). However, we will use the 28% sugar beet share reported by eBio (which calculates to 31.1% if we assume no other sources of bioethanol except bioethanol crops) and adjust the other ethanol crops shares according to the shares reported by Jank et al (2007). In this way the bioethanol crop shares that will be used for simulation of the EC bioethanol blend mandate policy while keeping the initial assumption that all EU bioethanol is produced within the region from bioethanol crops are the following: 25.85%, 10.24%, 10.24%, 22.57% and 31.1%.

As a sensitivity analysis, we will raise the share of sugar beet used in bioethanol production to 100% and subsequently analyse the impact of this sugar beet share increase on EU and global food markets. The use of sugar beet shares as a sensitivity analysis of the effects of the EC bioethanol blend mandate policy on global bioethanol crops commodities markets is in line with the scope of our study, which places emphasis on sugar markets. As mentioned before, it is expected that a higher sugar beet share used in bioethanol production will have less impact on global food markets given the fact that sugar is not a main food source for man and animals. As observed earlier, most of the bioethanol crops commodities (with the exception of sugar) are staple foods for the poorer ACP regions. In this way, their diversion to bioethanol production is expected to have adverse effects for these countries. Thus, increasing the sugar beet share in bioethanol production should result in lower welfare loss given the fact that households do not spend a lot of their income on sugar as a food source.

In addition, increasing the sugar beet share used in bieothanol production in the EU is also expected to improve income for most of the ACP region that grow sugar for trade purposes.

Bioethanol crops have different bioethanol production efficiencies depending on their energy contents and enzymatic ease of the fermentation process. For example, sugar beet contains on average 16% sugar, 80% of which can be recovered by the extraction process. One tonne of sugar beet gives therefore a maximum of 130 kg white sugar. The remaining sugar (non-crystallised) is left with the molasses, which contains 50% sugar. With yields ranging from 55 to 65 tonnes/ha, the expected sugar production could reach 7.8 tonnes per hectare of sugar beet in ideal conditions (FAO/European bank, 1999).

For the simulation of the EC bioethanol blend mandate policy, we need to link this Chapter with the bioethanol equilibrium quantities derived in Chapter 3. From the results of 5.75% EC binding bioethanol blend mandate the equilibrium quantity of bioethanol needed was calculated to be 226 thousand barrels of bioethanol a day. This equates to an annual EU27 production of 82.5 million barrels or 13.1 billion litres. At 10% blend mandate the equilibrium quantity of bioethanol was calculated to be 394 thousand barrels of bioethanol a day. This equates to an annual EU27 bioethanol production of 143.8 million barrels or 22.9 billion litres. These results are adapted directly from Table 3.7 in Chapter 3 and they form the key in the simulation of the EC bioethanol blend mandate policy.

Adapted from Table 3.7 therefore, Table 6.1 below shows the share of bioethanol that has to be derived from sugar beet at a sugar beet share of 31.1% as calculate from shares reported by Jank and eBio for EU bioethanol production in 2006.

Table 6.1: Bioethanol production from sugar beet at sugar beet share of 31.1%

Total annual EU ethanol demand (Billion litres)		Produced from sugar beet at 31.1 % sugar beet share	
5.75% blend mandate	10 % blend mandate	5.75% blend mandate	10% blend mandate
13.1	22.9	4.1	7.1

Table 6.1 above shows that 31.1 % share of sugar beet bioethanol equates to 4.1 and 7.1 billion litres per year at 5.75% and 10% blend mandate respectively. The higher the sugar beet share used in EU bioethanol production, the greater the impact the EC bioethanol blend mandate policy will have on the EU/global sugar industry. This means that a higher sugar beet share in the EU bioethanol production process will have greater significance on the sugar regime and economies of sugar producing ACP countries. It is envisaged *a priori* that a higher sugar beet share in the EU27 bioethanol production programme will potentially expand sugar production in ACP countries. Such expansion will increase sugar exports from ACP countries to the EU region and improve ACP countries trade balance and welfare. This is especially the case given the fact that most of these countries are low cost sugar cane growers and sugar producers.

After calculating the bioethanol equivalent of the sugar beet share in litres, the next step is to convert this share to sugar equivalent in tonnes. This is done in order to be able to artificially depress sugar output in the EU27 by the amount that will be demanded or diverted to the production of bioethanol. To convert bioethanol in litres to the corresponding bioethanol crops commodities in tonnes we use the bioethanol production convertion factors for the various bioethanol crops, which are indicators of their respective bioethanol production efficiencies. The conversion factors for bioethanol production from the various bioethanol crops commodities are shown in Table 6.2 below.

Table 6.2: Bioethanol productivity efficiency of grain crops and sugar beet

Commodity	Ethanol production factor(gallons per bushel)	Ethanol production factor(litres per tonne)
Barley	1.40	243.38
Corn (wet mill)	2.65	460.69
Corn (dry mill)	2.75	478.07
Wheat	2.80	486.77
Sugar beet		159.8
Rye[28]	2.10	364.11

Source: USDA (2006)

From Table 6.2 it can be seen that amongst the grain crops commodities, corn is a more efficient bioethanol producer than barley. Rye is intermediate between corn and barley and wheat is the most efficient producer with a yield of 486.77 litres of bioethanol per tonne. However, these production efficiencies notwithstanding, production of bioethanol from grain crops is generally not the best option given the fact that these crop commodities are vital food sources.

From Table 6.2 it can be seen that 1 tonne of sugar beet produces 159.8 litres of bioethanol. The sugar beet share in tonnes is further converted to sugar equivalent before it can be used in the GTAP model to artificially depress sugar output in the EU as a way of simulating the effect of the EC bioethanol blend mandate policy. As has been noted earlier, one (1) tonne of sugar beet gives a maximum of 130 kg white sugar. Because the GTAP7 database that will be used in our study to simulate the effects of the EC biofuel blend mandate policy is based on 2004 database, we will express the artificial depression of sugar production due to the mandate as a percentage of 2004 bioethanol crops commodities production in the EU. The conversion of the EU sugar beet bioethanol share to sugar equivalent is shown in Table 6.3:

[28] Source: calculated from Wang 1997

Table 6.3: Conversion of EU bioethanol sugar beet share from litres to tonnes equivalent at 31.1% (100%) sugar beet share

% Blend Mandate	Sugar beet share in billion litres of bioethanol	Sugar beet share in million tonnes equivalent
5.75	4.1 (13.1)	25.7 (81.5)
10	7.1 (22.9)	44.4 (143)

According to USDA in 2004, the EU produced 21.65 million tonnes of sugar. The quantities of sugar equivalent that will be demanded by the bioethanol blend mandate policy at the various sugar beet share (S_{sb}) and blend mandate percentages are shown in Table 6.4. These sugar equivalent quantities are also expressed as a percentage of the total 2004 EU sugar production[29].

Table 6.4: Conversion of EU bioethanol sugar beet share to sugar equivalent and as a percentage of 2004 sugar production at 31.1% (100%) sugar beet share

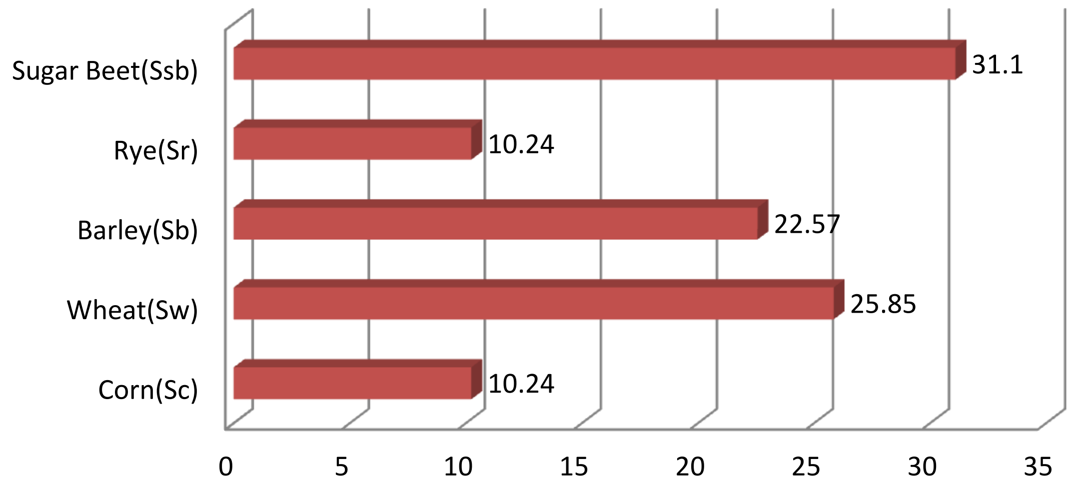
% Blend Mandate	sugar equivalent (million tonnes)	as a percetage of 2004 EU sugar production
5.75	3.3 (10.6)	15.3% (49.1%)
10	5.7 (18.6)	26.3% (85.9%)

Table 6.4 shows that a higher blend mandate percentage demands higher amounts of bioethanol sugar equivalence at equilibrium. A higher sugar beet share used in bioethanol production results in higher bioethanol sugar equivalence at equilibrium. All these outcomes are according to intuition. Similar analysis as has been undertaken for sugar beet in the EU bioethanol production process is also undertaken for the other bioethanol crops commodities namely wheat, barley, corn and rye.

[29] 2004 production statistics are used as a reference point since the GTAP 7 data base used to simulate the policies is based on 2004 global data set.

Using a sugar beet share of 31.1% as has been explained the bioethanol crops shares are summarized in Figure 6-2.

Figure 6-2: Calculated % bioethanol crops share in the EU27 for bioethanol production as has been reported in literature



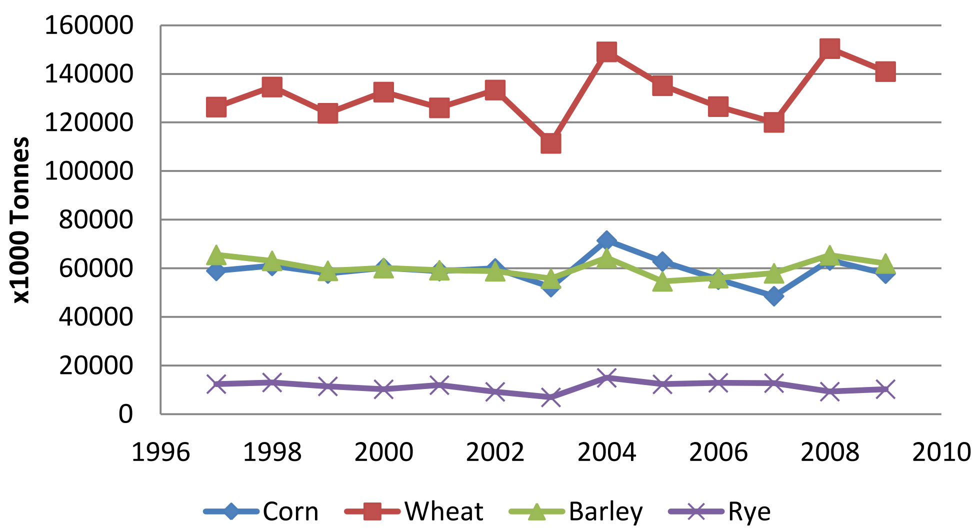
The equilibrium amount of bioethanol demanded by the blend mandate in the EU27 was calculated to be 13.1 and 22.9 billion litres per year at 5.75% and 10% blend mandate respectively. These results are reported in Table 3.7 of Chapter 3 and Table 6.1 of Chapter 6. Using these findings the bioethanol crop shares can therefore be converted to their equivalent in litres and tonnes by use of the respective conversion efficiency for each bioethanol crop. These Figures and conversions are shown in the Table 6.5 below.

Table 6.5: Bioethanol crop shares for bioethanol production in billion litres (and million tonnes equivalent)

	5.75% Blend mandate	10% Blend mandate
Ethanol crop shares	**25.85%, 10.24%, 10.24%, 22.57% and 31.1%**	**25.85%, 10.24%, 10.24%, 22.57% and 31.1%**
Corn+	1.3 (2.7)	2.3 (4.8)
Wheat	3.3 (6.7)	5.9 (12.1)
Barley	3 (12.3)	5.2 (21.4)
Rye	1.3 (3.5)	2.3 (6.3)
Sugarbeet	4.1 (25.7)	7.1 (44.4)
+The average of the wet and dry mill production efficiency is used		

The calculated bioethanol crops shares in tonnes equivalent are then expressed as a percentage of the 2004 EU27 bioethanol grain crop production. Figure 6-3 summarizes the annual EU27 bioethanol crops production from 1997 to 2009.

Figure 6-3: Annual bioethanol grain crop production in the EU27 from 1997-2009 (x1000 tonnes)



Source: Eurostat

Figure 6-3 shows that bioethanol crop production in the EU27 has generally been flat for the years 1997 to 2009 with barley and corn production at almost the same level of about 60 million tonnes per year on average. Wheat production was on average higher at 131 million tonnes per year while rye production was lower averaging about 11 million tonnes per year. According to the Eurostat database, in 2004 a downward output trend for wheat and maize was observed, partially due to the introduction of decoupled payments under the Common Agriculture Policy.

Therefore, using the 2004 base year production of grain crops as a reference point the EC bioethanol blend mandate will demand the following percentages as are shown in Figures 6-4.

Figure 6-4: Bioethanol crop shares for bioethanol production (at S_w=25.85%, S_r=10.24%, S_c=10.24%, S_b=22.57% and S_{sb}= 31.1%) as a percentage of 2004 EU27 bioethanol crop production

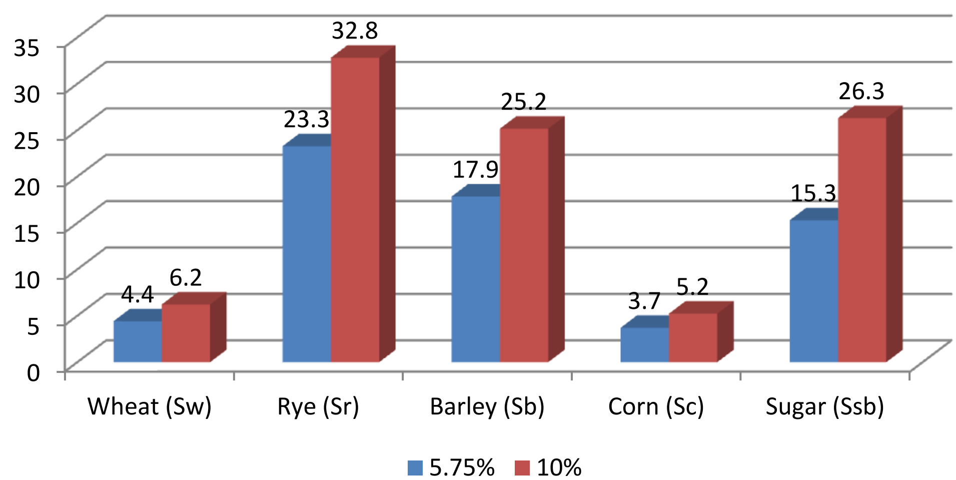


Figure 6-4 show that the bioethanol crops share for bioethanol production as a percentage of total EU bioethanol crop production depends also on the EU level of production of that bioethanol crop. This means that the EC bioethanol blend mandate will affect bioethanol crop commodities in the EU27 differently depending on the share that is used in the bioethanol production process and the EU level of production of that particular bioethanol crop. From the calculations, it is seen that the blend mandate will have a higher impact on the barley and rye markets where it will result in crop demand of more that 15% of 2004 EU27 production levels. The demand on the other grain crops i.e. corn and wheat on the other hand will be less than 10% of their 2004 production levels at both the 5.75% and 10% blend mandate.

Indeed the EU will be capable of producing all their bioethanol requirements from EU sugar beet as will be demanded by the blend mandate at equilibrium. This will require diversion of 49% and 86% of EU sugar production to bioethanol as has been calculated and presented in Table 6.4 above. It is envisaged, as has been discussed earlier, that using more sugar beet/sugar to produce bioethanol will have less adverse effects on global food markets and welfare. These dynamics and the effect of the blend mandate on sugar markets globally and especially on ACP member states will be analysed in the next section of this chapter.

