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INCORPORATING BIOFUELS INTO A PARTIAL EQUILIBRIUM MODEL OF THE EU AGRICULTURAL SECTOR

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Abstract

The impact of increased consumption of biofuels on agricultural markets has already been substantial, and will increase further as countries around the world seek to expand the proportion of their energy that they get from renewable sources. Models of the agricultural sector must therefore include some consideration of the demand for agricultural products for biofuels and the byproducts that are produced as part of the production process that are returned to the agricultural sector. In this paper the method of introducing biofuels into the FAPRI GOLD (grains, oilseeds, livestock and dairy) model is discussed. A scenario is run whereby the EU is assumed to introduce a binding 10% target by 2020 and the results are discussed in order to illustrate the workings of the model. The modelling effort is ongoing and planned work is discussed. The aim of the paper is to highlight major issues in building a model of this type.

Key words: Biofuels, partial equilibrium model, agricultural sector, EU policy

In response to the 2003 Biofuels Directive (European Commission, 2003) EU member states have introduced a variety of policies in order to meet their own national targets for biofuel contribution to transport energy consumption. These policies are a combination of exemptions from specific taxes applied to fossil fuels, mandated levels of biofuel incorporation, and more complex policy tools combining these. The result of these policies will be an increase in the demand for biofuels and therefore the feedstocks that are used to produce them. The increase in demand is significant for a number of feedstocks, with demand for rapeseed oil for biodiesel becoming larger than that for food use, for example. Biofuels markets therefore have to be addressed by models designed for policy analysis in the agriculture sector.

The modeling task is complicated, however, by the multiplicity of policy instruments determined at a member state level, and the need to address the demand for all fuels from the transport sector. In this paper a small model of the EU biofuels sector is presented. It is integrated into FAPRI's dynamic, simultaneous, partial equilibrium model of the agriculture sector in the EU, GOLD. The model is a system of single equations the parameters of which are, on the whole, imposed rather than estimated econometrically given the lack of data and the huge policy changes imposed in the sector in recent years. The model separates the markets of France, Germany, Italy, the UK, and a 'rest of the EU' region. The model estimates gasoline and diesel prices, fuel use for the transport sector and the supply and demand of ethanol and biodiesel for each of the regions. The model solves for EU ethanol and biodiesel prices by determining trade at the EU level.

The model is simulated to generate a baseline simultaneously with GOLD thereby capturing the impact of biofuels policy on the agriculture sector and vice versa. The model is then simulated to analyse the impact of the introduction of the proposed 10 percent of transport fuel use mandate at the EU level. The response of the model to this shock is presented and discussed, with the aim of highlighting the challenges that are faced by modellers of the interaction between agriculture and fuel markets.

The impact of increased demand for biofuels can already be seen in the markets as both the EU and US, along with many other countries in the world, aim to increase the proportion of energy that is sourced from renewable sources. In 2007 the surge in the demand for agricultural products was widely blamed for the significant increase in global commodity prices that occurred, although in many cases it was not the major driving factor. This example illustrates the need for biofuels markets to be built into models used for policy analysis in the agriculture sector as they impact on both the level of demand and, importantly, the elasticity of commodity prices with regard to external shocks. The paper aims to present an example of how this could be addressed, and stimulate discussion of both methodological issues and the impact of biofuels policies on commodity markets.

1. Challenges for the model

Models that seek to represent the EU have been presented with a number of challenges in recent years. The EU has enlarged twice, from 15 to 25 in 2004 and then to 27 member states in 2007. Some of these new member states have agricultural sectors that are significantly different from those in the EU-15, which complicates the analysis. As the EU has enlarged, the volume of data that has been available for the agricultural sectors has sometimes shrunk, with the USDA scaling back its country coverage and several important series published by EUROSTAT and the European Commission discontinued. Thus just the maintenance and the expansion of the models has been difficult, even without consideration of the changing policy environment.

