

**The effects of the EC ethanol blend mandate on the
EU/Global sugar Market and its implications on sugar
trade with ACP countries**

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Abstract

The study aims determine the effect of the proposed (European Commission) EC transport fuel/bioethanol blend mandate on European Union (EU27) ethanol market by use of a Partial Equilibrium Models as adapted from the FAPRI modelling framework for ethanol production. The outcomes of this study are to be used to study the potential shock this mandate will have on EU/global sugar market. It is envisaged that the proposed EC transport fuel/bioethanol blend mandate, with a tax rebates, will shock both the EU and world sugar market since the EU is a global player in sugar trade. Since bioethanol and sugar compete for the same feedstock, i.e. sugar cane or sugar beet, it is inevitable that the bioethanol blend mandate policies will have effects on the sugar market. By modelling the price of ethanol from that of transport fuel, the study has found that for the EU27 to meet the 5.75% blend mandate as proposed by the EC as a 2010 target, production of ethanol has to be increased by 185 % from 2008 levels and by 78 % from 2010 production forecast. The price of ethanol has to be increased by 226% above its average price from 1998 to 2008.

Introduction

Bio fuel 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 and more recently due to global warming 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. Dutta (1999) equated global warming to the tragedy of the commons thus giving rise to the idea of carbon tax where policies linked to the polluter pays principles are being attempted to reduce carbon dioxide emission into the atmosphere. Another reason for promoting bio fuels is to improve and diversify farm incomes where the production of biofuels is promoted by policies that protect local producers. The EU, being also a signatory to the Kyoto Protocol has also put in place targets that are aimed at promoting production of biofuels. Most notable of this is the EC directive of 2003.

This proposed EC biofuel directive, as outlined in a paper by Hingyi (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.*

Further to the above directive, the (Common Agricultural Policy (CAP) has in place a number of policies that can be viewed as supporting the production of biofuels in the EU.

For example, the CAP reform of 1992 introduced a favorable context for biofuel development through the introduction of compulsory “set-aside” land. In this area, only crops intended for non-food consumption can be cultivated. Farmers are allowed to produce non-food crops (including energy crops) on “set-aside” lands and benefit from a “set-aside” payment of about 63€/ha. The “set-aside” obligation was fixed at the rate of 10% of cereal, oilseed and protein (COP) areas. Since 2003, farmers have been able to take advantage of a special aid of 45€/ha for energy crops if they produce crops intended for biofuel production on arable land. This aid is limited to 1.5Mha for the whole of the EU (Bernard F et al, 2007).

The 2003 reform of the CAP introduced a specific area payment of €45/Ha for the production of energy crops, on up to 1.5 million hectares. From this policy, according to Kuta G et al. 2007, agricultural producers used more than 0.5 million hectares of the land eligible to receive this aid at a cost of EU budget of €25.6 million in 2005 alone. Farmers were also authorized to cultivate non-food crops i.e. feedstock for biofuels on land set aside from food production while still receiving the set aside area payment. As noted by Kuta et al, these set aside payments are in addition to other subsidies that exist in specific states, thus the promotion of biofuel in the EU come at a huge cost.

It is noted however 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 thus it will definitely impact on the dynamics of other crops and livestock activities should the market remain protected from imports.

Schnepf R, 2006 further noted that for the EU to action their policies that promote more use of bio fuels there has to be either major agricultural policies that are put in place to increase bio fuel production or alternatively, more research and investment in developing countries to promote bio fuel production at lower costs which can then be exported to the EU market to meet demand.

The aim of studying this EC directive on biofuel, with focus on bioethanol is to find out the potential shock this directive might have on the EU and global sugar market. Understanding the EU and global sugar markets and the potential effects of shocks on this market is important for African and Caribbean (ACP) Countries that derive revenue from trade in sugar both in the EU and world sugar market. Since the EU is a global player in sugar, a shock in this market will have ripple effects into the world sugar market with important trade implications for ACP countries. According to USDA (2008) the EU produce 15% of world sugar, only second to Brazil (20%) and also account for 13% of global sugar export, second to Brazil (38%). As noted by Huan-Niemi E (2005), the EU is a net exporter of sugar partly due to over production and preferential market access granted to developing countries making the EU an important exporter and importer in the world sugar market not because of having a comparative advantage in sugar production but

because of domestic policies. Since sugar and ethanol compete for the same feedstock, policies that promote ethanol production will inevitably have effects on the sugar market and the question then is what form these effects will take.

Biofuels also include biodiesel which is a mix of methyl esters produced from natural renewable sources like vegetable oils, the most common being rape-seed, sunflower and soybeans (Enguítanos M. et al 2002). Since the focus of the study is to find out the shock the biofuel mandate will have on the sugar industry, only the bioethanol market is analysed.

Model specification

The models to be used for the study are the Food and Agriculture Policy Research Institute (FAPRI) model and the Global Trade Analysis Project (GTAP) model.¹

The FAPRI model will be used for the initial analysis of the sugar and ethanol market in the EU. However, the EU27 ethanol data is not readily available and is of short duration. This is because ethanol production has only just begun in the EU and as such the data is not suitable for a conclusive econometric analysis to come up with meaningful, policy significant conclusions. It is then important to find a suitable model that will use equilibrium analysis scenario to model the effect of this mandate on other markets especially on the EU/global sugar market which will be more illuminating for policy and production decisions especially in ACP countries with an interest in EU and World sugar markets.