In the USA, bioethanol is produced from corn as has already been noted. According to Roberts and Schlenker (2012), enforcing the US Renewable Fuel Standard would require 12.4 billion bushels of corn, which translates to about 33% of USA corn production in 2010 and about 5% of world caloric production in the same year. The percentage requirement of bioethanol crops commodities for the USA bioethanol programme is comparable to those determined by our study with respect to the EC bioethanol blend mandate policy.

Ideally, when modelling the production of bioethanol from grain crops, the by-product DDGs should also be taken into account since they are used as an animal feed. Since DDGs is not a disaggregated product in the GTAP model it will be difficult to model its potential impact on markets due to the EC bioethanol blend mandate policy. For these reasons, the DDGs effect will be ignored in our analysis.

6.2 Transferring the bioethanol crops demanded into the GTAP model

The next step in our analysis of the effect of a binding EC bioethanol blend mandate policy is to transfer the bioethanol crops commodities equivalent as will be demanded by the mandate into the GTAP model. This will be done by artificially reducing the reference year 2004-bioethanol crop commodities production in the EU by an equivalent amount as will be demanded by the bioethanol mandate equilibrium conditions as derived in Chapter 3.

The reduction in quantities of bioethanol crops commodities due to the diversion of some of their output to the production of bioethanol will be modelled as an artificial reduction in demand for these commodities in the EU market. For example, it was calculated that 26.3% of total 2004 EU27 sugar production would be demand by bioethanol production at 10% blend mandate and sugar beet share (S_{sb}) of 31.1%. This change is therefore simulated as a reduction in demand for sugar in the EU27 by this percentage. The same concept is applied for the other bioethanol crops products i.e. wheat, rye, barley and corn. It should be noted that in the scenario when EU produces 100% of their bioethanol requirements from sugar beet/sugar, the other bioethanol crops would not be affected. In this case, only EU sugar production levels will be artificially reduced by 49% and 86% to simulate the effect of the blend mandate and 5.75% and 10% blend respectively.

Quantity changes are endogenous in the GTAP model and therefore cannot be altered directly. For this reason, the uncompensated own price elasticities of demand for the various bioethanol crop commodities are used and percentage changes in quantities are manipulated via changes in prices. Table 6.6 shows the elasticities of demand for the various ethanol crops in the EU27 as reported in the GTAP model.

Table 6.6: EU27 uncompensated own price elasticity of demand for bioethanol crop commodities

WheatFS	-0.027
GrainFS	-0.036
SugarFS	-0.049
Sugar	-0.631
Extraction	-0.640
ProcFood	-0.672
Petroleum Products	-0.692

Source: GTAP7 DataBase

The GTAP 7 database shows that the price elasticities of demand for corn, barley and rye are all equal with a value of -0.036 but their elasticity is not much different from that of wheat at -0.027. This means that EU27 bioethanol grain crops are not price elastic as per expectation, while sugar, which has a number of substitutes, is relatively more price elastic with an elasticity of -0.631. Petroleum products, which include petrol and diesel, have a price elasticity of -0.692.[30]

However, manipulation of this elasticity on the GTAP model is not possible without changing the theory and the database of the model. Given that we cannot manipulate the model and the database, we will use this elasticity as stated in the model database.

The artificial percentage decrease in quantities demanded for sugar, wheat, rye, corn and barley are modelled therefore as being due to an increase in their prices. Since price changes are also endogenous in the GTAP model and cannot be altered directly, they are simulated by changing the tax variable, which is exogenous in the model. The manipulation of the tax rate is the standard procedure used in the GTAP

[30] For example, Graham and Glaister (2002) estimated the long run price elasticities of demand for automobile fuel to be between -0.6 and -0.8 and short run elasticities between -0.2 and -0.3. These demand elasticities are within the ranges estimated in other studies (please see also Godwin et al., 2004; Romero-Jordán et al., 2010; Dahl and Sterner, 1991 as discussed in chapter 3)

model to obtain regional elasticities of various commodities in the model as has been discussed in chapter 5.

The demand elasticities for grain crops reported in the GTAP model are rather low. In this way, the method used to simulate the EC bioethanol blend mandate policy, given the low demand elasticities, requires very large price effects. This therefore means a large tax rate is used to artificially depress output and this effectively means the welfare effects are over-estimated by probably a magnitude of 10. Our simulation will therefore have a larger effect on bioethanol crops commodities than other studies but the qualitative results are expected to be intuitive. The problems with the elasticities reported in the GTAP model has also been observed by Berry (2011) who noted that the GTAP model uses elasticities that are estimated via simple (and incorrect) least squares techniques.

The calculated required changes in quantities {*qo (i,r)*} (which is the percentage change in the output of non saving commodity *i* supplied in region *r*) at 5.75% (10%) blend mandate and the different bioethanol crops shares have been calculated before and are summarised in the Table 6.7 below:

Table 6.7: Calculated % quantity changes {*qo (i,r)*} at 5.75 (10) % blend mandate and different bioethanol crops shares *

Sugar	Barley	Corn	Rye	Wheat
At S_{sb}=31.1%, S_c=10.24%, S_w=25.85%, S_b=22.57% and S_r=10.24%				
15.3 (26.3)	17.9 (25.2)	3.7 (5.2)	23.2 (32.8)	4.4 (6.2)
At S_{sb}=100%				
Sugar	**Barley**	**Corn**	**Rye**	**Wheat**
49.1 (85.9)	Nil	Nil	Nil	Nil
*These production percentages changes are with reference to 2004 EU27 commodities production, this being the base year for the GTAP7 Data base that is used in this study.				

Using the elasticities shown in Table 6.6 the calculated percentage increases in prices {*pm(i,r)*} required to bring about the artificial decrease in bioethanol crop quantities as will be demanded by the EC bioethanol blend mandate are reported in Table 6.8. The concept here is simple. The simulation of the EC bioethanol blend mandate policy into the GTAP model is by increasing the prices of bioethanol crops commodities in order to decrease their demand or output. The bioethanol crops commodities demand or output is decreased by an equivalent percentage as will be demanded by the EC bioethanol blend mandate. These percentages have been calculated and reported in Table 6.7 above and are with reference to the annual year 2004 EU bioethanol crops commodities output, 2004 being the base year for the GTAP7 database that is used in this analysis.

Table 6.8: Calculated % price changes *{pm (i,r)}* at 5.75 (10) % blend mandate and different ethanol crops shares

Sugar	Barley	Corn	Rye	Wheat
At S_{sb}=31.1, S_c=10.24, S_w=25.85, S_b=22.57 and S_r=10.24				
28.8(39.6)	312(457)	69 (102)	410 (582)	113 (152)
At S_{sb} =100%				
77 (136)	NIL	NIL	NIL	NIL

As has been noted before, the low price elasticity of demand for wheat, barley, corn and rye means that for a given percentage change in quantity demanded the percentage price change has to be high as is seen in the calculations reported in the Table 6.8.

Decrease demand for gasoline due to the bioethanol blend mandate (as discussed in Chapter 3) needs also to be modelled into the GTAP model. Therefore using a similar approach for the bioethanol crops, the EC bioethanol blend mandate effect on transport fuel is then analysed.

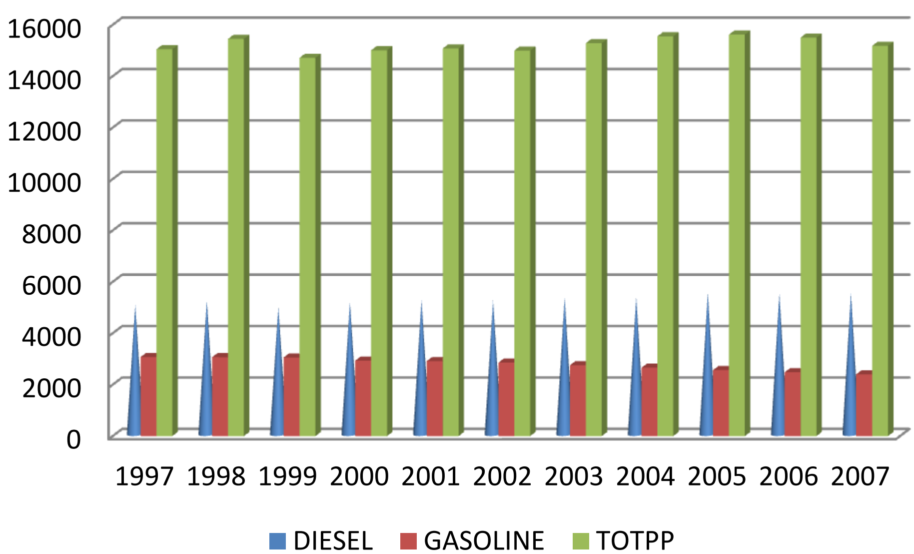
6.3 Modelling the EC bioethanol blend mandate on petroleum products

The effect of the blend mandate on the EU27 transport fuel market is modelled into the GTAP by altering the petroleum products sector of the model. This sector consists of the manufacture of coke oven products, refined petroleum products (which include petrol and diesel) and the processing of nuclear fuels. These sectors form part of the heavy manufacturing sector of the GTAP database. Petrol and diesel production are not isolated out in the model thus it is not possible to analyse accurately changes that affect these commodities. The method of analysing the effect of the EC bioethanol blend mandate on transport fuel is similar to that which was employed for the bioethanol crops commodities, i.e. uncompensated own price elasticity of demand for petroleum products is used.

The simulation of the effect of the EC bioethanol blend mandate policy on petroleum products is simply to simulate a decrease in gasoline quantity or demand by 5.75% and 10%. This represents the amount of gasoline displaced by bioethanol at a blend mandate of 5.75% and 10%.

Figure 6-6 shows the EU27 annual production of petroleum products (which include diesel and gasoline) in the EU27 from 1997 to 2007.

Figure 6-5: EU27 annual total petroleum products, diesel and gasoline production (x1000 barrels per day) 1997-2008



Source: EIA (2010)

Figure 6-6 shows that the demand for diesel in the region has been steadily increasing and is higher than that of gasoline. In 2004 the average demand for diesel was 5.34 million barrels per day which equates to an annual demand of 310 billion litres, about 34% of total petroleum products production in the EU27.

In 2004, the EIA estimated the EU27 demand for transport gasoline to be 2.66 million barrels of gasoline per day. This equates to an annual demand 154 billion litres, which is about 17% of total petroleum products production in the EU27. In the GTAP model, gasoline is aggregated as part of total petroleum products. Therefore, to model the decrease in demand for gasoline we have to calculate the percentage decrease in total petroleum products according to the share of gasoline in this aggregated commodity.

This means that the percentage decrease in EU petroleum products demand as a result of a decrease in gasoline demand can be calculated as follows:

5.75%(8.6% in energy equivalent) reduction of 17% = 1.46%

10% (15% in energy equivalent) reduction of 17% = 2.55%

These percentage reductions are the changes that will be transmitted to the GTAP model to simulate a change in output of total petroleum products due to the blend mandate. The required percentage changes on petroleum products are summarised in Table 6.9 below:

Table 6.9: Elasticity and % change in quantity and price for petroleum products in the EU27 due to the EC bioethanol blend mandate

Blend Mandate	Elasticity	**qo (i,r)*	**pm (i,r)*
5.75%	-0.692	1.46%	2.11%
10%	-0.692	2.55%	3.68%

*Where *qo (i,r)*= % change in quantity; *pm (i,r)*= % change in price due to the blend mandate

Table 6.9 shows that the effect a 5.75% and 10% blend mandate will be to reduce the demand for manufactured petroleum products in the EU27 by 2.11% and 3.68% respectively. These percentage price increases are simply to model the effect of the displaced gasoline by bioethanol. The price of gasoline and the gasoline mixture demanded will however stay the same because of the assumption of the existence of a subdisy in the production of bioethanol as discussed in details in Chapter 3.

Finally, the alterations that are transmitted into the GTAP model to simulate the EC bioethanol blend mandate policy in the EU27 are shown in the Table 6.10 below.

Table 6.10: Alterations of the exogenous tax variable τ to simulate the effect of the EC bioethanol blend mandate policy

Ethanol crop share (%)	Blend mandate	Commodity	Elasticity	*qo (i,r)*	*pm (i,r)*	*Target tax rate*
S_{sb}=31.1 S_b=22.57 S_c=10.24 S_r=10.24 S_w=25.85	5.75%	Sugar	-0.631	15.3	28.8	22.2
		Barley	-0.036	17.9	312	282.4
		Corn	-0.036	3.7	69	58.6
		Rye	-0.036	23.2	410	321.4
		Average				218.1
		Wheat	-0.027	4.4	113	83.4
		Petroleum Products	-0.692	1.46	2.11	2.2
	10%	Sugar	-0.631	26.3	39.6	24.5
		Barley	-0.036	25.2	457	291
		Corn	-0.036	5.2	102	68
		Rye	-0.036	23.2	582	371.2
		Average				248.4
		Wheat	-0.027	4.4	152	98.8
		Petroleum Products	-0.692	2.55	3.68	4.23
S_{sb}=100	5.75%	Sugar	-0.631	49.1	77	62.3
		Petroleum Products	-0.692	1.46	2.11	2.2
	10%	Sugar	-0.631	85.9	136	89.4
		Petroleum Products	-0.692	2.55	3.68	4.23

We now have all the information needed to be transferred into the GTAP model to simulate the EC bioethanol blend mandate policy, which we do in the next section.

6.4 EC bioethanol blend mandate policy simulation

In this section, we run the actual simulation of the EC bioethanol blend mandate policy and analyse the results. To run this simulation we use the GTAP model and GTAP 7 database. As has been mentioned, the simulation of the EC bioethanol blend mandate policy is done through an artificial reduction in the reference 2004 EU biethanol crop commodities production by the percentages as will be demanded by a binding mandate. This depression of bieothanol crops commodities output will be simulated by increasing their output tax, which artificially decreases their demand. The same concept is used to artificially decrease the demand for gasoline in the region. This demand decrease is by an equivalent percentage as will be displaced by bioethanol at the stipulated 5.75% and 10% blend mixture.

Table 6.10 shows the tax changes that are transmitted into the GTAP model. This means that four simulations will be run differentiated by the blend mandates percentages and the sugar beet shares. The different sugar beet shares act as a sensitivity analysis brought about by varying it from 31.1% to 100%. The interest is to determine the effect of these different EU bioethanol sugar beet shares on international bioethanol crops commodities markets.

The solution method applied in the analysis to determine the changes as a result of the mandate is the Johansen method as discussed in Chapter 5. The GTAP 7 database consists of 57 commodities and 113 regions. The 113 regions are defined as aggregates of 226 countries using the GTAP standard country list. The Alpha-3 codes defined by the International Organization for Standardization (ISO) are used as country codes for the GTAP primary regions.

In the sectoral definitions used in the GTAP 7 database, GTAP agricultural and food processing sectors are defined by reference to the Central Product Classification (CPC). The other GTAP sectors are defined by reference to the International

Standard Industry Classification (ISIC) since this is the reference classification point for I-O statistics tables where the GTAP data is sourced. The CPC was developed by the statistical office of the United Nations (UN) and serves as a bridge between the ISIC and other sectoral classifications (Narayanan et al 2008).

The aggregation of the database for the study use the complete GTAPAgg software licensed to the author. Simulation experiments are done using RunGTAP, which is a graphical user environment developed by Mark Horridge of the Centre of Policy Studies at Monash University.

6.4.1 Country aggregation

The countries are aggregated into the following 3 categories:

ACP Countries – African and Caribbean Countries
EU27 – The 27 countries of the European Union
ROW – Rest of the World

The GTAP database is aggregated into 113 regions some of which cannot be disaggregated meaning that some countries have been misclassified.
The following countries have been classified as ACP countries but are not:
French Polynesia, Guam, New Caledonia, Norfolk Island, Tokelau and Wallis and Futuma (Aggregated into Rest of Oceania), Falkland Islands, French Guiana (Aggregated into Rest of South America), Dominican Republic, Grenada, Puerto Rico, Virgin Islands, Anguilla, Aruba, Cayman Islands, Cuba, Guadeloupe, Martinique, Montserrat, Netherlands Antilles (Aggregated into Caribbean). Another case is that of South Africa which has been intentionally classified as an ACP country. It is reasonable to classify this country as such since it part of Southern African Customs Union (SACU) and Southern African Development Community (SADC) and most members of these regions are ACP countries.