In addition to the enlargement there has also been a radical reform of the CAP. The introduction of the single farm payment (SFP) has resulted in a need to model a different type of payment of which there is little historical precedence. Although there are some studies of the impact of decoupling of payments, neither the studies of the old CAP payments, or of the similar, direct payments made in the USA provided definitive answers to how the SFP would influence production. These changes are occurring against a background of international prices that are not just high, but at record levels in some cases at two or three times those witnessed historically. As a result of these changes some of the agricultural markets in the EU are experiencing things that were unthinkable five or ten years ago, such as the EU being a net importer of beef or exporting dairy products without the aid of export subsidies.

Policies promoting the use and production of biofuels result in new challenges. In many markets energy policy is having a greater impact than CAP reform. For example, the elimination of intervention for wheat in the EU, should it come about, is likely to have little impact as long as the EU's Renewable Energy Directive (European Commission, 2007) is implemented along with pro-biofuels policies in other countries. This is mirrored in the US where the agreement of a new Energy Bill will probably have a bigger impact on agricultural markets than whatever is agreed in the final farm bill.[1]

[1] The interested reader is directed to FAPRI-Missouri's website (www.fapri.missouri.edu) where analysis of both the Energy Bill and proposals for the Farm Bill are available for comparison.

Modelling the biofuels sector requires a somewhat different approach than that taken with other commodities. Biofuels have been produced within the EU for many years, but the scale of production has changed dramatically in the last three years. This means that there is not a long time series of data with which to work with and the econometric estimation of a system is not possible or desirable. Biofuels on this scale are new globally, so there are a limited number of studies upon which to parameterize the model. Inevitably the model must be calibrated on a short time series using parameters that are based on what previous studies and economic theory suggest, validated through scenario simulation with feedback from experts.

The amount of data and sources has increased in the last couple of years. For the fossil fuel energy market a comprehensive dataset is available from EUROSTAT. Exogenous variables used in the model come from Global Insight for the macroeconomic and global energy variables, with projections for global agriculture and biofuels markets from FAPRI's global modelling system. Some biofuels data is available from EUROSTAT, but most of the biofuels model data is from Biofuels Barometer. Prices are sourced from FO Lichts where available. For the remaining data needed there are two problems, the first is that many of the data are sensitive commercially, such as industry costs and returns, and also that many of the markets for byproducts do not have extensive data such as prices.

Another of the problems for the biofuels model data is the variety of different units that are used. In the model units are chosen to be consistent with those used in the FAPRI global modelling system, and otherwise collated from a variety of sources. Some sort of review of these conversion coefficients would benefit the modelling community as the difference between estimates can in some cases be substantial.

In an ideal world it would be desirable to incorporate a model of the transport energy market into the analysis. Within some range of prices biofuels compete with fossil fuels (in Europe this has been the case with the help of tax incentives) and so their demand will in part be determined by the relative prices of different fuel options. In other cases compulsory blending requirements are utilised and so projections of diesel and gasoline usage are required. These can sometimes be sourced externally, but there are some scenarios, for example if one wanted to look at the impact of different oil prices on the demand for biofuels and the subsequent impact on agricultural markets where an endogenous model would be necessary.

It is clear that even if the EU tried to reach the 2003 Biofuels Directive target of 5.75 percent of total transport fuels from biofuel that a considerable amount of this would need to be imported in some form. A significant challenge for the model is to decide which form this will be. Feedstocks themselves could be imported and the trade barriers to these is well known. In the case of biodiesel, however, whether rapeseed or oil is imported is hard to model as this depends on crushing capacity whose determination is difficult where crush margins are not the only factor.[2] Also GMO considerations are important as much of the rapeseed that is produced globally is of this type. Biofuels themselves can be imported, but the trade barriers to doing this are not clear, at least to the authors. The fuel itself can be imported under different tariff lines. However, it is the national policies themselves that will determine whether fuel or feedstock is imported, in that it is only if the imported fuel can be counted towards the French Taxe Générale sur les Activités Polluantes (TGAP) or the British Renewable Transport Fuel Obligation (RTFO) or similar programs will it be imported (from outside Europe).