For this reason, a GTAP model is more suited to analyze this scenario. However, as a historical analysis of the ethanol industry in the EU and its relationship with ethanol feedstocks the FAPRI will provide vital insights into the design of the model to be used in GTAP analysis. The GTAP is a Computable General Equilibrium (CGE) Model that consists of multiple commodities and multiple regions. The GTAP then is a standard modeling framework that employs simple but robust assumptions of constant return to scales and perfect completion to achieve Walrasian Equilibrium. Given the fact that it comes with a software to manipulate the data to the modeler's aim and with its regional and multi commodity data base, it is ideal to study regional policies like the EU27 biofuel mandate and its spillovers to world sugar market in which ACP countries have an interest in terms of trade in sugar and indeed in future ethanol trade and climate change mitigation initiatives in those countries

¹ The FAPRI model has been developed at the University of Missouri-Colombia (MU) and is extensively used to study supply and demand of major US agricultural commodities i.e. crops and livestock markets, input costs and retail prices, farm incomes and government costs and world trade model while the GTAP is a General Equilibrium Model developed by Hertel in 1997 which can be integrated into multiple regions and commodities.

Modeling the Demand for transport fuel

Initial demand for gasoline (in millions of gallons) without blend can be modeled as follows;

$$Q_{GD}^{EU27} = \alpha_1 + \beta_1 \cdot P_G^{EU27} + \phi_1 \cdot GDP^{EU27} \quad (1d)$$

The above model is as developed by Tokgoz (2009).

From the above, the demand for gasoline in the EU27 (Q_{GD}^{EU27}) is related to its price (P_G^{EU27}) and the Gross Domestic product (GDP^{EU27}).

In the above equation, $\beta_1 < 0$ while ϕ_1 and $\alpha_1 > 0$.

The demand for ethanol is a derived demand from the demand for gasoline in (1d) and is derived simply as follows

$$Q_{EDm}^{EU27} = Q_{GD}^{EU27} \cdot M \quad (2d)$$

Where M is the mandate blend $\in [0, 1]$

From equation (2d) above the derived demand for ethanol in the EU27 with a binding mandate (Q_{EDm}^{EU27}) is simply the demand for gasoline (Q_{GD}^{EU27}) multiplied by the % blend ratio M in energy equivalence as stipulated in the mandate.

The energy equivalent of ethanol is about 2/3 of that of gasoline meaning that a 5.75% blending ratio in energy equivalence is equivalent to 5.75%*3/2=8.6% of ethanol blended with gasoline in volume equivalence.

The blend mandate will affect the price of gasoline and that of ethanol depending on the supply and demand elasticities and tax rebate for using ethanol as opposed to conventional gasoline.

The price of the fuel blend under a mandate can be motivated as shown in the equation below:

$$P_{ge} = M * P_e + [1 - M] * P_g \quad (3d)$$

Where

P_{ge} = price of the gasoline and ethanol blended fuel

P_e = price of ethanol

P_g = price of gasoline

To find the market equilibrium prices it is necessary to equate market supply of fuels to market demands. This involves the derivation of a total fuel supply curve $S_{ge}(P_{ge})$ and then disaggregating it into its components as shown in the motivation below;

$$M * S_{ge}(P_{ge}) = S_e(P_e) \quad (4d)$$

$$[1 - M] * S_{ge}(P_{ge}) = S_g(P_g) \quad (5d)$$

Where $S_e(P_e)$ and $S_g(P_g)$ is the total supply of ethanol and gasoline respectively as a function of their prices and $S_{ge}(P_{ge})$ is the total supply of the fuel blend as a function of its price.

To derive the equilibrium quantities of ethanol P_e , a binding mandate imposes that the consumption of ethanol must be as follows;

$$S_e(P_e) = M D_{ge}(P_{ge}) \quad (6d)$$

Since at equilibrium total supply of gasoline $S_g(P_g)$ must be equal to the total demand $MD_{ge}(P_{ge})$. In this case $D_{ge}(P_{ge})$ is the total demand for the gasoline mixture as a function of its price.

As noted by De Gorter et al (2009) if the fuel demand is perfectly inelastic, such that both the D_{ge} and $M D_{ge}$ curves are vertical, then the mandate will have no impact on fuel consumption, but each gallon of ethanol will exactly displace one gallon of gasoline consumption.

Including a tax credit or tax relief for gasoline blended with ethanol, the effects of a tax credit on the price relationships is as follows:

$$P'_{ge} = M[P'_e + t - tc] + [1 - M]P'_g + t \quad (7d)$$

Where P'_{ge} = taxed price of gasoline blended with ethanol

P'_g = the untaxed price of gasoline

P'_e = the untaxed price of ethanol

t = tax on all fuel

tc = tax credit for using ethanol

M = blend mandate $\in (0, 1)$

Looking at equation (7d) above, blenders of ethanol and gasoline will tend to bid higher the price of ethanol until it is above the market price of gasoline by an amount of the tax credit. If the price premium over gasoline were less than tax credit, then blenders would be making a positive profit from government subsidy by pocketing the difference. But competition among

the blenders will ensure that ‘there will be no free money left on the table’ and thus the price of ethanol will therefore not exceed that of gasoline by the full tax credit. In this case of fixed gasoline price, ethanol simply displaces gasoline consumption. Consumers in this case are not affected but taxpayers pay for the tax credit or tax relief. In this case the blend mandate is shouldered by taxpayers. The motivation of equation 7d and the argument has been adapted from De Gorter et al (2009).