The countries which could not be disaggregated from their GTAP aggregation and appropriately classified and which have therefore been classified as ACP countries when they are not are mainly those from the Rest of Oceania region and the Caribbean. Most of them are not large economies and as such, their misclassification is not expected to affect the result much. Besides, since they are located in the same region as most of the ACP member countries their economies are expected to be linked to those of these ACP member states. The effects of an international trade policy that affects some countries of a regional bloc are expected to have spill-overs to the other member countries of that bloc.

It is with such reasoning that South Africa in Southern Africa has been classified as an ACP county when it is not. Because South Africa is part of SADC, it is therefore also affected by policies that affect the SADC region. As such, it makes sense to classify it as part of ACP when the aim is to study international policies that affect the SADC region. Besides, global models especially static ones like the GTAP model are not exact due to problems of data, aggregations and changes in country and regional status.

6.4.2 Sectoral aggregation

For the purposes of the experiment related to an EC bioethanol blend mandate, the original 57 GTAP sectors are aggregated as follows:

- The standard GTAP7 commodities i.e.
    1. MeatLstk – Livestock and meat products
    2. Extraction – Mining and Extraction
    3. ProcFood – Processed Food
    4. TextWapp – Textile and Clothing
    5. LightMnfc – Light Manufacturing
    6. HeavyMnfc – Heavy Manufacturing
    7. Util_Cons – Utilities and Construction

8. TransComm – Transport and Communication
9. OtherServices – Other Services

- and the following new disaggregated sectors:

10. WheatFS – Wheat
11. Sugar
12. SugarFS – Sugar Cane and Sugar Beet
13. GrainFS – Grain crops that can be used as ethanol feed stocks i.e. Maize, Barley, Rye, Oats, Other cereals
14. GrainsCrops – Other crops other than those that can be used to produce bioethanol
15. Petroleum Products – manufacture of refined petroleum products (which is a sector that is part of manufacture of coke oven products, refined petroleum products and processing of nuclear fuel)

It has not been possible to isolate out petrol and diesel from the petroleum product sector but this does not affect the analysis much since their respective percentage shares in the sector is used in our analysis as calculate earlier.

It has not been possible in the database to separate the bioethanol grain crops i.e. maize, barley and rye into their respective component commodities. Only wheat is disaggregated in the model database and the rest of the bioethanol crops commodities are aggregated into grain crops sector which include maize, barley, rye, oats and other cereals in the original GTAP7 sector aggregation. For this reason, these commodities are analysed as an aggregated commodity that is disaggregated according to their respective percentage shares in bioethanol production as calculated earlier. Only wheat, sugar beet, sugar cane and sugar have therefore been disaggregated.

6.4.3 Closure

We apply the Standard GTAP closure rules for this simulation experiment as discussed in chapter 5. In this closure rule, *psave* (the price of composite capital good supplied to savers by global bank) varies by region; *pfactwld* (World price index of primary factors) is the numeraire variable.

The results and analysis of the effects of the EC bioethanol blend mandate policy on ACP/EU regions will focus on welfare changes as a direct result of the application of this policy in the EU region. Analysis will also focus on bioethanol crops commodities output in the various regions and changes in their trade balance. These parameters under analysis are important economic developmental indicators and will form important policy conclusion to the potential economic effects the EC bioethanol blend mandate policy on ACP countries' economies. Emphasis on the sugar industry in our analysis is because of the importance of this sector to many ACP countries' economies as has been discussed before.

It is expected that the increased demand for bioethanol crops in the EU region because of a binding EC bioethanol blend mandate policy will result in increased export sales of bioethanol crops commodities from ACP countries to the EU. In this way, we expect that ACP countries will expand their production of bioethanol crops. However, the need to increase bioethanol crops prices in the EU region in order to encourage their supply to meet the demand created by the mandate will result in overall global welfare loss. The aim of our analysis therefore is to explore these dynamics empirically in order to make informative policy conclusions on the potential economic effects the EC bioethanol blend mandate policy on ACP countries, especially its effect on ACP sugar industries.

The results reported will therefore be at the two levels of blend mandate percentages i.e at 5.75% and 10% blend mandate. They will also be on the two sets of bioethanol crops shares (in percentages), these being i.e (1) S_{sb}=31.1, S_c=10.24, S_w=25.85, S_b=22.57 and S_r=10.24 and (2) S_{sb}=100.

Section 6.5 below presents and discusses the results of the EC bioethanol blend mandate policy simulation.

6.5 Results and discussion

To discuss the effects of the EC bioethanol blend mandate policy on ACP/EU bioethanol crops commodities we first analyse its welfare outcomes. The results of the simulation show that the EC bioethanol blend mandate policy will result in global welfare loss[31]. The welfare outcomes in the different regions are shown in Table 6.11 below.

Table 6.11: Welfare loss as a percentage of GDP of a 5.75% and 10% EC bioethanol blend mandate at sugar beet share of s_{sb}=31.1 (100%)

	5.75% Blend	10% Blend
ACP countries	0.25 (0.13)	0.32 (0.15)
EU 27	0.38 (0.32)	0.48 (0.39)

The absolute welfare losses are shown in Table A6.1 in the appendix section. At a bioethanol blend mandate of 5.75% and a sugar beet share of 31.1% there is an overall global welfare loss of US$53 billion. The EU27 region accounts for 80% of the global welfare loss. ACP countries and ROW account for 2.3% and 13.7% of this welfare loss respectively. At 10% blend mandate and a sugar beet share of 31.1%, the global welfare loss increases to US$60 billion. Again, the EU accounts for a

[31] This welfare loss is measured in equivalent variation (EV) in the GTAP model and its theoretical foundations are discussed in chapter 5.

larger share of this welfare loss. Generally, a higher blend mandate percentage translates to a higher welfare loss as expected.

As a percentage of GDP, the welfare loss is again higher in the EU region that ACP countries at all levels of sugar beet share and blend mandate percentages. For example, at a sugar beet share of 31.1% and blend mandate of 5.75%, the welfare loss experienced by ACP countries is 0.25% of their total GDP while that experienced by EU27 region is higher at 0.38% of their GDP. Of note however is that increasing the sugar beet share used in EU bioethanol production result in lower global welfare loss. For example, increasing the sugar beet share from 31.1% to 100% result in 28% percent drop in global welfare loss from US$53 billion to US$37 billion at 5.75% blend mandate. Again, these results are seen in the appendix in Table A6-1.

However, the EU still accounts for a higher welfare loss both in absolute terms and as a percentage of GDP at this higher sugar beet share. For example, at 100% sugar beet share and 10% blend mandate, the welfare loss experienced by the EU27 region is 0.39% of their GDP while it is 0.15% of GDP for ACP countries. The lower welfare loss at a higher sugar beet share for the EU bioethanol production programme is expected. This is because sugar is not a main food source compared to the other bioethanol crops commodities as has been noted earlier. In other words, household spend less of their income on sugar based food commodities in comparison with the other bioethanol crops commodities. For this reason, it is expected that households will not be as adversely affected if the share of sugar used in bioethanol production is increased.

ACP welfare loss is much lower compared to that of the EU27 region as the sugar beet share used in EU bioethanol production is increased. For example, at a blend mandate of 5.75%, as the sugar beet share is increased from 31.1% to 100%, ACP welfare loss drops by 48% from 0.25% of GDP to only 0.13% of GDP. For the EU region, the corresponding fall in welfare loss is about 16%, from 0.38% to 0.32% of GDP. This could be a competitive advantage indicator in that the EU is a high cost sugar producer. Increasing sugar use in the EU promotes sugar production and trade from ACP countries to the EU region. This is turn improves ACP terms of trade and income and ultimately a higher welfare gain relative to the EU region.

Another possible reason for the lower ACP welfare loss at higher sugar beet share can be explained by the fact that sugar is not a main food source in many ACP countries. This means therefore that the other bioethanol crops commodities, most of which are used as food sources and therefore take a large portion of household budgets, are spared when the sugar beet share for EU bioethanol production goes up.

Policies that increase staple food prices generally have a more significant negative impact on household income and welfare. This is the reason why a higher sugar beet share for bioethanol production in the EU region results in lower impact on ACP household incomes and welfare. The welfare effect of important food commodities has a more significant impact on ACP countries since most of these countries households are poor. Poor households spend a larger portion of their income on food meaning policies that increase basic food prices will have more impact on their welfare.

The global bioethanol crop commodities price increases is the cause for the observed global welfare loss through reduction in household income and utility as mentioned. Indeed the much higher prices of bioethanol crop commodities in the EU region compared to other regions is the reason why the EU region accounts for the majority of the welfare loss. The price changes as a result of the EC bioethanol blend mandate policy are shown in Tables 6.12 and 6.13 below:

Table 6.12: Selected results of % change in market prices due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1

	Regions		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	2.49 (2.82)	3.84 (4.47)	5.06 (6.10)
WheatFS	9.60 (9.94)	86.61 (92.43)	13.30 (15.41)
GrainFS	13.80 (14.23)	88.38 (94.36)	9.20 (10.23)
Sugar	2.10 (2.76)	11.12 (12.34)	3.56 (3.92)
MeatLstk	2.35 (2.78)	15.21 (16.65)	4.43 (5.21)
ProcFood	2.14 (2.67)	6.31 (6.82)	3.05 (3.67)
PetroleumPro	0.96 (1.43)	1.27 (1.83)	1.00 (1.12)

Table 6.13: Selected results of % change in market prices due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=100%

	Regions		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	1.21 (1.61)	2.13 (3.72)	4.12 (5.02)
WheatFS	3.12 (3.83)	7.32 (10.4)	8.11 (9.27)
GrainFS	2.02 (3.32)	10.9 (11.5)	6.23 (8.31)
Sugar	12.91 (14.62)	96.12 (109.13)	13.62 (15.22)
MeatLstk	2.15 (2.21)	11.54 (11.84)	3.91 (4.15)
ProcFood	2.01 (2.13)	4.12 (5.21)	2.95 (3.02)
PetroleumPro	0.92 (1.41)	1.22 (1.81)	1.09 (1.11)

Rosegrant et al. (2006) have also reported a rise in global bioethanol crops commodities prices due to increased biofuel production. Using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), their study concluded that global biofuel production will increase world market prices by 26% for sugar cane, 11% for wheat and 20% for maize in 2010. These percentage price increases will be 66% for sugar cane, 30% for wheat and 41% for maize by 2020. The Rosegrant et al model contains three categories of commodity demand namely food, feed and other use demand. Their study manipulated the “other use” demand for the bioethanol crops commodities namely maize, sugarcane, sugar beet, wheat, and cassava. This means that their analysis of bioethanol production effect on global food markets was similar to ours although they did not report any changes in outputs as a result of their simulations.

For a sugar beet share of 31.1%, our analysis shows that there is a higher price increase in bioethanol crops commodities in the EU region than those reported by Rosegrant et al. The reason could be that our study assumes a binding EC bioethanol blend mandate policy and that the EU region produces all bioethanol from local bioethanol crops commodities. Increasing the sugar beet share in bioethanol production increases global prices of sugar relative to those of the bioethanol crops commodities as seen in the Table 6.12 and 6.13. This corresponds to the expected lower welfare loss as the sugar beet share used in bioethanol production is increased. This is because sugar is not an important household food commodity as has already been mentioned. Even at this high sugar beet share of 100% the price increases as a result of the EC bioethanol blend mandate are bigger in the EU region compared to ACP and ROW regions. The price increases of the rest of the bioethanol crops commodities at a sugar beet share of 100% could be due to a domino effect.

Welfare decomposition has shown that allocative efficiency accounts for most of the welfare loss experience by the regions. However, ACP countries experience a positive terms of trade welfare outcome. This is mainly because the mandate has the effect of increasing prices of bioethanol crops commodities in the EU region; promote bioethanol crop commodities output in ACP countries and increase ACP bioethanol crop commodities export to the EU market. Results of the welfare decomposition are shown in Table A6.2 in the appendix section.

In CGE modelling, industry output response because of a policy change is one of the indicators of the competitiveness of that given industry. Industry output response can be an indicator of which sectors will potentially benefit from a change in policy. For this reason, analysis of this variable has important economic and policy implications for ACP and EU countries. The results of bioethanol crops commodities industry output as a result of the EC bioethanol blend mandate policy are shown in Table 6.14 and 6.15 below.

Table 6.14: Selected results of % change in industry output due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1

	Regions		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	-1.21 (-1.52)	2.24 (2.72)	-0.72 (-0.77)
WheatFS	47.62 (52.74)	-14.12(-18.22)	28.89 (34.32)
GrainFS	15.81 (16.77)	-48.42 (-56.22)	16.20 (18.58)
Sugar	64.21 (68.81)	-25.32 (-27.32)	30.17 (44.72)
MeatLstk	2.12 (2.62)	-5.89 (-6.91)	0.81 (0.74)
ProcFood	0.74 (0.85)	-2.32 (-2.46)	0.15 (0.19)
PetroleumPro	3.39 (3.77)	-1.62 (-3.22)	1.11 (1.35)

Table 6.15: Selected results of % change in industry output due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=100

	Regions		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	-0.11 (-0.22)	0.32 (0.41)	-0.11 (-0.26)
WheatFS	-0.32 (-0.34)	-0.11(-0.22)	0.50 (0.53)
GrainFS	0.78 (0.82)	-0.42 (-0.44)	0.20 (0.42)
Sugar	206.21 (235.52)	-86.12 (-92.19)	120.14 (140.23)
MeatLstk	0.91 (1.06)	-1.72 (-1.94)	0.40 (0.62)
ProcFood	-2.77 (-5.83)	-45.39 (-52.19)	-10.85 (-12.92)
PetroleumPro	2.43 (3.39)	-2.62 (-3.82)	2.23 (2.98)

As mentioned before, the EC bioethanol blend mandate policy has the effect of increasing global demand for bioethanol crops commodities. This increase in demand has the effect of raising their output in ACP countries and ROW. For example, Table 6.14 shows that sugar output increases by 64.21% in ACP countries at a blend mandate of 5.75% and sugar beet share of 31.1% and this output increases to 68.81% at 10% blend mandate. When the sugar beet share used in EU bioethanol production is increased to 100%, sugar output in ACP countries increases by 206.21% at 5.75% blend mandate and 235.52% at 10% blend mandate as shown in Table 6.15 and this is as expected. Sugar output response is higher for ACP countries than the ROW region at all levels of sugar beet share and blend mandate percentage. This could be an indicator of the competitiveness of ACP sugar industries. Of note is the decrease in processed food products as the sugar beet share used in bioethanol production increases. This is because a variety of processed food products uses sugar. In this way, if more sugar is diverted to bioethanol production, output of such processed foods decreases.

The ACP output response for wheat, like that for sugar, is higher than the ROW at 31.1% sugar beet share and both levels of blend mandate as shown in Table 6.14 above. However, for the other bioethanol grain crops commodities i.e. corn, barley and rye, the ROW output response is higher than that for ACP countries at a sugar beet share of 31.1% and at both 5.75% and 10% blend mandate.

Output response for the rest of the bioethanol crops commodities besides sugar is low in all regions as the sugar beet share for EU bioethanol production is increased to 100%. This observation signifies that a higher sugar beet share for the EU bioethanol programme will have less impact on global bioethanol crops commodities (with the exception of sugar) as expected.

Besides industry output, trade balance outcome of a policy is also an important variable to analyse since it affect income or revenue of a given region. In this way, it has welfare consequences. Trade balance analysis may also be an indicator of industry competitiveness following a policy change. Trade balance analysis of the EC bioethanol blend mandate policy show that all the regions other that the EU27 experience a positive terms of trade for all bioethanol crops commodities as shown in Tables 6.16 and 6.17 below.