Which brings us to perhaps the biggest challenge of the modelling project, that is the interpretation and incorporation of national policies. For each country the policies for reaching the biofuels targets are different. Under current policy, even the targets themselves are different. Where a country imposes a compulsory blending requirement then this is relatively straightforward to model. But some of the schemes operated by other countries (for example the TGAP or the RTFO) employ more complicated approaches where the targets might not be met under certain market circumstances. It is also questionable whether rigid targets would be adhered to under circumstances of rapidly increasing prices of either feedstocks or biofuels. The language included in the 2007 Renewable Energy Source Directive regarding energy balances and sustainability of feedstock production will add to this complexity.

2. The model

Details of the GOLD model itself can be found in the manual (Hanrahan, 2000). It is a partial equilibrium dynamic model of the agricultural sector. The GOLD model that was used in the generation of these results covers the EU-25. On the supply side it includes components for France, UK, Germany, Italy, UK, Ireland, rest of EU-15, Poland, Hungary, rest of NMS-10 (New Member States). Due to data constraints the demand side is limited to EU-15 and NMS-10. The biofuels model has a different level of aggregation with France, UK, Italy and Germany broken out and the rest of the EU in a composite group.

The level of aggregation is an important issue for the model, since the EU currently leaves the individual member states to set their own targets and make their own policy. As always there is a trade off with the complexity of the model. In the biofuel model there are components for France, UK, Italy, Germany and the rest of the EU-25. Those four countries together account for about 60 percent of total EU energy transport usage. One of the major concerns in aggregating the rest of the countries is that the evolution of transport energy varies between the member states in that group. In particular, countries in the EU-15 have generally got stable or declining energy transport use, whereas the NMS-10 countries have generally got fast growing incomes and fuel use. In a compulsory blending type environment with different targets this could lead to systematic errors in the estimation of the biofuel requirement.

A simple representation of the interaction between the biofuels model and the GOLD model is presented in Figure 1. The biofuels model takes the prices of feedstocks used for biofuel generation from the GOLD model, and the subsequent feedstock demand from the biofuels model is added to food and feed demand determined in the GOLD model. The models are solved simultaneously to

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[2] Oilseed crushing capacity has expanded in recent years by a larger extent than crushing margins themselves would suggest.

determine equilibrium prices. In the discussion below the main equations of the model are presented and this is not an exhaustive list of equations.

For the baseline (a constant policy, normal weather simulation that forms a yardstick for policy evaluation), world prices are determined as exogenous and come from the FAPRI global system. When the model is used to generate a policy scenario reduced form equations of the global system are used to estimate the impact of changing EU biofuels trade on world prices.

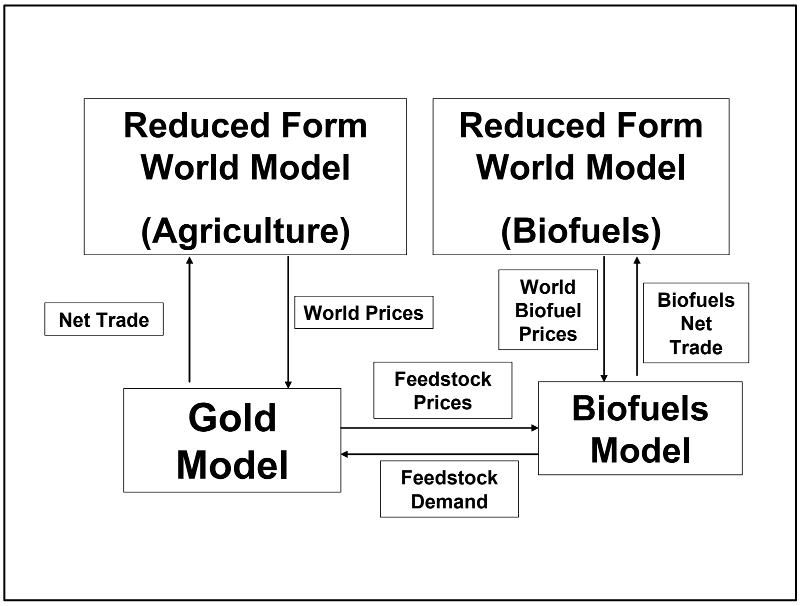

Figure 1: Biofuel/GOLD model interaction.