As before the identities below hold

$$D'_{ge}(P'_{ge}) = S'_g(P'_g) + S'_e(P'_e) \quad (8d)$$

$$MD'_{ge}(P'_{ge}) = S'_e(P'_e) \quad (9d)$$

As before, the above identities equate demand to supply for ethanol and gasoline under a binding mandate and a tax credit.

Equation (7d) contains the price relationship between ethanol, gasoline and fuel blend, requiring that fuel retailers charge marginal cost for fuel mixture. Equation (8d) describes the market clearing conditions and equation (9d) describe constrain imposed by the mandate.

Using a tax relief instead of a tax credit, equation (7d) then becomes

$$P^t_{ge} = M[P^t_e - t] + [1 - M]P^t_g \quad (10d)$$

Where t = the tax relief for using ethanol instead of fossil fuels. The identities in equation (8) and (9) remain unchanged.

Equation (10d) above shows that only the ethanol portion benefit from a tax relief.

Where P^t_{ge} = taxed price of gasoline blended with ethanol

P^t_g = the untaxed price of gasoline

P^t_e = the untaxed price of ethanol

t = tax on all fuel

M =blend mandate $\in (0, 1)$

Equation 10d is a derived price motivation of ethanol as adapted from that derived by De Gorter et al (2009) in equation 7d.

The average EU tax on petrol constitutes about 75% of the retail price of gasoline and this includes excise taxes and value added taxes (VAT). As noted by the European Environmental

Agency (EEA, 2003), excise duties have corrected for inflation and risen by one third in the case of petrol in the past 22 years while the VAT has remained stable. The share of tax in fuel prices has risen from 50-55% in the early 1980s to 70-75% today.

Most countries in the EU adopt a full tax exemption on use of renewable fuel, thus a full tax exemption of 70% of the price of gasoline will be used in this study. The equilibrium identity above can then be used to solve for the supply/demand dynamics at the modeled price of ethanol to complete the ethanol market picture in the EU. If supply>demand it means there is no market for ethanol in the EU and the excess can be exported at the modeled ethanol price and if demand>supply it means the market for ethanol exist in the EU and ethanol can be imported at the prevailing price.

The equilibrium quantity and price of ethanol in the EU is found when total supply is equated to total demand and these equilibrium situations can then be used in the GTAP to analyze their implication on the EU/global sugar markets. The initial motivation of the supply and demand for ethanol in the EU assumes that there are no imports of ethanol allowed into the region. This assumption is reasonable and can illuminate the full implication of the ethanol blend mandate in the region and it is a reasonable one if the EU is to promote biofuel production.

The demand for gasoline after a binding mandate can then be derived as thus:

$$Q_{GDm}^{EU27} = \alpha_2 + \beta_2 \{M[P_e^t - t] + [1 - M]P_g^t\} + \phi_2 \cdot GDP^{EU27} \quad (11d)$$

To motivate this new demand and how it will impact on the prices it is necessary to design the supply curve for ethanol and gasoline in the EU and to make certain assumptions about the ethanol and gasoline market in the transport sector.

Modeling the price of ethanol

It is difficult to come up with prices of ethanol that reflect its true market value or the willingness of consumers to pay for it. Assuming a binding mandate that is in place, then the price of ethanol can be derived from that of fossil fuels using the idea of the consumer willingness to pay as the derivation below shows: this derivation assumes that the mandate does not affect consumers i.e. they still pay the same amount for fuel before and after the mandate. This means that the blended fuel cost exactly like the unblended fuel. From equation 10d above i.e.

$$P_{ge}^t = M[P_e^t - t] + [1 - M]P_g^t \quad (10d)$$

Where as before,

P_{ge}^t = the price of the blended fuel
 P_e^{EU} = the derived price of ethanol in the EU
 P_g^{EU} = the price of gasoline in the EU
 t = tax relief to blenders for using biofuels

And assuming $P_{ge}^t = P_g^t$ then the equation below holds:

$$P_e^{EU} = P_g^{EU} + t \quad (13)$$

The motivation of the price above makes the notion that consumers must pay the same amount for fuel before and after the mandate, i.e. the mandate must not change the prices of fuel. This assumption is justified in that it helps set the prices of ethanol that are likely to prevail under the blend mandate. In a sense the mandate in this case is structured such that it leaves consumers indifferent between blended fuel and unblended fuel i.e. the mandate does not harm consumers in any way.

Using the binding mandate, the market price for ethanol is derived from that of fossil fuels using the logic that the mandate should not affect the price consumers pay for transport fuel.

From the above motivation, equation 13 means that the mandate does not have an effect on the price of ethanol but the price of ethanol will be above that of gasoline by the tax rebate. This observation has also been made by De Gorter and Just (2009) who noted that use of ethanol tax credit, which act as a government subsidy for use of ethanol will result in blenders of ethanol and gasoline bidding up the price of ethanol until it is above that of gasoline by the amount of the tax credit.

Since the price of ethanol is derived from that of gasoline in the motivation above, the demand for ethanol can be derived from that of gasoline by use of the blend mandate, which will be a derived demand. This demand can be simulated starting in much earlier years for more data. The demand for gasoline in the EU27 from the years 1984 to 2007 is obtained from US Energy Information Administration (EIA). From this demand for gasoline, the demand for ethanol can be calculated directly using equation (2d) derived earlier, i.e.

$$Q_{EDm}^{EU27} = Q_{GD}^{EU27} \cdot M \quad (2d)$$

where

Q_{EDm}^{EU27} = Demand for Ethanol in the EU27

Q_{GD}^{EU27} = Demand for Transport Gasoline in the EU27

M = The Blend Mandate in place

Thus using the formula below as derived before i.e.

$$Q_{GD}^{EU27} = \alpha_1 + \beta_1 \cdot P_g^{EU27} + \phi_1 \cdot GDP^{EU27} \quad (1d)$$

Where;

Q_{GD}^{EU27} = The Demand for Transport Gasoline in the EU27

P_g^{EU27} = The Average Price of Gasoline in the EU27

GDP^{EU27} = The Gross Domestic Product in the EU27

From the above, the demand for gasoline in the EU27 (Q_{GD}^{EU27}) is related to its price (P_g^{EU27}) and the Gross Domestic product (GDP^{EU27}).