Table 6.16: Selected results of changes in trade balance (in US$ million) as a result of the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1%

	Regions		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	-101.61 (-122.1)	222.21 (424.56)	-4008.64 (-4222.22)
WheatFS	72.31 (83.34)	-1492 (-1712.3)	10527.13 (11192.31)
GrainFS	228.2 (354.24)	-872 (-901.6)	7537.14(8151.62)
Sugar	832.33 (935.92)	-1118.62 (-1253.73)	1372.96 (1292.34)
MeatLstk	192.34 (213.24)	-4238.62 (-4823.14)	4134.21 (4313.12)
ProcFood	232.12 (318.31)	-3026.22 (-3212.86)	2431.52 (2521.39)
PetroleumPro	122.4 (169.83)	-5022.7 (-5512.8)	4623.23 (4892.13)

Table 6.17: Selected results of changes in trade balance (in US$ Million) due to the EC 5.75% (10%) bioethanol blend mandate at Sugar beet Share of S_{sb}=100%

	Regions		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	-10.15 (-12.72)	426.8 (433.56)	-372.62 (-392.18)
WheatFS	12.32 (15.54)	-136.2 (-142.6)	450.66 (540.34)
GrainFS	16.43 (18.23)	-26.7 (-83.8)	462.41 (676.13)
Sugar	1232.21 (1412.45)	-1916.56 (-2077.34)	1421.23 (1662.36)
MeatLstk	13.52 (14.62)	-41.8 (-45.81)	28.22 (30.29)
ProcFood	172.03 (188.19)	-1942.82 (-1986.41)	1541.73 (1498.72)
PetroleumPro	122.31 (161.18)	-5184.2 (-6124.4)	4774.40 (6122.23)

For example, at a sugar beet share of 31.1 %, ACP countries experience a positive sugar trade balance of about US$832 million at 5.75% blend mandate and US$936 million at 10% blend mandate. On the other hand, the EU27 experience a corresponding negative trade balance of US$1.1 billion and US$1.3 billion at 5.75% and 10% blend mandate respectively. The ROW also experience a positive sugar trade balance of US$1.4 billion at 5.75% blend mandate and US$1.3 billion at 10% blend mandate. These are rather surprising results for the ROW region since one would expect that a higher sugar demand in the EU region would increase the trade balance for the ROW regions as has been observed for ACP countries. This highlights the positive competitive response of ACP sugar industries compared to those of the ROW regions, a trend that has also been supported by the industry output.

An increase in the sugar beet share from 31.1% to 100% results in ACP countries experiencing a positive trade balance in sugar of US$1.2 billion at 5.75% blend mandate and US$1.4 billion at 10% blend mandate. The EU negative trade balance for sugar worsens as the sugar beet share for bioethanol production increases as expected. This trend means that a binding EC bioethanol blend mandate policy will promote sugar industries in ACP countries and improve their foreign revenue when the sugar beet share used in EU bioethanol production is increased.

Trade balance analysis of the EC bioethanol blend mandate policy also shows a trade deficit for wheat and the other bioethanol grain crops in the EU region at a sugar beet share of 31.1%. This wheat trade deficit is about US$1.5 billion at 5.75% blend mandate. As the sugar beet share is increased to 100%, the EU27 wheat trade balance become modest at only US$136 million at 5.75% blend mandate. This signifies the impact of producing EU bioethanol from sugar beet, in which case there is less adverse effect on the market for the rest of the bioethanol crops commodities.

At the lower sugar beet share of 31.1%, the EU27 becomes a net importer of livestock and meat products with the rest of the regions being net exporters. This could be due to the reduction in EU27 grain produce, which is used as animal feed. It is likely that this adverse effect of the EC bioethanol blend mandate policy on the livestock industries could have been less significant or reversed had the model been able to include the effects of DDGs.

An increase of the sugar beet share in the EU bioethanol production programme to 100% result in a modest trade balance impact for meat and livestock products. This is as expected since the grain crops that are used as livestock feed are spared as the sugar beet share for bioethanol production is increased.

An anomaly is that of petroleum products which include gasoline and diesel. The blend mandate has been modelled as decreasing demand for gasoline due to the displacement of some of the it by bioethanol. However, the model results show that the EU27 becomes a net importer of petroleum products as shown by the EU27 negative trade balance reported in Tables 6.16 and 6.17.

This outcome is counter intuitive and could be due to that the increase in the size of the EU region to 27 countries possibly results in an overall high trade deficit in petroleum products for the enlarged region. The petroleum trade deficit as a result of the increase in size of the EU region could be what the model is picking up, with this trade deficit overwhelming the fall in demand brought about by the bioethanol blend mandate. Besides, in the GTAP 7 database, petroleum products not only include gasoline and diesel but also coke oven products and nuclear fuel. It is thus possible that the high aggregation of this sector makes its policy simulation outcomes less accurate.

The bioethanol crops commodities trade balance trend discussed above is supported by the changes in ACP bioethanol crops commodities export to the EU as reported in Tables 6.18 and 6.19 below.

Table 6.18: Selected results of % change in ACP export sales due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=31.1%

	Destination Regions	
Commodities	**EU27**	**ROW**
GrainsCrops	-6.43 (-7.22)	2.34 (2.83)
WheatFS	72.32 (76.01)	34.23 (36.23)
GrainFS	77.42 (82.34)	15.14 (15.83)
Sugar	78.34 (83.84)	8.12 (8.23)
MeatLstk	32.34 (36.45)	10.34 (12.48)
ProcFood	5.12 (6.13)	4.11 (5.34)
PetroleumPro	9.13 (9.48)	1.63 (1.92)

Table 6.19: Selected results of % change in ACP export sales due to the EC 5.75% (10%) bioethanol blend mandate at sugar beet share of S_{sb}=100%

	Destination Regions	
Commodities	**EU27**	**ROW**
GrainsCrops	-6.23 (-7.25)	1.62 (2.17)
WheatFS	8.21 (9.52)	4.12 (5.66)
GrainFS	4.51 (6.31)	12.34 (14.11)
Sugar	178.22 (185.45)	17.23 (18.26)
MeatLstk	10.62 (12.56)	5.42 (6.56)
ProcFood	23.38 (26.56)	2.34 (2.78)
PetroleumPro	8.12 (8.23)	1.34 (1.26)

As can be seen from the Tables above, the EC bioethanol blend mandate policy results in increase in ACP export of bioethanol crops commodities to the EU region. For example, at a 5.75% blend mandate and a sugar beet share of 31.1% there is an increase in ACP export of wheat to the EU27 of 72.32%. This export is higher at 10%

blend mandate, being 76.01% and this trend is followed by all the other bioethanol crops commodities. Also, the higher the sugar beet share used in EU bioethanol production, the higher the sugar export to the EU from ACP countries.

At a sugar beet share of 31.1% sugar export from ACP countries to EU27 increases by 78.34% at a blend mandate of 5.75% and 83.84% at 10% blend mandate. When the sugar beet share for the EU bioethanol production programme increases to 100%, there is a corresponding increase in sugar exports from ACP countries to the EU27. At this sugar beet share, ACP sugar export to the EU increases by 178.22% at 5.75% blend mandate and 185.48% at 10% blend mandate. This is according to intuition since a higher sugar beet share in EU bioethanol production increases EU sugar demand and this expands sugar import from ACP countries.

Sugar export from ACP countries to ROW markets (which represent the world market) increases by 8.12% at 5.75% blend mandate and by 8.23% at 10% blend mandate and a sugar beet share of 31.1%. This export share increases to 17.23% at 5.75% blend mandate and 18.26% at 10% blend mandate when the EU27 bioethanol sugar beet share is increased to 100%. This shows that the EU27 sugar market has an impact on world sugar markets. The increased ACP sugar export to the world markets is because less EU sugar is exported to the world market as a result of the blend mandate policy. Therefore, the EC bioethanol blend mandate will promote ACP sugar industries by promoting sugar export both into the EU27 and the world market, with ACP export expansion to the EU27 market being higher that to the world market. This is as expected since the increase sugar export to world markets by ACP countries is an indirect effect.

Generally, the EC bioethanol blend mandate policy effect of decreasing EU bioethanol crops commodities exports and increasing their prices is not unique to our study. For example, our result compare favourably with those by Koizumi and

Yanagishima (2005) who examined the impact in 2010 of Brazil blending 8% bioethanol in gasoline fuel in 2006. Their study found that Brazilian sugar exports fell by 2.9 percent and sugar prices rose by 5.5 percent as a result of this policy.

The export performance of ACP sugar to the EU27 shows that ACP sugar is more competitive than sugar from the ROW as is summarised in the Table 6.20 below.

Table 6.20: Sugar export % change to the EU27 from various regions at the different sugar beet shares and blend mandate

	Origin Region	
Blend Mandate, Sugar beet share	**ACP Countries**	**ROW**
5.75% Blend, S_{sb}=31.1	78.34	42.23
10% Blend, S_{sb}=31.1	83.84	45.47
5.75% Blend, S_{sb}=100	178.22	76.38
10% Blend, S_{sb}=100	185.45	78.62

Table 6.20 above shows that in terms of export performance, ACP sugar outperforms ROW sugar for the EU market at all levels of the EC bioethanol blend mandate percentage and sugar beet share. The better performance of ACP sugar compared to that from the ROW could be a competitive advantage outcome. It could also be because of internal EU policies that discriminate between ACP sugar and that from the ROW. This highlights the importance of performing this analysis under different policy scenarios like the EPA policies that liberates trade between the EU27 and ACP countries. The blend mandate also increases export of petroleum products and meat and livestock commodities from ACP countries to EU27. Export of petroleum products is less affected by changes in bioethanol crops commodities share used in EU bioethanol production as expected.

For the meat and livestock commodities however, as the EU bioethanol sugar beet share increases ACP export of these commodities to the EU27 falls. This outcome is according to expectations since the EU bioethanol grain crops commodities are also used as animal feed. This means therefore that reducing their share in EU bioethanol production promote livestock industries in the EU region.

6.6 Conclusion

This chapter has motivated the modelling of a binding EC bioethanol blend mandate policy into the GTAP model in order to analyse its potential global spill over effects. Analysis of the EC bioethanol blend mandate policy was based on its welfare outcomes, effects on bioethanol crops commodities output and trade changes mainly in ACP countries and the EU region. Special emphasis of the discussion and analysis was on ACP sugar industries because of the importance of this sector to many ACP countries. The simulation of the EC bioethanol blend mandate followed from the equilibrium bioethanol quantities derived from the model developed in Chapter 3.

Overall, it has been shown that a binding EC bioethanol blend mandate policy will result in global welfare loss. This welfare loss is higher for the EU region than for the rest of the regions, which are namely ACP countries and the ROW. However, the welfare loss is lower as the sugar beet share used in EU bieothanol production is increased. Welfare decomposition has shown that allocative efficiency accounts for most of the welfare loss experience by the regions. However, ACP countries experience a positive terms of trade welfare outcome. Increase in demand for bioethanol crops commodities in the EU result in increased imports of these commodities from other regions. The increase in demand for bioethanol crops commodities in the EU region also result increase in ACP industry output. These outcomes are further supported by trade balance analysis. Trade balance analysis generally shows that the EU region will experience a negative terms of trade in bioethanol crops commodities while the other regions including ACP countries show a positive trade balance.

Undesirable welfare outcomes of bioethanol production have also been a conclusion of several studies. For example, de Gorter and Just (2009) estimated the annual deadweight cost of the combination of USA biofuel mandate and tax credit to be about US$11 billion by 2022. Oladosu and Kline (2010), using the GTAP-E model, concluded that USA ethanol use between 2001-2006 as an output mandate with adjusting household ethanol and petroleum tax rates resulted in a welfare loss of US$ 4304 million in the USA and US$335 million in the EU27. The lower EU welfare loss compared to our result is likely due to the fact that their study analyses the USA biofuel program with the EU being affected indirectly. Further, the USA only uses corn for bioethanol production meaning their bioethanol programme will have lesser impact on the other food commodities like wheat that compete with bioethanol production in the EU region. Khanna et al (2011) estimated the welfare cost of USA biofuel subsidy policies to be around US$122 billion over the 2007–2022 period.

However, the welfare outcomes notwithstanding, the EC bioethanol blend mandate policy will be beneficial to ACP countries' sugar producers. The extent of this benefit depends on the amount of EU sugar that is diverted to bioethanol production. The lower welfare loss because of the increasing the sugar beet share in EU bioethanol production means such a move will also appeal to EU sugar beet farmers. These will benefit from higher EU sugar beet prices and increase in demand for sugar beet in the region.

Our results therefore are not different from those in other studies but our analysis has used a unique approach of first designing an EU bioethanol model in order to simulate the effect of the EC bioethanol blend mandate policy. The global simulation of the mandate has used the GTAP model, a widely used modelling framework to simulate trade policies. In this way, our results can be applicable and comparable to other studies given our model selection and method of investigation. The assumptions made in our study are extreme but are useful in analysing the full extent of the EC bioethanol blend mandate policy on global food markets. The modelling assumptions have been clearly stated and in line with economic principles and in this way, our findings are valid.

However, shortcomings of the GTAP model include the low price elasticities of demand for bioethanol crops commodities. For this reason, in our simulation of the blend mandate (simulated as an artificial decrease in EU27 bioethanol crops demand) we had to increase the prices of bioethanol crops commodities by a huge margin. However, despite the shortfall of the GTAP model, our study approach and the results obtained have been informative.

In the next chapter, we analyse the potential effects of the EPA policies to ACP/EU regions and their potential interaction with the EC bioethanol blend mandate policy.

Chapter 7

EPA/EC bioethanol blend mandate policy simulation on EU/ACP countries

7.0 Introduction

The aim of this chapter is to analyse the potential effects of the Economic Partnership Agreements (EPA) policies and their potential interaction outcomes with the EC bioethanol blend mandate policy. Analysis will focus on ACP/EU welfare effects, production and terms of trade changes in bioethanol crops commodities because of these policies. This analysis is motivated by the fact that policies do not act in isolation. Besides, both policy measures have significant potential trade impacts and they are likely to run concurrently. It is therefore important to take into account the interaction between these policies so as to make more informative conclusions on their potential effect on global trade and welfare.

In an effort to comply with the World Trade Organisation (WTO), the EU and ACP countries have been engaged in EPA trade negotiations. These EPAs are aimed at bilateral liberalization of 'substantially' all trade between EU and ACP member states. In this way, they have potential benefits to ACP countries in that increased trade with the EU will enhance their export earnings, promote their industrialisation and encourage diversification of their economies. As noted by Perez and Karingi (2007) cuts in domestic tariffs will also benefit ACP consumers, who will enjoy lower prices as imported goods become cheaper, as well as promote the most efficient ACP firms, which may improve their integration into the global supply chain.

Beneficial effects of the EPAs to ACP countries have also been found by Morrissey and Zgovu (2009). Their study concluded that even assuming 'immediate' complete elimination of all tariffs on agriculture imports from the EU, and when excluding up to 20% of imports as sensitive products, over half of ACP countries are likely to experience welfare gains. Perez and Karingi (2007) found an ACP welfare gain of US$270 million with deeper regional integration. Without regional integration however, ACP countries experience a welfare loss of US$584 million while the EU had a welfare gain of US$2.7 billion.

Milner, Morrissey and Mckay (2005), using a partial equilibrium model, estimated the welfare gain from a full EPA for 34 ACP countries to be 0.004 % of their Gross Domestic Product (GDP). A study by Keck and Piermartini (2008), using the Global Trade Analysis Project (GTAP) 6 model and database concluded that an EPA with the EU is welfare enhancing for Southern African Development Community (SADC) ACP countries leading to increase in their real GDP. They estimated gains for the region as a whole to be of the order of US$1.5 billion (in constant 2001 dollars) but found some evidence of trade diversion from the rest of developing countries.