Using identity 1d above, then the price elasticity of demand for gasoline in the EU27 can be modeled. By extension the demand for ethanol can also be modeled as shown below:

$$Q_{EDm}^{EU27} = \alpha_{1a} + \beta_{1a} \cdot P_e^{EU27} + \phi_{1a} \cdot GDP^{EU27} \quad (14)$$

Where;

Q_{EDm}^{EU27} = The Demand for Transport Ethanol in the EU27

P_e^{EU27} = The Average Price of Transport Ethanol in the EU27

GDP^{EU27} = The Gross Domestic Product in the EU27

This means that from the demand for transport gasoline in the EU27, we have all the information to model the demand for transport ethanol. Variations in the blend mandate will only shift the demand curve for ethanol leaving the price unchanged while variation in the tax rebate will affect the price of ethanol since as discussed before (equation 13), the price of ethanol will be above that of gasoline by the amount of the tax rebate.

EU27 GDP data is obtained from International Monetary Fund (IMF) World Economic Data Base. The EU27 is younger than the data used in this analysis but the data used is obtained by aggregating the data of the various member countries and 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.

The ethanol supply in the EU

Ethanol in the EU is produced from a number of feedstocks each of which is envisaged to have a different elasticity with different impacts on other agricultural products. It is then instructive to develop the various supply curves from the different feedstocks used in the EU27 to come up with one general supply curve that will be used to completely analyze the effects of the blend

mandate in as far as elasticities, welfare effects and equilibrium prices and quantities of ethanol is concerned. From here it will then be possible to study the possible implications of these proposed blend mandates and targets on the EU/global sugar markets and what consequences these will have on ACP countries trading on sugar in these markets. This approach to the study of the blend mandate is novel and will be useful in studying the implications of EU policies that have a potential to shock the EU/Global sugar market. Such implications have direct relevance to ACP countries that benefit from trade in EU and global markets.

According to the model developed by Amani and Tokgoz Simla (2008), the share of sugar cane in ethanol production is related to the prices of sugar cane and ethanol by the equation below;

$$S_E^C = \alpha_1 + \beta_1 \cdot (P_E/P_s) \quad (1s)$$

Where S_E^C = share of sugar cane in ethanol production

P_E = Price of ethanol

P_s = Price of sugar

This relationship implies that the proportion of sugar cane used in the production of ethanol is directly related to the prevailing price of ethanol and inversely related to the prices of sugar. This means that prices of the commodities are the drivers of the production decisions.

As mentioned before, the EU uses a number of feedstocks to produce bioethanol and the most important ones recently are wheat, corn, barley, rye and sugar beet and these are the feedstocks to be used to develop the ethanol supply curve in the EU.

Supply of ethanol from grain crops

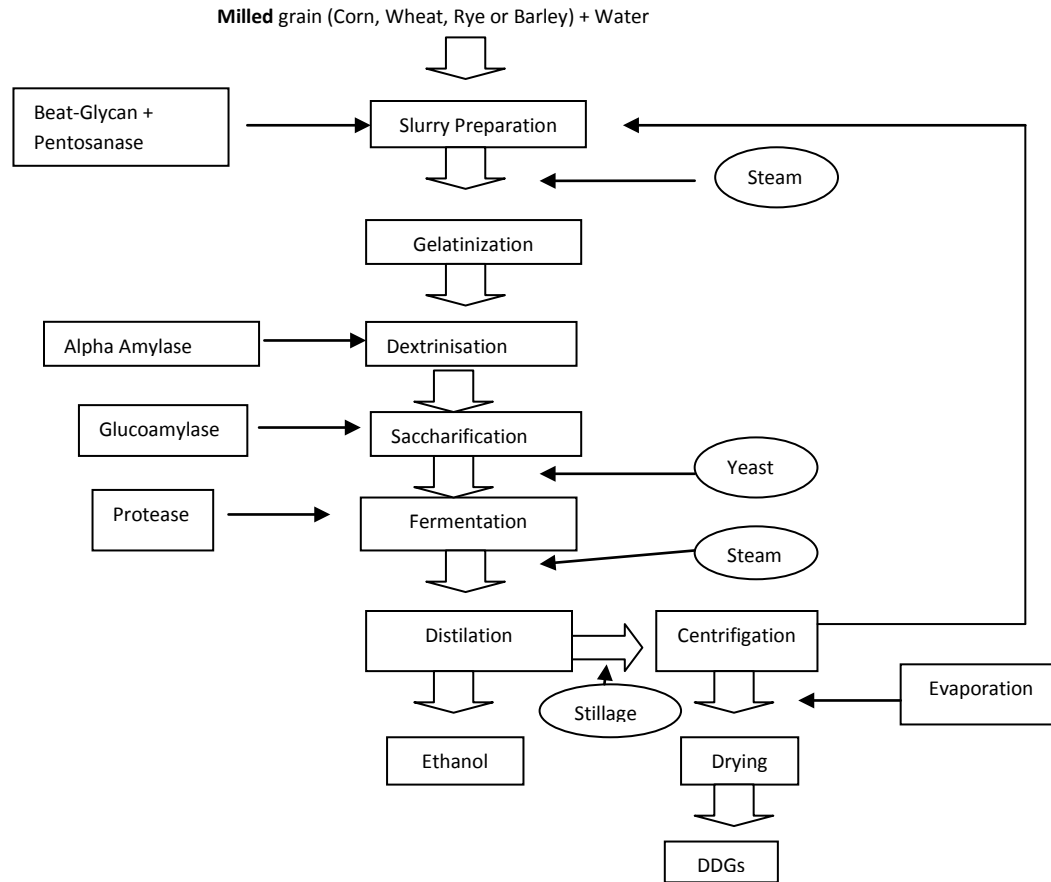
Ethanol production from grain crops like wheat, barley, corn and rye follows the same process of fermentation and the end result is ethanol and dry distillers grain (DDGS) used as an animal feed. This means that modeling the production of ethanol from grain crops follow the same concept. The only difference are the production efficiencies since some of the feedstocks have higher starch or energy contents than others and the prices of the end products of the feedstocks for production of other products other than the alcohol are different which means the elasticities will be different for the different feedstocks, being driven by the price differences of the respective feedstocks.

The production of ethanol from sugar beet is similar to the production of ethanol from sugar cane thus modeling the supply of ethanol from sugar beet will follow similar arguments to the production of ethanol from sugar cane.

The main aim is to come up with one supply curve that relates all these forces and to come up with one ethanol supply elasticity in the EU.

Production of ethanol from grain crops can be summarized by the flow diagram (diagram 1) below:

Diagram 1: Fuel Ethanol from grain crops



Olsen S H (2007) (19)

The supply curve of ethanol from grain crops

The ethanol supply curve from grain crops can be motivated with the guidance of the FAPRI model and the supply curve of USA ethanol from corn as motivated by Amani and Tokgoz Simla (2008).

The net return per kilogram of grain for ethanol plant can be expressed as follows:

$$NR_c^{EU} = \alpha_{ec} P_{ec}^{EU} + \alpha_{ddgc} P_{ddgc}^{EU} - P_c^{EU} - P_{oc}^{EU} \quad (2s)$$

In the above equation;

NR_c^{EU} = the net return per kilogram of corn (or any grain crop) for ethanol production
 P_{ec}^{EU} = the price of ethanol in the EU
 P_{ddgc}^{EU} = the estimated prices of distillers gains and other byproducts from ethanol production
 P_c^{EU} = the price of corn (or the other grain commodities) in the EU
 P_{oc}^{EU} = the price of other byproducts of corn (or the other grain crops) production
 α_x = the conversion rates that are used to convert each price to Euros per kilogram of corn (or the other grain crops).

The breakdown of the byproducts of ethanol from starch crops are combined into the distillers' grain share because of lack of data.

The ethanol production function from corn (and the other grain crops) is given by the identity below:

$$Y_c^{EU} = c + \beta_{ec} NR_c^{EU} \quad (3s)$$

Where

Y_c^{EU} = the ethanol production function in the EU from grain

c = a constant

β_{ec} = the elasticity of ethanol production to its net return from grain, which is expected to be positive

NR_c^{EU} = the net return per kilogram of grain crop for ethanol production

The ethanol production function from sugar beet

The same argument used to motivate the supply functions above is used for the production of ethanol from sugar beet with slight motivations since the byproducts are different from those for ethanol production from grains. In the case of ethanol production from sugar beet, no DDG is produced. Thus we obtain the following production function:

$$NR_{sb}^{EU} = \alpha_{esb} P_{esb}^{EU} - P_s^{EU} - P_{osb}^{EU} \quad (6s)$$

Where;

NR_{sb}^{EU} = net return per kilogram of sugar beet for ethanol production

P_{esb}^{EU} = price of ethanol in the EU

P_s^{EU} = price of sugar in the EU

P_{osb}^{EU} = price of other products from sugar beet production

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

Then the ethanol production function from sugar beet is given by the following relationship

$$Y_{sb}^{EU} = c + \beta_{esb} NR_{sb}^{EU} \quad (7s)$$

Where

Y_{sb}^{EU} = the ethanol production function in the EU from sugar beet

c = a constant

β_{esb} = the elasticity of ethanol production to its net return from sugar beet, which is expected to be positive

NR_{sb}^{EU} = the net return per kilogram of sugar beet for ethanol production

In this case, no distillers' grain is produced so it is left out of the equation.

This supply curves motivate the production of ethanol from existing feedstocks in the EU and looks at the price relationships of converting the feedstocks to ethanol production and the effects this would have on the products of the feedstocks markets.