Computable General Equilibrium (CGE) models show that with price flexibility, trade liberilisation improves welfare by promoting economic efficiency (Choudhri et al, 2006). Opening up to trade improves the terms of trade for trading regions in that it promotes competitive industries to develop and export more. Indeed, the reduction of import tariffs has the effect of reducing domestic prices, increasing household income and improving welfare. Welfare gains also arise from improvements in the variety of goods on sale through the idea of consumer 'love for variety' but this aspect is difficult to measure empirically. The theory of the welfare effects of a reduction in import tariff has been discussed in Chapter 5. It is envisaged however that this welfare gain arising from the EPAs will be undermined by the EC bioethanol blend mandate policy, which has been shown in the previous chapter to result in global welfare loss.

Again, in analysing these policies emphasis will be placed on ACP/EU sugar production and trade changes. It is expected that since many ACP countries have a competitive advantage in sugar production, accession to EPA policies, *ceteris paribus,* will increase the amount of sugar that is exported by these states to the EU27 region. This is because the EPAs do not place a quota limit to the amount of sugar that can be exported by the ACP member states to the EU. It is also expected *a priori* that the EC bioethanol blend mandate policy together with the EPA policies will result in an overall increase in ACP sugar production and export to the EU region than is the case when these policies act in isolation. In this way, these policy interactions are expected to benefit ACP sugar producing member states.

However, the possible trade changes in bioethanol crop commodities, other than sugar, as a result of the EPAs is unpredictable. It is part of the aim of this chapter to analyse these trade changes in an attempt to answer the following questions:

1. Can the EPA policies result in the EU region importing enough bioethanol crops commodities to meet the EU27 demand as will be created by a binding bioethanol blend mandate? 2. What will be the effects on output of bioethanol crops commodities in the EU27/ACP regions as a result of these policies? and lastly, 3. What will be the global welfare effects of these policies?

Given these objectives, the chapter is therefore organised as follows; section 7.1 simulates the EPA policies on EU/ACP countries and presents and discusses the outcome of these policies. The EC bioethanol blend mandate policy/EPA policy interactions simulation is undertaken in section 7.2, which also presents and discusses the results while section 7.3 is the general conclusion to the chapter.

7.1 Modelling the EPA policies on EU/ACP countries

7.1.1 Policy simulation

To model the effects of the EPAs on EU/ACP regions, the countries and sectors are aggregated as described in chapter 6. To simulate the full EPA policies using the GTAP model, the exogenous variable {*tms (i,r,s)},* which is the tax on imports of tradable commodity *i* from source *r* to destination *s* (levied in region *s*) is reduced to zero percent between the EU27 and ACP countries and vice versa because of reciprocity.

This is the extreme case situation since it does not consider sensitive products that need to be protected and not liberalised and it takes the EPA clause of substantial liberalisation as full liberalisation. Although this is an extreme case it does offer a useful insight into the potential regional comparative outcomes of these policies as an upper bound scenario.

7.1.2 Results and discussion

To analyse the effects of the EPA policies, welfare outcomes of these policies, as shown by the changes in equivalent variations are first analysed: The results of the equivalent variation are shown in Table 7.1:

Table 7.1: Welfare gain of the EPA policies in million US$ (and as % of GDP)

ACP Countries	723 (0.14)
EU_27	6059 (0.047)
ROW	-2419

Table 7.1 shows that the EPA policies will result in overall welfare gains for all the regions involved in these trade agreements. Welfare increase by US$732 million in ACP countries and about US$6 billion for EU27 member states while the Rest of the World (ROW) experience an overall welfare loss of US$2.4 billion. Expressed as a percentage of GDP, ACP countries are the winners from these policies compared to the EU27 region. As seen in Table 7.1 above, the EU27 welfare gain from the EPA policies is only 0.047% of their GDP while that of ACP countries is 0.14%. The high EU27 GDP compared to the other regions could be the reason why the EU27 welfare gain is lower than that for the ACP region. This ACP welfare gain is much

higher than that found by Milner, Morrissey and Zgovu (2005), which was 0.004% of ACP GDP.

However, overall, these policies will be beneficial to the regions that engage in them based on welfare outcomes. Welfare decomposition (Table 7.2) shows that allocative efficiency forms the major source of welfare gain in all the regions.

Table 7.2: Welfare decomposition outcomes (in US$ million) of an EPA policies

Region	Allocative Efficiency	Terms of Trade	Investment/Savings
ACP Countries	472	164	87
EU27	4244	1453	362
ROW	-362	-1949	-108

For example, allocative efficiency welfare gain accounts for 65% of welfare gain in ACP countries and 70% for the EU region. This is because of the re-direction of resources to sectors that are more productive and competitive. Bilateral abolition of import duties between the EU and ACP countries also results in terms of trade welfare gain for these regions. This is a result of reduction in the cost of imports for both trading partners as theory predicts. There is also a welfare gain as a result of investment/savings gains. Again, this welfare gain is expected since opening up to trade results in import of cheaper commodities. In this case, household income improves and so do savings and investments.

In analysing the trade changes in bioethanol crops commodities due to the EPAs policies between the EU and ACP countries, we first analyse their import and export changes due to the effects of these policies. To undertake this analysis we first consider the baseline situation of exports and imports of commodities of bioethanol significance by the EU27 from ACP countries and the ROW and this is shown in Tables 7.3 and 7.4.

Table 7.3: Bilateral export values -VXMD (i,r,s) at world prices from EU27 to other regions – Baseline Data

	Destination Region	
Commodities	**ACP Countries**	**ROW**
GrainsCrops	168.7	6829.3
WheatFS	75.6	1438.2
GrainFS	7.6	582.2
Sugar	54.3	983.6
MeatLstk	227.2	8838.2
ProcFood	2478.1	49831

Source: GTAP7 Data Base

Where:
*VXMD (i,r,s) = PFOB (i,r,s) * QXS (i,r,s)* and is given in millions of US$. In this formula *PFOB (i,r,s)* is the Free on Board Price of commodity *i* exported from region *r* to region *s*. *QXS* is the quantity of commodity *i* exported from region *r* to region *s*.

Table 7.4: Bilateral import values (*VIWS i,r,s*) at world prices from all other regions to EU27- Baseline Data

	Source Region	
Commodities	**ACP Countries**	**ROW**
GrainsCrops	3164.3	31772.3
WheatFS	14.2	1682.2
GrainFS	21.4	1231.3
Sugar	955.1	783.8
MeatLstk	448.8	8933.2
ProcFood	3323.6	37382.4

Source: GTAP7 Data Base

Where:

*VIWS (i,r,s) = PCIF (i,r,s) * QXS (i,r,s)* and is also in millions of US$. In this formula, *PCIF (i,r,s)* is the Cost Insurance and Freight Price of commodity *i* imported from region *r* to region *s*. *QXS (i,r,s)* is the quantity of commodity *i* imported from region *r* to region *s*.

The Tables show that the EU27 is both an exporter and importer of sugar. It is a net exporter to the world market and a net importer from ACP countries. For wheat, the EU27 is a net exporter to ACP countries. It is a net importer from the rest of the world. For the other grain crops commodities, these including maize, oats, barley, rye and other cereals the EU27 is a net importer from all the regions. To convert these values to quantities we divide them by a common price, which is the world market price for the commodity at the time. For sugar, converting the values to quantities is done by dividing the values with the average world market price of sugar in 2004, which was US$231.70/tonne.

Tables 7.5 and 7.6 below show the percentage changes in exports from the EU27 to the other regions and vice versa due to the application of the EPA policies.

Table 7.5: Export sales of commodity *i* (% changes) from other regions to the EU27 after EPA policies

	Source Region	
Commodities	**ACP**	**ROW**
GrainsCrops	17.38	-18.52
WheatFS	26.81	-0.71
GrainFS	6.43	-3.0
Sugar	242.84	-78.42
MeatLstk	138.55	-1.23
ProcFood	20.03	-0.8

Table 7.6: Export sales of commodity i (% changes) from EU27 to other regions after EPA policies

	Destination Region	
Commodities	**ACP Countries**	**ROW**
GrainsCrops	58.22	1.92
WheatFS	31.98	0.63
GrainFS	5.73	1.13
Sugar	95.16	2.63
MeatLstk	86.9	3.42
ProcFood	62.06	-0.02

The results in Table 7.5 and 7.6 above show that full application of the EPA policies will increase sugar exports from ACP countries to the EU by of 242.84% while exports from EU27 to ACP countries increase by 95.16%. This direct effect of the EPAs highlights the competitiveness of ACP sugar industries as compared to the EU27.

Sugar exports from the EU27 to the ROW increase by 1.53% while exports from the ROW to the EU27 shrink by 78.42%, possibly due to the displacement of the Rest of World sugar by duty free sugar from ACP countries. Quantitative analysis of the sugar trade balance in the EU27 shows that the EPA policies will result in an overall increase in sugar in the EU27 of 7.36 million tonnes.

The question then is what is the implication of this change with respect to the EC bioethanol blend mandate policy? The amounts of sugar demanded by the EU27 after an application of the EC bioethanol blend mandate were calculated to be as follows:

25.7 million tonnes of sugar beet =3.3 million tonnes of white sugar (15.3% of total 2004 EU sugar production)- **5.75% Blend, S_{sb}=31.1%**

44.4 million tonnes of sugar beet = 5.7 million tonnes of white sugar (26.3% of total 2004 EU sugar production)- **10% Blend, S_{sb}=31.1%**

81.5 million tonnes of sugar beet =10.6 million tonnes of white sugar (49.1% of total 2004 EU sugar production)- **5.75% Blend, S_{sb}=100%**

143 million tonnes of sugar beet = 18.6 million tonnes of white sugar (85.9% of total 2004 EU sugar production)- **10% Blend, S_{sb}=100%**

This means that the full application of the EPA policies will result in an overall increase in sugar imports into the EU27 that can meet the demand created by a binding bioethanol blend mandate at a sugar beet share of S_{sb}=31.1%. However, this is not the complete story since it is expected that the EPA trade policies will depress the price of sugar in the EU27 due to increased imports. For this reason, it is expected that sugar production in the EU region will go down. This is confirmed by the results of industry output after the full application of the EPA policies as shown in Table 7.7.

Table 7.7: Industry output of commodity i in region r (% change) due to an EPA policies

	Region		
Commodities	**ACP Countries**	**EU27**	**ROW**
GrainsCrops	2.23	-0.52	0.21
WheatFS	-1.7	0.12	0.10
GrainFS	-0.23	-0.14	0.93
SugarFS	26.43	-6.76	-0.74
Sugar	48.93	-18.82	-0.83
MeatLstk	2.62	-0.34	-0.14
ProcFood	-0.88	0.12	-0.19

The results in the Table 7.7 show that the industry output for sugar in the EU27 shrink by 18.82% while it goes up by 48.93% in ACP countries. This is because the EU does not have a competitive advantage in sugar production and will therefore lose out to more efficient sugar producers from tropical nations in the ACP groups of countries. In terms of EU sugar output, El Obeid and Beghin (2005) predicted a substantial decrease of 61% under multilateral liberalization.

According to USDA data, the EU produced 21.65 million tonnes of sugar in 2004. A reduction of 18.82% equates to an output decrease of 4.1 million tonne from the overall 2004 production data. The difference between this output decrease and the increase from imports result in a total of 3.16 million tonnes of sugar. This amount of sugar is not enough to cover its upper demand at a blend mandate of 10% and sugar beet share of 31.1% (as calculated to be 5.7 million tonnes).

Similar analysis is also undertaken for the other bioethanol crops commodities after the application of the EPA policies. From Table 7.6, wheat exports from EU27 to ACP countries increase by 32% while imports from ACP countries increase by 26.8%. This means there was a net outflow of wheat from EU27 to ACP countries, a situation that will worsen the demand for wheat in the EU when these policies are interacted with the bioethanol blend mandate policy. For wheat trade between the EU27 and ROW regions, the trade effects of the two policies are not significant since both EU27 imports and exports of wheat change by less than 1%.

The import structure of the ACP-EU region due to the EPAs is comparable to that from a study by Morrissey and Zgovu (2009) who found an increase in EU import of 18.03% of total agricultural products (including sensitive products) as a result of the EPAs. Milner et al (2009) concluded that the EPAs will result in ACP import increase of all products of 0.08%, which is much lower compared to the changes observed for bioethanol crops commodities from our study.

For the other grain crops, there is an increase in EU27 exports to ACP countries of 5.73% while their imports increase by 6.43%. There is thus not much overall change from the baseline scenario. Considering the grain crops trade between the EU27 and ROW there is an increase in EU27exports of 1.13% while imports decrease by 3%. This means there is an overall outflow of grain crops from the EU27 to the

ROW. Again, there is no significant change from the baseline scenario since the difference between the percentage changes in export and import is small.

The overall conclusion of this analysis is that the EPA policies will result in overall increase in sugar imports from ACP to the EU27. These ACP sugar imports would be enough to meet the demand as would be created by a binding bioethanol blend mandate at a lower blend mandate of 5.75% and sugar beet share of 31.1%. For the other bioethanol crops commodities, such policies will not bring much change from the baseline scenario. This means therefore that the EU27 region will have to increase internal production of bioethanol crops in order to meet demand as will be created by a binding EC bioethanol blend mandate policy. This observation is also supported by insignificant changes in industry output of these commodities in the EU27. The EPA policies only result in EU output changes of less than 1% for wheat and the other bioethanol grain crops commodities.

The results in Tables 7.8 and 7.9 show the changes in prices of commodities after the application of the EPA policies between the EU27 and ACP countries.

Table 7.8: Market price of composite import of commodity *i* in EU27 after EPA policies

Commodity	% Price Changes
GrainsCrops	-0.65
WheatFS	-0.07
GrainFS	-0.12
Sugar	-23.72
MeatLstk	-0.4
Extraction	-0.01
ProcFood	-0.24

Table 7.9: Market price of commodity *i* in EU27 after EPA policies

Commodity	% Price Changes
GrainsCrops	-0.14
WheatFS	-0.07
GrainFS	-0.12
Sugar	-0.31
MeatLstk	-0.05
Extraction	0.01
ProcFood	-0.02

The results above show that the price movement of significance is basically that of sugar imports into the EU27 whereby the import price goes down by 23.72%. The import prices of the other bioethanol crops commodities (as well as market prices of all the bioethanol crop commodities) also go down as expected due to the removal of import duties but the percentage changes are not large. The small price changes of import prices of bioethanol crops commodities into the EU is basically due to the fact that EPA policies liberate commodities from ACP countries. These countries are generally higher cost producers of these commodities possibly because of lack of technology and/or producer subsidies. In this way, the prices of EU imports of these commodities reflect the production costs in these regions.

Sugar is an exception since most ACP countries are efficient producers of this commodity, thus low costs of production imply low import prices for the EU region. The market price in the EU region for the bioethanol crops commodities also goes down by a small amount after the EPA policies. These market prices reflect production cost differences between ACP countries and the EU region once markets return to equilibrium after trade liberalisation. High production costs of bioethanol crops commodities in ACP countries and high cost of sugar production in the EU means trade liberilisation will not reduce prices of these commodities.

The EPA policies' price effects on bioethanol crops commodities outcomes are in contrast to those of the EC bioethanol blend mandate policy, which result in significant price increases in these bioethanol crops commodities in the EU region as we have seen.

Given the results above we now investigate the potential interaction outcomes between the EPA policies and the EC bioethanol blend mandate policy on trade in bioethanol crops commodities between the EU and ACP countries and on overall welfare changes in these regions.

7.2 Simulation of the EC bioethanol blend mandate/EPA policy interactions on ACP countries

7.2.1 Policy simulation

In this section, we will determine the effect of the interplay between the EC bioethanol blend mandate policy and the EPA policies between the EU27 and ACP countries. In this analysis, the simulations of the EC bioethanol blend mandate policy as discussed in Chapter 6 is undertaken together with the simulation of the EPA policies as discussed above.

As mentioned before, analysis will focus on ACP/EU welfare effects, production and trade changes in bioethanol crops commodities because of these policies. The countries and sectors are aggregated as in the simulation of the EC bioethanol blend mandate discussed in Chapter 6 and the model closures are again the standard GTAP 7 closures.