The final ethanol supply curve

The final ethanol supply curve is the combination of all the supply curves from the different feedstocks divided into the share that each feedstock contributes to the ethanol production function. The ethanol production is as shown below:

$$Y_{Tt}^{EU} = \alpha + \beta P_{Et}^{EU} + (s_w + s_r + s_c + s_b) \left(\frac{\partial P_{DDGt}^{EU}}{\partial s_r s_r P_{rt}^{EU}} - \frac{\partial P_{DDGt}^{EU}}{\partial s_b s_b P_{st}^{EU}} \right) - \partial_c s_c P_{ct}^{EU} - \partial_w s_w P_{wt}^{EU} - \partial_{bt} s_b P_{bt}^{EU} - \quad (12s)$$

In the above formula;

Y_{Tt}^{EU} = total ethanol supply in the EU from the various feedstocks at time t

P_{Et}^{EU} = price of ethanol in the EU at time t

P_{DDGt}^{EU} = the price of DDG in the EU at time t

P_{ct}^{EU} = the price of corn in the EU at time t

P_{wt}^{EU} = the price of wheat in the EU at time t

P_{bt}^{EU} = the price of barley in the EU at time t

P_{rt}^{EU} = the price of rye in the EU at time t

P_{st}^{EU} = the price of sugar in the EU at time t

s_w = share of ethanol production from wheat

s_r = share of ethanol production from rye

s_b = share of ethanol production from barley
 s_c = share of ethanol production from corn
 s_{sb} = share of ethanol production from sugar beet

With the assumption that all the ethanol under study is produced from the above feedstocks considered then

$$s_w + s_r + s_c + s_b + s_{sb} = 1$$

Data

The demand data for ethanol has been calculated from the demand for gasoline, sourced from the Energy Information Administration (EIA) and has been aggregated for the EU27 countries from 1984 to 2008. Prices have for gasoline in the EU27 has been calculated by taking the average prices for each member states. The GDP has been the aggregate of all the individual GDPs in each member state from 1984 to 2008. This then means that the analysis assumes that the EU27 began in 1984, and by using aggregation of the data from each member state, this assumption has no significant effect and it help shed some light on the possible developments in the EU.

The supply data for ethanol in the EU27 has also been sourced from the EIA. However, the supply of ethanol in the EU is only available from the late 1990s and as such; the ethanol supply data starts from 1999 to 2008. This is because the biofuel industry has gained importance as a transport additive in the late 1990s as the available data shows. Also, ethanol production in the EU only began in the early 1990's following the CAP reform. This means then that the supply data for ethanol is of a shorter duration than the demand data for use in regression analysis. For this reason, a truncated regression model was run for the supply curve.

The prices of the feedstocks in the EU27 are derived from the Eurostat data base.

Results

The regressions are run at a 5.75% blend mandate and 10% blend mandates and at a tax rebate of 70%, 60% and 80%. However, the different blend mandates only affect the demand curve. The supply curves is only affected by the tax rebates which result in different prices for ethanol, thus for the supply regression, we only run the regression at a price determined at 70% tax rebate, 60% tax rebate and 80% tax rebate, the 60% and 80% acting as sensitivity analysis.

The summary of the regression results for the demand curves are shown in the table 1 below:

Table 1: Regression results for the demand for transport ethanol in the EU			
*Blend Mandate %	Tax Rebate %	Price Elasticity of Demand	Constant

5.75	70	-0.03553879	305.0136
5.75	60	-0.0375996	305.0136
5.75	80	-0.0334219	305.0136
10	70	-0.0617231	532.004
10	60	-0.0655808	532.004
10	80	-0.0582941	532.004

*The blend mandate % is in energy equivalence, the p values for the coefficient are 0.176 and 0.000 for the constant

The elasticities of supply for ethanol, by use of truncated regression are shown in table 2 below:

Table 2: Regression results for the supply of ethanol in the EU	
% Tax rebate on ethanol	Ethanol supply elasticity*
70	0 .0167 (0.555)
60	0.0178 (0.555)
80	0.0158 (0.555)

*the value in brackets is the p-value.

The elasticities for the other feedstocks are also summarized in the table 3 below:

Table 3: Regression results for the supply of ethanol feedstocks in the EU						
%Tax rebate	Elasticities of supply (p-values are shown in brackets)					
	wheat	rye	barley	Sugar beet	maize	DDG
70,60,80	-7.743(0.008)	-0.9016(0.19)	6.83 (0.04)	-1.24 (0.12)	6.527 (0.02)	0.0938 (0.33)

The equilibrium conditions at 5.75% blend mandate are summarized in table 4 below:

Summary of equilibrium price and quantities at 5.75% blend mandate

Table 4: Equilibrium Prices and Quantities of ethanol in the EU at 5.75% blend mandate		
%Tax rebate	Equilibrium Price (Euros)	Equilibrium Quantity (Barrels per Day)
70	5612.9	105.8
60	5292.7	105.8
80	5957	105.8

The equilibrium conditions at 10% blend mandate are summarized in table 5 below:

Summary of equilibrium price and quantities at 10% blend mandate

Table 5: Equilibrium Prices and Quantities of ethanol in the EU at 10% blend mandate		
%Tax rebate	Equilibrium Price (Euros)	Equilibrium Quantity (Barrels per Day)
70	6633.2	122.8
60	6238.9	122.8
80	7020.9	122.8

The equilibrium conditions were solved by General Algebraic Modelling System (GAMS) as a Mixed Complementarity Problem (MCP).

Discussion

The results show that the effect of an increase in tax rebate result in a less elastic price demand curves for ethanol. Assuming the same supply curve, this will increase the price of ethanol demanded at equilibrium resulting in an increase in the quantity supplied. This increase in quantity is purely an effect of the tax rebate and not increases in quantity demanded by the consumers.

When viewed in this light then, a policy that increases the tax rebate acts as a subsidy to ethanol producers. The effect of a decrease in tax rebate has an opposite effect. It results in a more elastic demand curve and a decrease in price and quantity demanded at equilibrium.

The tax rebate does not have an effect on the equilibrium quantity of ethanol demanded which is 105.8 thousand barrels per day at 5.75% blend mandate and 122.8 thousand barrels per day at 10% blend mandate.

As expected, an increase in the blend mandate has the effect of increasing the equilibrium quantity of ethanol demanded. A 74% increase in the blend mandate from 5.75% to 10% result in a 16% increase in the equilibrium quantity of ethanol demanded by the transport market.

The tax rebate only affect the equilibrium price, being higher at a higher tax rebate and lower at a lower tax rebate as expected. A 10% increase in the tax rebate at 5.75% blend mandate from 70% to 80% result in a 6.1% increase in the equilibrium price while a 10% decrease in a tax rebate from 70% to 60% result in a 5.7% decrease in the equilibrium price of ethanol.

At a 10% blend mandate, a 10% increase in the tax rebate from 70% to 80% result in a 5.9% increase in the equilibrium price while a 10% decrease in a tax rebate from 70% to 60% result in a 5.8% decrease in the equilibrium price of ethanol.

The results above mean that a 10% increase or decrease in tax rebate has the effect of increasing or decreasing the market equilibrium price of ethanol by about 6% irrespective of the blend mandate in place.

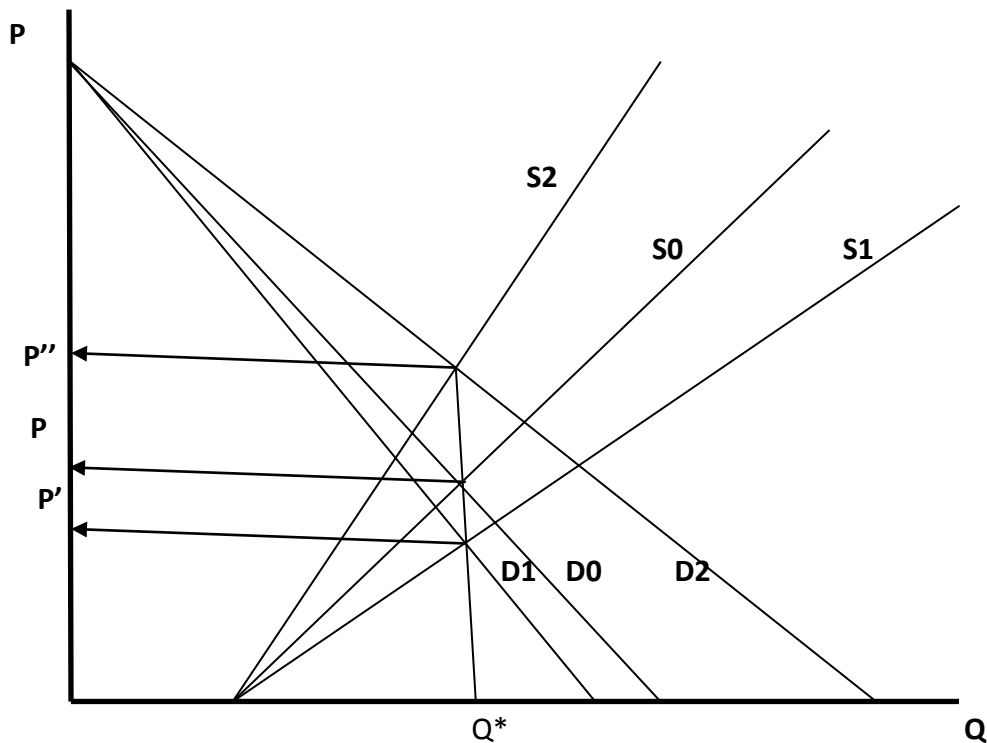
The results above mean that an ethanol blend mandate is important in determining the equilibrium prices and quantities of ethanol. A higher blend mandate will result in a higher equilibrium prices and quantities. However, the price movements from the equilibrium quantities are affected by the tax rebate that is in place. This means that the blend mandate alone is not very informative in itself on the effects it will have on the market for ethanol. It is important that it is analyzed in cognizance of the role the tax rebate play in determining the prices that will prevail due to the mandate that is in place.

The signs in the elasticities of demand for the feedstocks are ambiguous in that in some cases some feedstocks have the expected sign while others do not. The results show that wheat, rye and sugar beet have the expected negative signs in that they will be negatively related to the price of ethanol as theory predicts. However, the elasticities for maize and barley are positive, which is counter intuitive. These ambiguous elasticities are maybe due to the fact that ethanol production EU is still at a small scale and its effect on the prices of competing feedstocks is still not significant and therefore result in ambiguous elasticity outcomes.

The elasticity on DDG is expected to be positive and respond to price movements of ethanol since it is a direct product of ethanol from grain. The elasticity of demand for DDG has the predicted sign but is static and does not change with the changes in the prices of ethanol due to the tax rebate. For the study, the tax rebate only shocks the price of ethanol while in actual sense it should also shock the price of DDG since the two commodities are related. Again the DDG market in the EU is not well developed and the prices for this commodity that were used for this research were abstracted from the prices of DDG in the USA and as such, ambiguous results cannot be ruled out. The above discussion notwithstanding, the analysis has shed some light on the potential effect of a blend mandate and a tax rebate in the EU due to the proposed EC directive on biofuels.

The results can be summarized by the graph 2 below;

Graph 2: Summary of the effects of the EU blend mandate and tax rebates on ethanol equilibrium



**graph not drawn to scale*

The graph above shows that the equilibrium quantity is only affected by the blend mandate, being higher at a higher blend mandate as expected since the blend mandate shift the whole demand curve as opposed to the tax rebate that changes the elasticities. In the above diagram, Q^* is the equilibrium quantity at a given blend mandate and P , P' and P'' are the equilibrium prices at 70%, 60% and 80% tax rebates respectively. A change in blend mandate will not affect the above graph analysis but only the positions of the equilibriums.