7.2.2 Results and discussion

To analyse the outcomes of the EC bioethanol blend mandate/EPA policy interactions, we first discuss their welfare outcomes. Results (Table 7.10) show that the EC bioethanol blend mandate policy will overwhelm the positive welfare gain due to EPA policies. For this reason, this policy is undesirable especially for the EU region where prices of bioethanol crops commodities increase much more than is the case for the other regions resulting in the observed welfare loss.

Table 7.10: The welfare loss as a percentage of GDP of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1 (100) %

	EV (5.75%)	EV (10%)
ACP countries	0.21 (0.11)	0.28 (0.12)
EU27	0.32 (0.29)	0.44 (0.35)

Again, as in the case with the blend mandate policy alone, the higher the blend mandate percentage the higher the global welfare loss. For all the regions, the higher, the sugar beet share used in the production of bioethanol in the EU27 the lower the welfare loss. Still, for all the regions, welfare loss is higher when the EC bioethanol blend mandate is applied on its own than when combined with the EPA policies. The absolute welfare effects and welfare decomposition are shown in Table A7.1 and A7.2 respectively in the appendix section.

These welfare outcomes compared to previous results show the importance of the analysis of policy interactions. It can be seen that while trade liberalisation has the effect of improving global welfare in terms of improved terms of trade, better allocation of resources and lower prices, there are other policies that have a potential to undermine such welfare gains. The EC bioethanol blend mandate policy is one of such policies. Positive welfare outcomes of trade liberalisation are one of the key benefits of these endeavors as promoted by the WTO. For this reason, it is important that negotiations of trade liberalisation agreements consider other policies that have a potential to negatively affect the welfare gains of free trade.

Again, the welfare loss is as result of the increase in bioethanol crops commodities prices mainly as an adverse outcome of the EC bioethanol blend mandate policy. The prices changes as a result to these policy combinations are shown in Tables 7.11 and 7.12 below.

Table 7.11: Selected results of the % change in market price due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=31.1 %

	Regions		
Commodity	**ACP countries**	**EU27**	**ROW**
GrainsCrops	2.32 (2.78)	1.21 (1.42)	1.82(2.23)
WheatFS	10.24(11.76)	54.12 (59.32)	4.11(5.31)
GrainFS	14.14 (14.86)	74.4 (76.23)	4.42(3.82)
Sugar	3.34 (3.83)	21.23 (22.78)	1.28 (1.63)
MeatLstk	1.13 (1.18)	4.73 (5.84)	1.63 (2.49)
ProcFood	0.86 (1.21)	2.72 (2.84)	1.67 (1.83)
PetroleumPro	0.45 (0.74)	1.21 (1.34)	0.44 (0.56)

Table 7.12: Selected results of the % change in market price due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=100%

	Regions		
Commodity	**ACP countries**	**EU27**	**ROW**
GrainsCrops	1.21 (1.62)	1.32 (1.53)	2 .22(2.52)
WheatFS	3.13 (2.76)	6.42 (9.23)	4.11 (4.62)
GrainFS	1.23 (1.86)	8.2 (8.9)	3.43 (3.92)
Sugar	10.87 (12.07)	93.96 (94.43)	41.47 (43.66)
MeatLstk	1.83 (1.12)	3.34 (4.23)	1.61 (1.82)
ProcFood	0.78 (0.83)	1.32 (2.42)	1.13 (1.24)
PetroleumPro	0.23 (0.42)	3.12 (4.27)	0.3 4(0.41)

The results above show that for example, at an EC bioethanol blend mandate of 10% and a sugar beet share of 31.1% the EC bioethanol blend mandate/EPA policy combinations result in increase in wheat prices of about 59% in the EU region. The prices for the other bioethanol grain crops commodities and sugar increase by about 76% and 23% respectively. For ACP countries, the corresponding price increases are only almost 12% for wheat, 15% for the other bioethanol grain crops commodities and 4% for sugar.

However, a possible ambiguity of our simulation is observed in the prices of bioethanol crops commodities. Results show that ACP prices of bioethanol crops commodities are much higher with the EC bioethanol blend mandate/EPA policies than is the case with the EC bioethanol blend mandate policy alone. For example, at a blend mandate of 5.75% and sugar beet share of 31.1% the price of wheat increase by 9.6% for the EC bioethanol blend mandate. The price increase for the combination policies for wheat is 10.24%. These results are shown in Table 6.12 and Table 7.11. All the bioethanol crops commodities including sugar show this trend. This is an ambiguous finding in that one would expect that opening up trade barriers would result in efficient production and lowering of prices in ACP countries. In this way, the price increases will be lower for the combination of the policies than for the EC bioethanol blend mandate policy on its own.

The EPA policies, as has been observed in the previous section, do not significantly reduce the prices of bioethanol crops commodities in the EU and ACP regions. In our simulation, we have modelled the EC bioethanol blend mandate policy as a tax on bioethanol crops commodities output or demand. In this way, resources shift away from bioethanol crops commodities sectors to sectors that are more efficient. This result in high production costs for bioethanol crops commodities which is made worse by trade liberalisation and further shifting of resources to other more efficient sectors. This could in part explain the abnormal observation of higher bioethanol crop commodities prices in the ACP regions for the combination of the EC bioethanol blend mandate/EPA policies.

Welfare decomposition shows that ACP countries experience a positive terms of trade welfare outcome after the EC bioethanol blend mandate/EPA policy interactions. However, this positive terms of trade welfare gain is lower than when the EC bioethanol blend mandate policy is applied on its own. These results are shown in Table 7.13 below;

Table 7.13: Welfare decomposition (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1 (100) %

Region	*BM%	Allocative Efficiency	Terms of Trade	Investment/Savings
ACP	5.75%	-705(-562)	126 (64)	-23 (-27)
Countries	10%	-1090 (-1002)	202 (154)	-57 (-64)
	5.75%	-30420 (-29494)	-4020 (-5002)	-292(-471)
EU-27	10%	-47234(-43480)	-4983 (-3680)	-617(-862)
	5.75%	-5328 (-5490)	-554 (-285)	-83 (-73)
ROW	10%	-6388 (-5780)	-612 (-662)	-213 (-281)

*BM = Blend Mandate

Table 7.13 above shows that ACP countries' terms of trade welfare gain for the EC bioethanol blend mandate/EPA policy interaction is US$ 126 million at a blend mandate of 5.75% and sugar beet share of 31.1%. This terms of trade welfare gain is higher at US$ 412 million for the EC bioethanol blend mandate policy alone as shown in the appendix A6.2

It is therefore likely that bilateral reduction of trade barriers of the EPAs between the EU and ACP countries increases EU export of other commodities to ACP countries. This therefore reduces ACP overall terms of trade.

After the welfare analysis of these policy combinations, we now turn to industry output and changes in trade profiles of bioethanol crops commodities in ACP countries because of these policies. Again, our analysis will place emphasis on sugar production and trade in ACP countries.

Table 7.14: Selected results of % change in industry output due to the EC 5.75% (10%) bioethanol blend mandate/EPA policies at sugar beet share of S_{sb}=31.1

	Regions		
Commodities	**ACP countries**	**EU27**	**ROW**
GrainsCrops	2.13 (2.83)	1.41 (1.65)	1.72 (1.86)
WheatFS	42.26 (45.34)	-15.23(-17.31)	26.42 (28.45)
GrainFS	4.32 (5.62)	-50.23 (-58.31)	14.02 (16.21)
Sugar	78.31 (88.72)	-10.22 (-16.15)	49.28 (55.18)
MeatLstk	2.23 (2.53)	-4.35 (-5.28)	1.24 (1.82)
ProcFood	1.35 (1.96)	-3.13 (-4.23)	1.12 (1.23)
PetroleumPro	2.23 (2.68)	-1.31 (-1.84)	1.35 (1.48)

Table 7.15: Selected results of % change in industry output due to the EC 5.75% (10%) bioethanol blend mandate/EPA policies at sugar beet share of S_{sb}=100

	Regions		
Commodities	**ACP countries**	**EU27**	**ROW**
GrainsCrops	1.23 (1.34)	1.45 (1.82)	-3.33 (-3.78)
WheatFS	4.24 (5.67)	-2.45(-3.24)	5.52 (6.32)
GrainFS	1.25 (1.72)	-1.51 (-1.83)	1.31 (1.63)
Sugar	266.45 (288.34)	-89.43 (-95.92)	128.43 (142.32)
MeatLstk	1.01 (2.11)	-2.24 (-2.39)	1.38 (1.84)
ProcFood	-2.60 (-3.23)	-46.21 (-54.21)	-11.52 (-13.28)
PetroleumPro	2.41 (3.14)	-2.13 (-2.78)	1.24 (1.78)

Industry output show that at a sugar beet share of 31.1% and a blend mandate of 5.75% the other bioethanol crops commodities output is 15.81% for the EC bioethanol blend mandate while it is 4.32% for the EC bioethanol blend mandate/EPA policies as shown in Tables 6.14 and 7.14 respectively. The same trend is shown by wheat but not sugar. ACP sugar output is higher with the EC bioethanol blend mandate/EPA policies than is the case when these policies act independently.

Tables 7.16 summarises the ACP sugar industry output as a result of various policy combinations.

Table 7.16: Summary % changes in sugar output at various policy combinations for ACP countries

Region	Industry output	Policy instrument	Sugar beet % share	Blend mandate %
ACP	78.31 88.72 266.45 288.34	*EBBM/EPA	31.1 31.1 100 100	5.75 10 5.75 10
ACP	64.21 68.87 206.21 235.52	EBBM	31.1 31.1 100 100	5.75 10 5.75 10
ACP	48.93	EPAs		
*EBBM=EC Bioethanol Blend Mandate; EPA=Economic Partnership Agreement				

These outcomes suggest that the combination of the EC bioethanol blend mandate with the EPA policies will promote sugar production in ACP countries much more than the EC bioethanol blend mandate or EPA policies alone. This shows that ACP countries are relatively competitive in sugar. Policies that liberate trade and increase demand for bioethanol crops commodities result in re-allocation of resources to sectors that are more efficient. This is the reason therefore why the ACP sugar industry expands relatively more than the other bioethanol crops commodities sectors. As a result, the EC bioethanol blend mandate policy promotes sugar production in ACP countries despite its negative welfare effects.

The relative competitiveness of ACP sugar industries is also supported by higher trade balance when policies that increase bioethanol crop commodities are combined with those that reduce trade barriers. These results are presented in Tables 7.17 and Tables 7.18 below.

Table 7.17: Selected results of change in trade balance (in US$ million) due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=31.1 %

	Regions	
Commodity	**ACP countries**	**EU27**
GrainsCrops	122.22 (113.34)	2633.24 (3213.24)
WheatFS	48.34 (53.23)	-1321.7 (-1623.7)
GrainFS	94.23 (101.35)	-6469.13 (-7451.45)
Sugar	2622.34 (2718.98)	-3456.23 (-3688.30)
MeatLstk	578.13 (614.34)	-3819.73 (-4261.87)
ProcFood	-151.6 (-123.67)	-1724.33(1753.31)
PetroleumPro	665.34 (734.34)	-49823.42 (-64949.32)

Table 7.18 Selected results of change in trade balance (in US$ million) due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=100%

	Regions	
Commodity	**ACP countries**	**EU27**
GrainsCrops	123.23(114.25)	3424.72(4241.34)
WheatFS	22.32(28.23)	-16.6(-19.23)
GrainFS	26.62(28.56)	-12.56(-10.83)
Sugar	3193.82(3298.24)	-2172.5(-2172.45)
MeatLstk	649.2(678.33)	-5182.32(-5843.78)
ProcFood	-63.23(-67.23)	-2832.54(-3073.23)
PetroleumPro	661.6(713.34)	-49541.7(-64032.8)

For example, the EC bioethanol blend mandate /EPA policies result in an increase in ACP sugar trade balance of US$2.6 billion at a blend mandate of 5.75% and sugar beet share of 31.1%. The wheat trade balance at the same blend mandate and sugar beet share is US$48 million as shown in Table 7.17. In comparison, the trade balance for the EC bioethanol blend mandate policy without the EPA policies is US$823 million for sugar and US$72 million for wheat as seen in Table 6.16 in the previous chapter. Sugar trade balance trend follows that of industry output for ACP countries and these results are summarised in Table 7.19 below.

Table 7.19: Summary of changes in sugar trade balance (in US$ millions) at different policy instruments for ACP countries

Region	Trade Balance Change	Policy Initiative	Sugar Beet % Share	Blend Mandate %
ACP	2622.34 2718.98 3193.82 3298.24	*EBBM/EPA	31.1 31.1 100 100	5.75 10 5.75 10
ACP	832.33 935.92 1232.12 1412.45	EBBM	31.1 31.1 100 100	5.75 10 5.75 10
ACP	2077.24	EPA		
*EBBM=EC Bioethanol Blend Mandate; EPA=Economic Partnership Agreement				

The ACP export performance of bioethanol crops commodities is better for the EC bioethanol blend mandate /EPA policy combinations than is the case when the EC bioethanol blend mandate policy is applied on its own as expected. ACP export changes as a result of the EC bioethanol blend mandate /EPA policy combinations are shown in Table 7.20 and 7.21 below;

Table 7.20: Selected results of the % change in ACP export due to an EC 5.75% (10%) bioethanol blend mandate/EPA policies at S_{sb}=3.11%

	Destination regions	
Commodities	**EU27**	**ROW**
GrainsCrops	9.56(10.22)	-1.32(-0.61)
WheatFS	76.23(86.45)	42.32(44.21)
GrainFS	82.12(87.31)	20.12(22.24)
Sugar	193.22 (212.89)	48.23(56.65)
MeatLstk	13.45(16.45)	4.81(5.63)
ProcFood	6.34(7.47)	2.41(3.08)
PetroleumPro	9.62(9.83)	1.10(1.72)

Table 7.21: Selected results of the % change in ACP export due to an EC 5.75% (10%) bioethanol blend mandate policies at S_{sb}=100 %

	Destination regions	
Commodites	**EU27**	**ROW**
GrainsCrops	10.06 (8.8)	-2.47 (-3.52)
WheatFS	9.34 (9.86)	4.73 (5.52)
GrainFS	4.91 (6.62)	2.23(2.84)
Sugar	252.3 (288.21)	75.29 (84.32)
MeatLstk	5.22 (6.27)	3.45 (3.91)
ProcFood	22.72(23.67)	3.52 (4.37)
PetroleumPro	7.21 (7.42)	1.08 (1.56)

Table 7.21 shows for example that the combination of these policies results in ACP export increase of the other bioethanol grain crops commodities to the EU of 82.12% at 5.75% blend mandate and sugar beet share of 31.1%. This export increase percentage is lower at 72.32% for the EC bioethanol blend mandate policy as shown in Table 6.18 of the previous chapter. These rather large export increases

are purely the full effect of the application a binding EC bioethanol blend mandate policy in the EU region and are mainly due to our basic assumption that the EU produces bioethanol from their 'current' bioethanol crops commodities production. As such, these Figures show the full impact the mandate.

ACP bioethanol crop commodities exports to the EU are much lower for the EPA policies than for the EC bioethanol blend mandate policy. This is as per expectations since EPAs only eliminate trade barriers while the EC bioethanol blend mandate creates demand for bioethanol crops commodities in the EU. This EU demand must be associated with increase imports from ACP countries.

Tables 7.22 summarises the ACP export changes for sugar at the various policy combinations.

Table 7.22: Summary of % changes in sugar export to EU27 at different policy instruments for ACP countries

Region	% Change in Export	Policy Initiative	Sugar Beet % Share	Blend Mandate %
ACP	193.22 212.89 252.3 288.21	*EBBM/EPA	31.1 31.1 100 100	5.75 10 5.75 10
ACP	78.34 83.84 178.22 185.45	EBBM	31.1 31.1 100 100	5.75 10 5.75 10
ACP	242.84	EPA		
*EBBM= EC Bioethanol Blend Mandate; EPA=Economic Partnership Agreement				

In summary, therefore, the EC bioethanol blend mandate/EPA policies will promote ACP sugar industries relatively more than the other bioethanol crops commodities. The export performance of ACP bioethanol crops commodities is generally higher with the policy combinations that when the EC bioethanol blend mandate policy is applied on its own.