Discussion of the results

The results show that if the EU go ahead or had gone ahead with her blending mandate plans as outlined in the EC directive i.e., a 5.75% blend mandate by 2010 and a blend mandate of 10% by 2020, the region would have been required to produce 105.8 thousand barrels of ethanol per day to satisfy the requirements of the mandate and at the proposed blend mandate of 10% by 2020, 122.8 thousands of barrels of ethanol per day would be demanded by this mandate. This analysis is looking at the extreme case where the ethanol is assumed to be produced within the EU with no imports allowed. This extreme case approach is ideal in illuminating the full effect such a mandate would have or would have had on the EU market for ethanol and

other feedstocks that produce ethanol and more especially the sugar market which is the focus of this study.

105.8 thousands of barrels per day equates to an annual EU production of ethanol of 38617 thousand barrels per year or 6 140 103 thousand liters of ethanol per year.²

According to the USDA (2008) the EU produced 2 155 000 thousands of litres of ethanol in 2008 with a forecasted increase to 3 446 000 by the end of 2010. This means that at the 5.75% blend mandate, the production of ethanol in the EU has to increase to by 185% from 2008 production levels to satisfy the expectations of the mandate and for production to be increased by 78% from 2010 forecast.

A total of 122.8 thousands of barrels per day, which will be the equilibrium quantity at 10% blend mandate equates to an annual EU ethanol production of 7 126 250. This means that at 10% blend mandate, the production of ethanol in the EU has to increase by 230% from 2008 production levels to satisfy the requirements of this mandate.

These increases are significant when one considers the pressure they will put on the ethanol feedstocks and the implication on prices. This analysis assumes also that all the ethanol produced in the EU will be used as transport fuel, which is the extreme case assumption.

However, according to the USDA the production potential forecast is expected to be 8,999,000 thousands of liters by 2010. This may seem as if the EU27 can be able to produce enough EU to satisfy the expectation of the mandate but it is not possible to use fully the projected production potential due to other external effects. For example, the USDA noted that in 2007, only about 45 % of the available capacity was utilized due to high grain prices, in particular wheat. This is as expected in that increased production puts a lot of pressure on the demand and prices of the ethanol feedstocks making the full utilization of the potential not feasible.

A market clearing condition of 105.8 thousand of barrels of ethanol a day equates to 1230.2 thousand of barrels per day of gasoline at a blend mandate of 5.75%. In 2008, the EIA estimated that the EU demands 2286.56 thousand barrels of gasoline per day.

The total gasoline blend needed then at 5.75% blend mandate equates to 1336 thousand barrels of the gasoline blend. This means that the blend mandate actually result in a decrease in the demand for the gasoline blend. Using the 2008 total demand of 2286.56 thousands of fuel per day this means a 71% decrease in demand for transport fuel. This decrease in demand is due to the need to increase the price of ethanol to enable supply to be equal to demand. This means that, although the price of ethanol was derived so as to leave consumers indifferent, the equilibrium conditions dictates that the price of ethanol has to increase, which will inevitably increase the price of the fuel blend and due to this price increase, the demand will go down. This means that even though the ethanol price due to the mandate and tax rebate was initially derived to leave consumers indifferent, it will have a negative impact on consumers and will

² This calculation is based on the conversion of 1 barrel (oil, petroleum)=158.99L

make the blended fuel expensive, result in less demand for fuel. This is an unexpected outcome of the analysis which means that consumers will be forced to drive less, which will be beneficial for the environment. Thus, even if the mandate is modeled such that it has no initial effect on consumers of transport fuel, it will inevitably have negative welfare effects on consumers by increasing the price of ethanol and thus the price of transport fuel unless imports are allowed to enter the EU to satisfy this demand.

This means that it is unlikely that the EU27 can or could have successfully apply the suggested blend mandates proposed by the EC without opening up their borders to ethanol imports.

The price implications of the blend mandate

The equilibrium prices of ethanol at 5.75% blend mandate and 70% is 5612.9/1000l and at 10% blend mandate and 70% tax rebate it is 6633.2/1000l.

The average price of ethanol for the years from 1998 to 2008 has been modeled to be 1719.1/1000l. This means that the price of ethanol has to increase by 226% from this 10 year average to satisfy the 5.75% mandate and by 285% to satisfy the 10% blend mandate.

These huge increases in the prices will also affect the prices of the ethanol feedstocks. Thus it is important to model dynamic price movements for the other feedstocks that respond to changes in the prices of ethanol. This means that more feedstocks will be used to produce ethanol and this will increase the prices of the other commodities that compete with ethanol production. Specifically, these changes will shock the sugar market and thus affect trade with ACP countries both in the EU and world market. How these forces will be transferred into the EU/global sugar market will be analysed by use of GTAP modeling.

Conclusion and extensions

The study has shown the possible effects of the EC ethanol/transport fuel blend mandate and using models adapted from the FAPRI modeling it has been shown that this mandate will result in increased demand and prices of bioethanol in the EU. For the full study of the mandate where it is assumed that all the bioethanol will be produced in the region, this increase in demand will result in higher prices of transport fuel and will affect the market of the ethanol feedstocks. The potential effect of these mandates on the EU/global market will best be modeled the GTAP modeling.

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