7.3 Conclusion

This chapter has shown that policy interactions result in trade and welfare outcomes that are different from the case when such interacting policies act in isolation. In this chapter, we have analysed the effects of the EPA policies on EU and ACP countries and their potential interaction with the EC bioethanol blend mandate policy. It has been shown empirically that the EPA policies tend to reduce the global welfare loss as a result of the EC bioethanol blend mandate policy. This is because the EPA policies result in overall welfare gain for regions engaged in them while the EC bioethanol blend mandate policy results in global welfare loss.

The chapter has also shown that ACP countries stand to benefit from the combination of the EC bioethanol blend mandate/EPA policies in that these policies increase ACP export of bioethanol crops commodities to the EU. This increase in export of bioethanol crops commodities because of these policies is also supported by an increase in industry output of these bioethanol crops commodities in ACP countries and their positive trade balance. The analysis has also revealed that ACP countries have a relative comparative advantage in sugar production. This is because the sugar sector expands relatively more that the other bioethanol crops commodities sectors because of these policies. The combination of the EC bioethanol blend mandate and the EPA policies generally has the effect of creating demand for bioethanol crops commodities in the EU region while abolishing duty and quota restrictions for commodities from ACP countries to the EU region. Therefore, bioethanol crops commodities sectors where ACP countries have a relative competitive advantage expand relatively more. These policy combinations therefore could be pro-developmental for ACP countries. However, because of the

EC bioethanol blend mandate effect of increasing bioethanol crops commodities prices, some of which are important food sources, such policy combinations result in overall negative welfare outcomes that are undesirable.

Chapter 8

Summary, conclusion and extension

8.1 Summary and conclusion

The research has reviewed the international economic implications of an EC bioethanol blend mandate policy as per the EC biofuel directive of 2003. Biofuels generally refers to bioethanol and biodiesel. Biofuels are being promoted around the globe due to growing concern about energy security and as a need to reduce GHG emissions associated with traditional fossil fuels. However, biofuels promotion remain a controversial issue given their competition with food production in a world that is still not food secure.

The EU is one of the regions that has enacted policies and directives aimed at promoting the uptake and use of biofuels as an alternative to traditional fossil fuels, the EC directive of 2003 being one example. This directive aims to mandate the blending of traditional transport fuels with 5.75% biofuel component, with the aim to increase it to 10% by 2020. First generation biofuels are those produced mainly from crops. Our interest in this research therefore has been on bioethanol production because it competes directly with the production of bioethanol crops commodities. The EU produces bioethanol mainly from rye, sugar beet, wheat, barley and corn. This means that the EC biofuel directive or specifically the EC bioethanol blend mandate will have an impact on the market for these commodities. Such commodities are important food sources meaning that their use to produce bioethanol will have global effects on food markets and welfare, given the fact that most households especially in developing countries use a substantial amount of their income for the purchase of food. Increased demand for these bioethanol crops commodities around the globe because of diversion of some of them to the production of bioethanol is therefore expected to result in global welfare loss.

One important bioethanol crop commodity especially for ACP countries is sugar. For many of these countries, sugar is an important foreign revenue earner. The EC bioethanol blend mandate policy is expected to have an impact on the markets for this commodity as well.

It is interesting therefore, to analyse such impacts in terms of their global welfare outcomes and effects on trade balance, production and export performance of bioethanol crops commodities in EU and ACP countries. This is especially so for the sugar industries, which remain vital in the economies of most ACP countries in the light of the 'traditional' sugar trade arrangements such countries have had with the EU. These trade arrangements between the EU and ACP countries were discussed in Chapter 4.

Studies on the EC bioethanol blend mandate policy and indeed on the economics of a blend mandate for the EU region are scant. There is therefore no model that attempts to analyse the implication of the EC bioethanol blend mandate policy on EU and global bioethanol crops commodities markets. This is despite the fact that such a policy will have significant trade implication for ACP countries that trade with the EU region especially in sugar. Of note also is that the EU is an important sugar producer and trader despite the fact that the region is a high cost sugar producer. To promote local sugar production the EU region uses support policies (also discussed in Chapter 4) that are aimed at protecting the region's sugar markets. A binding EC bioethanol blend mandate policy is expected to have an impact on the EU sugar and global markets with important trade implication for ACP countries.

Lack of a suitable model on the EC biofuel blend mandate economics means that our study has had to design such a model under certain assumptions. In Chapter 3, we therefore designed an EU bioethanol partial equilibrium model under the assumption that the EU region produces all bioethanol requirements locally by diverting some bioethanol crops commodities to bioethanol production. Another key assumption was that the EC bioethanol blend mandate policy is binding. In order for bioethanol not to have a price effect on transport fuel, a subsidy that promotes its production was assumed to exist.

The equilibrium conditions of the EU bioethanol partial equilibrium model has been used to analyse its implication or impact on ACP bioethanol crops commodities markets using the GTAP model, a global computable general equilibrium model which we motivated in Chapter 5. As mentioned, focus of our analysis has been on EU/ACP countries sugar productivity, changes in trade balance and on general welfare outcomes.

Simulation of the global effects of the EC bioethanol blend mandate policy using the GTAP model was then undertaken in Chapter 6. Key findings of this analysis were that an EC bioethanol blend mandate policy would result in significant global welfare loss. This welfare loss will be highest in the EU region in absolute terms and even when expressed as a percentage of GDP. Such global welfare loss is as expected since increase in bioethanol crops commodities demand due to the mandate exerts an upward pressure on their prices. The EC bioethanol blend mandate policy effect of increasing bioethanol crops commodities prices has the opposite effect to the EU policy that aims to cut the intervention prices of sugar. The cuts in intervention prices will decrease sugar output in the region, increase consumption and further worsen the demand for sugar. As noted by Elbehri et al (2008), the combined effect of cuts in the sugar intervention prices and production quotas will lead to lower EU sugar production, lower prices for consumers and increase consumption.

Another important finding was that the higher the sugar beet share used in bioethanol production in the EU region, the lower the global welfare loss. A possible reason for this trend is that sugar is generally not a main food source. This means therefore that the other bioethanol crops commodities, most of which are used as food sources and therefore take a large portion of household budgets, are saved when the sugar beet share for EU bioethanol production goes up.

The EC bioethanol blend mandate policy will also increase production of bioethanol crops commodities in ACP countries. This increase in bioethanol crops commodities productivity is positively correlated with the share of that bioethanol crop used in EU bioethanol production in the EU. The EC bioethanol blend mandate policy is therefore also associated with a positive trade balance for bioethanol crops commodities in ACP countries due to the demand created in the EU for these commodities.

However, the EC bioethanol blend mandate policy is not a policy in isolation. There are other important policies that will form the future trade framework between the EU and ACP countries. These policies include the EPA policies (also discussed in Chapter 4). The aim of the EPAs is to abolish quota and tariff restrictions on trade between the EU and ACP countries. It is therefore interesting to analyse the potential interaction outcomes between the EC bioethanol blend mandate policy and the EPA policies. This policy interaction simulation was undertaken in Chapter 7. For this analysis, we first simulated the EPA policies on their own and then on their interaction with the EC bioethanol blend mandate policy.

Key findings are that the EPA policies will result in global welfare gains for all regions involved in these policies, including ACP regions. There is also an increase in sugar output and export from ACP countries because of these policies. This finding is an indicator that many ACP countries are low cost sugar producers and have well developed sugar industries. Further analysis of trade changes due to the EPA policies found that these policies will result in overall increase in sugar exports from ACP to the EU27. EU sugar imports will be enough to meet the demand that will be created by the EC bioethanol binding blend mandate at a lower EU bioethanol sugar beet share. For the rest of the bioethanol crops commodities, the EPA policies will not bring much trade changes from the baseline scenario. This means therefore that the EU27 region will have to increase internal production of bioethanol crops in order to meet demand as will be created by a binding EC bioethanol blend mandate policy.

The EC bioethanol blend mandate/EPA policy interactions however will result in overall global welfare loss, despite the welfare gains due to the EPA policies alone. This signifies the adverse effects the EC bioethanol blend mandate policy will have on global food markets. The welfare loss is again highest in the EU region.

A combination of the EC bioethanol blend mandate/EPA policies also result in ACP bioethanol crops commodities output expanding more than is the case when these policies are simulated in isolation. There is a notable increase in sugar and other bioethanol crops commodities export to EU markets supported by a positive trade balance in these commodities for ACP countries. This means that, the welfare outcomes notwithstanding, the combination of the EC bioethanol blend mandate/EPA policies will be pro-developmental for ACP countries. However, questions remain on their sustainability given the finding that they will result in welfare loss in most of the regions.

The negative welfare outcomes experienced by the EU region as a result of the EC bioethanol blend mandate policy means that it is not in the regions interest to attempt to produce bioethanol to meet the blend mandate demand locally. It would therefore be helpful for the region to consider moving bioethanol production plants to low cost producers like ACP countries where bioethanol can be produced from sugar cane more cost effectively. Another possibility is for the EU region to use policies that promote biethanol importation from low cost producers like Brazil. Investing in bioethanol plants in low cost ACP sugar cane producers will be beneficial for both the EU and ACP countries. The EU will benefit from low cost bioethanol production while ACP countries will benefit from diversification of their sugar industries and improvements in their export base.

8.2 Shortfall of the research and possible extensions

One possible extension of the research is to try making a dynanimc model in the analysis of the EC bioethanol blend mandate policy. CGE models have the shortfall in that they are static and therefore policy impacts cannot be simulated with time frame outcomes. In this way, the policy impact is only analysed at a single point in time and the model does not clearly state the time adjustment process of the policy outcomes. A dynamic CGE model has been used for example by Arndt et al (2008) in their analysis of biofuels, povery and growth in Mozambique.

The CGE model used has also assumed perfect competition. This is not true in reality given for example the various market distorting policies and non-tariff barriers that exist in global trade. Of note about the GTAP model is also that the demand elasticities for grain crops reported are rather low. Therefore, our method used to simulate the EC bioethanol blend mandate policy, given the low demand elasticities, required very large price effects, which overestimated our findings. A possible remedy for this shortfall of the GTAP model is to develop a trade model similar to that by Milner et al. (2005) in their analysis of the trade and welfare effects of the Economic Partnership Agreements.

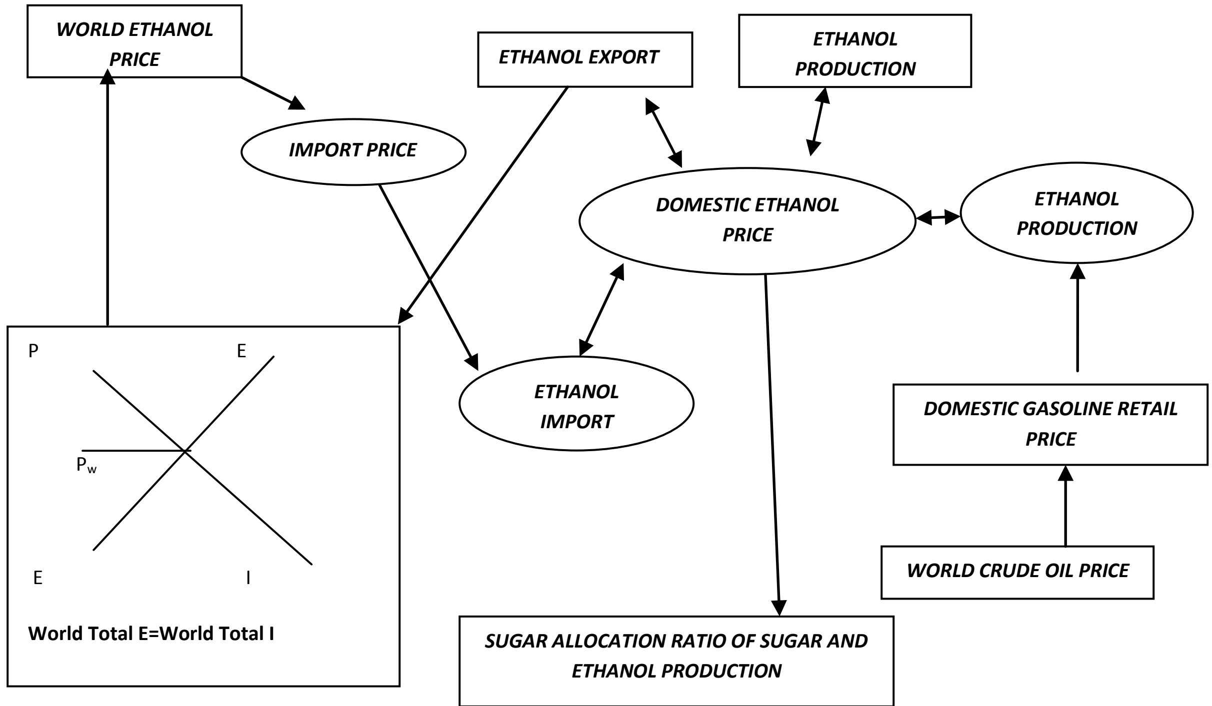
For our anlaylsis of the EC bioethanol blend mandate policy we have not taken into consideration the effect of this policy on land use. This is because we have assumed that the EU produces all the region’s bioethanol requirements from “current” local production of bioethanol crops commodities. This is a strong assumption, which needs to be relaxed to include the potential for the EU to use idle land to produce more bioethanol crops.

Another aspect that could be pursued in this study is the environmental consequences of a binding EC bioethanol blend mandate policy. The use of a certain percentage of renewable fuel as transport fuel is envisaged to reduce GHG emission. The amount of carbon units saved and their impacts on carbon tax and tax credits schemes could be analysed. For reasons of the scope of our analysis, we did not elaborate on the outcomes of the EC bioethanol blend mandate policy on transport fuel and GHG emissions.

Our analysis of the EC bioethanol blend mandate policy and its potential interactions with the EPA policies has been illuminating despite the shortcomings of the GTAP model. These shortcomings are mainly to do with the level of aggregation of the energy sector. This has made it difficult to similate the possible effect of the EC bioethanol blend mandate policy on energy markets. This is because this policy basically affect gasoline, which is not isolated as a stand alone commodity in the model. Biofuels have also not been isolated out as stand alone sector in the GTAP 7 model and database. A new version of the GTAP model called GTAP-E does isolate out bioefuls but this version is again limited in that gasoline is still aggregated as petroleum products.

The level of regional aggregation in the model has resulted in the misclassification of some countries. It is recommended therefore that extension work of this study and intepretation of results take into account the shortcomings of the model.

Figure A3-1: The world Bioethanol model



WORLD SUGAR MODEL

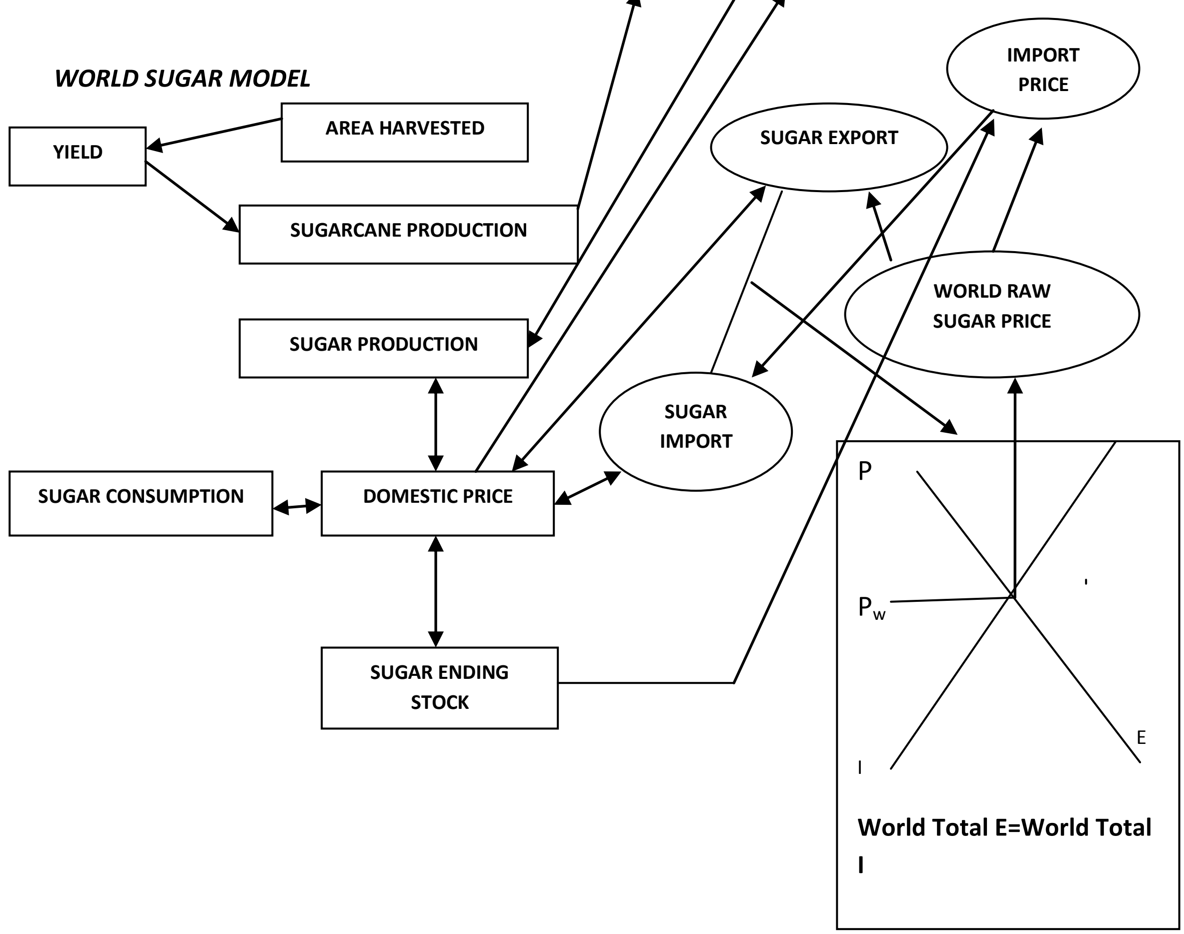


Figure A3-2: Brazilian bioethanol model

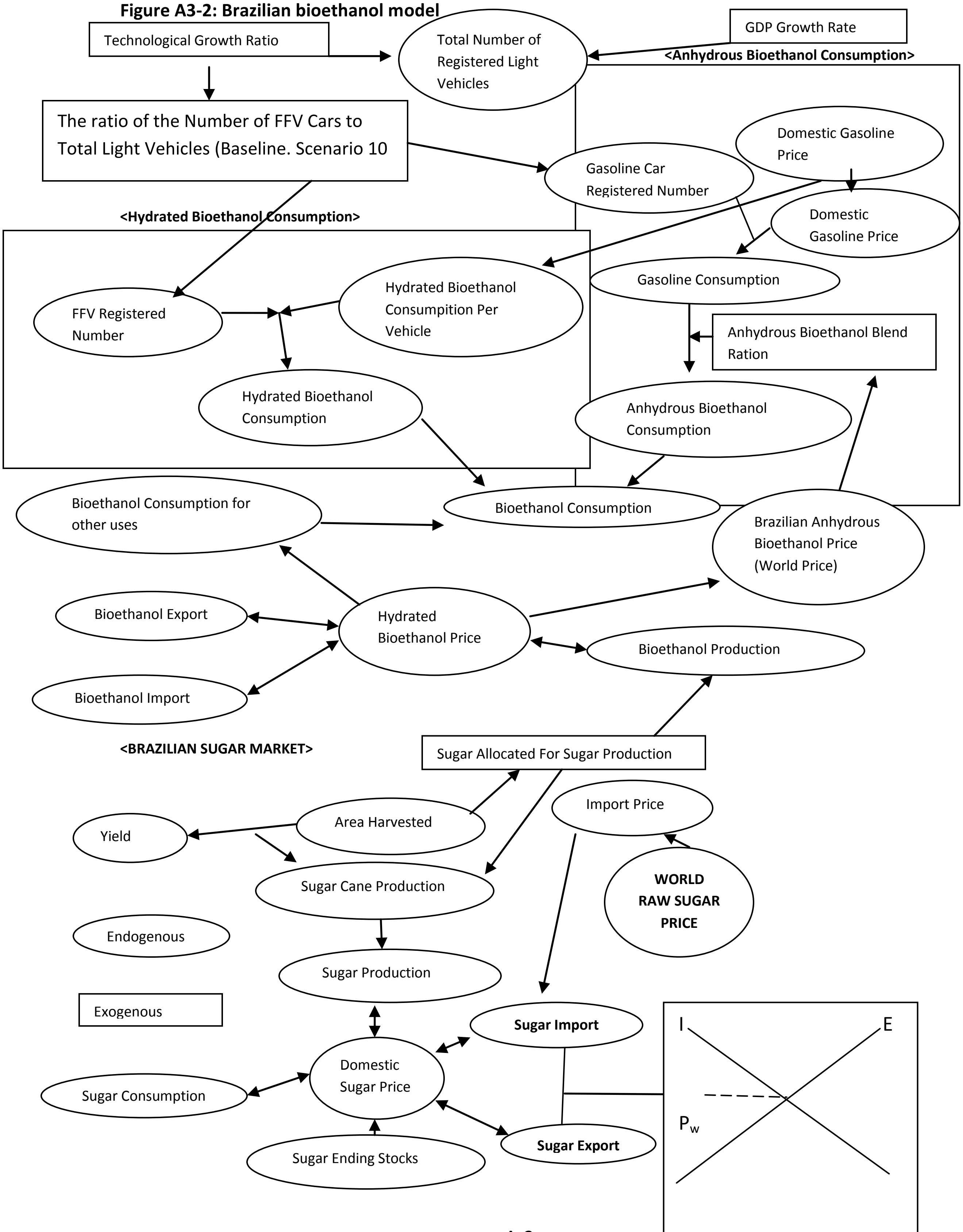


Figure A3-3: USA Bioethanol Model

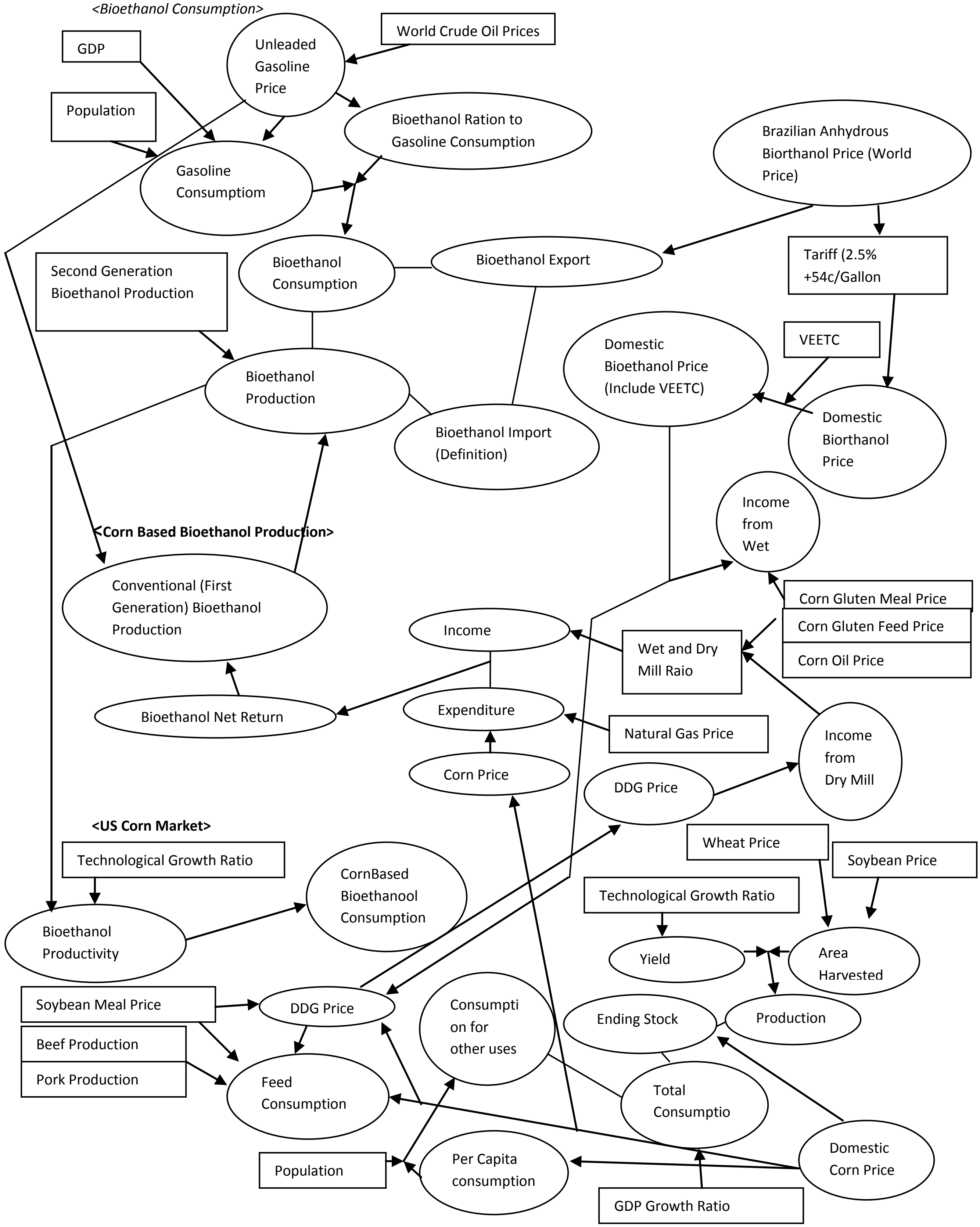


Figure A3-4: Proposed EU-27 Bioethanol Model

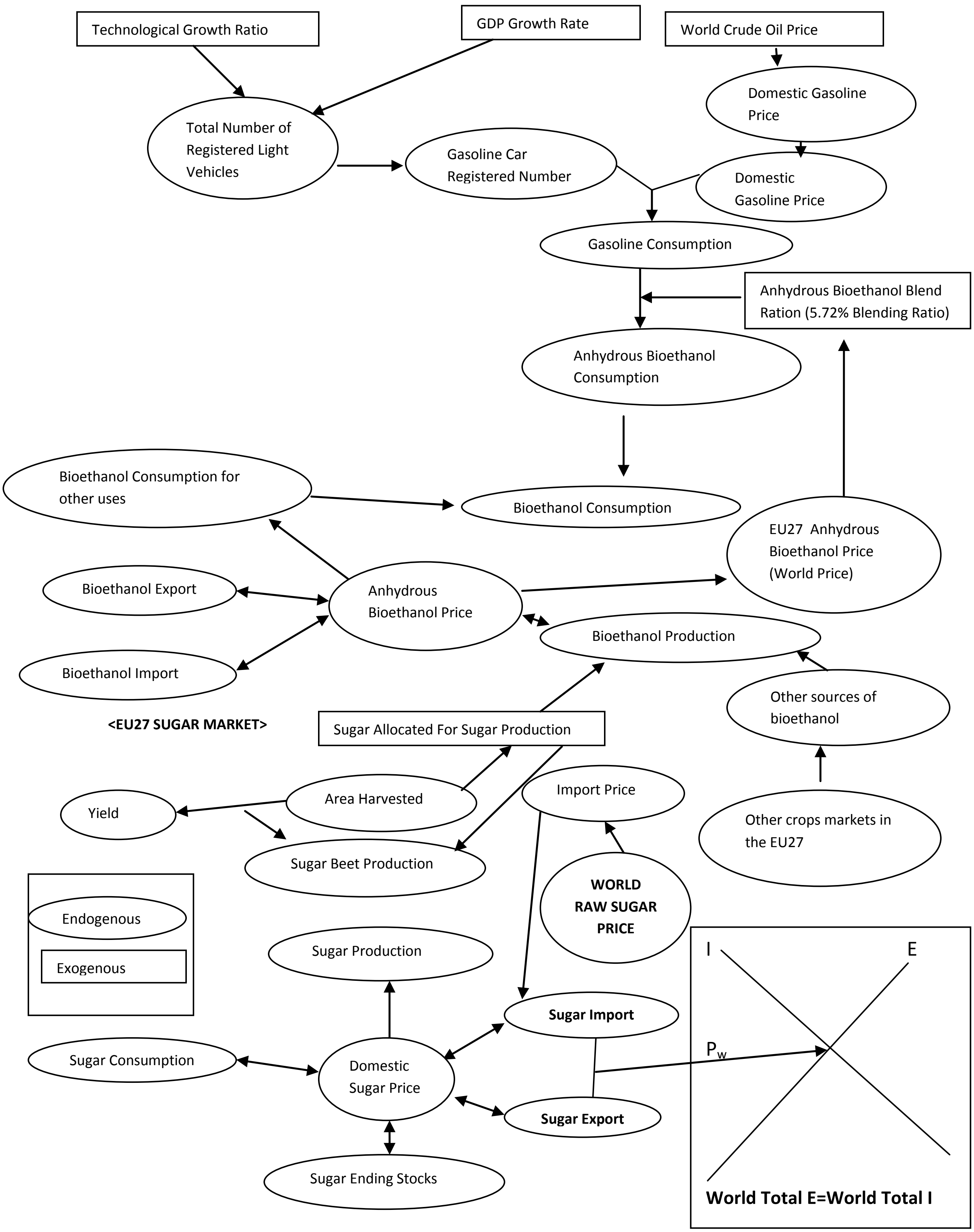


Table A6.1: Welfare effects or Equivalent Variation-EV (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate at sugar beet share of s_{sb}=31.1 (s_{sb}=100)

	Equivalent Variation (5.75%)	Equivalent Variation (10%)
ACP Countries	-1235 (-807)	-1388(-901)
EU-27	-44208 (-32817)	-55292 (-41012)
ROW	-7119 (-4256)	-3632 (-3540)
Total	-5256 2(-37880)	-60312 (-45453)

Table A6.2: Welfare decomposition (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate at sugar beet share of s_{sb}=31.1 (s_{sb}=100)

Regions	*BM%	Allocative Efficiency	Terms of Trade	Investment/Savings
ACP Countries	5.75 10	-1321(-1161) -1482 (-1222)	412 (202) 625 (512)	-326 (-152) -531 (-191)
EU-27	5.75 10	-40112 (-28820) -52202(-42312)	-1317 (-1785) -858 (-2618)	-3413(-2212) -2232 (-1318)
ROW	5.75 10	-6014 (-3825) -2620 (-2682)	-651 (-231) -882 (-632)	-454 (-200) -130 (-226)

*BM= Blend Mandate

Table A7.1: The welfare effects (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1(100) %

	Equivalent Variation (5.75%)	Equivalent Variation (10%)
ACPCountries	-524(-451)	-654(-312)
EU_27	-34632(-32147)	-43463(-40134)
ROW	-5621(-5012)	-6234(-5614)

Table A7.2: Welfare decomposition (in US$ million) of a 5.75% and 10% EC bioethanol blend mandate/EPA policies at S_{sb}=31.1 (100) %

Region	*BM%	Allocative Efficiency	Terms of Trade	Investment/Savings
ACP	5.75%	-605(-462)	106 (33)	-25 (-22)
Countries	10%	-820 (-413)	212 (135)	-46 (-34)
	5.75%	-30220 (-29284)	-4120 (-2731)	-292(-132)
EU-27	10%	-37332(-33480)	-5658 (-6530)	-473(-124)
	5.75%	-5212 (-4490)	-126 (-359)	-283 (-163)
ROW	10%	-5868 (-5283)	-156 (-128)	-210 (-203)

*BM = Blend Mandate

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