The model could take the energy market as being exogenous and take projections of fuel prices and fuel consumption from external sources. Projections of fuel consumption are available, but fuel prices are also needed as in some markets biofuels will compete with fossil fuels (with the benefit of tax incentives). Increasingly, however, compulsory blending requirements are likely to drive the market and the demand for biofuels is likely to be a simple function of the total fuel requirements of the market. In order that an increased number of scenarios can be simulated (such as those that involve different oil price projections) an energy market component was constructed using data from EUROSTAT, a diagram of which is presented in Figure 2. The energy model is a very simple representation given the constraints posed by model size and cannot reflect the complexity of the market so the projections can be validated against external projections or even replaced by them if necessary.

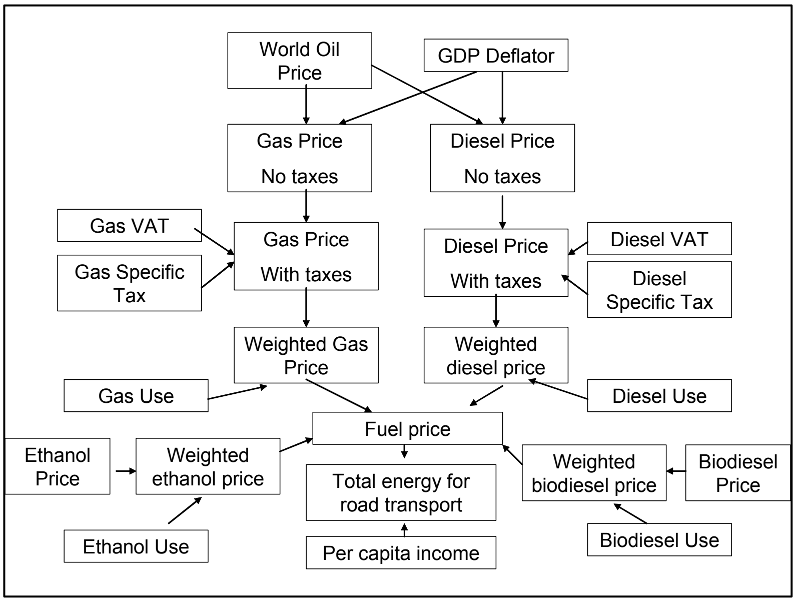

Figure 2: Energy market component of biofuels model.

In the energy model the world oil price and GDP deflator come from Global Insight. The gasoline and diesel price are determined by the oil price and the GDP deflator. Interestingly, there is some evidence that the diesel price has been rising relative to the gasoline price in recent years, perhaps as a result of the increasing proportion of diesel demanded.[3] With the proportion of diesel cars sold increasing then this share is likely to increase over time and this could be the major issue. The important equations from the energy model are:

$MGPR_i = f(POILERAP, G3EIT_i)$, $DIPR_i = f(POILERAP, G3EIT_i)$

$FUTOTC_i = f(FUWPR_i, RGDPC_i)$

$DIPROP_i = f(DIMGPT_i, trend)$

$MGPR_i$ = gasoline price; $DIPR_i$ = diesel price; POILERAP = oil price; $G3EIT_i$ = GDP deflator; $FUTOTC_i$ = total energy use in transport; $FUWPR_i$ = weighted fuel price; RGDPCi = GDP per capita; DIPROPi = proportion of diesel in fossil fuel use; $DIMGPT_i$ = relative diesel and gasoline prices, where *i* denotes country/region.

The weighted fuel price is calculated by taking the prices of all the fuels, fossil and biofuels, and weighted them by there level of use. Since the biofuels prices are determined endogenously in the model then changes in biofuels policies or agricultural markets can impact on the total demand for transport energy, athough that impact is small. The trend that is chosen for the proportion of diesel in fossil fuel use is an important variable, as it has a direct impact on biodiesel demand where there are mandatory incorporation rates. In the projections here a trend is chosen such that the rate at which the

[3] Once the proportion of diesel that is extracted from oil is increased beyond a certain level then the cost of that extra diesel rise rapidly (Kabalov and Peteves, 2004).

proportion of fossil fuel that is diesel is increasing falls over time, but still rises to 70 percent at the end of the period. Over the projection period the taxation policies of the member states with regard to fossil fuels is kept at current levels, athough for many countries the tax advantage for diesel has been reduced over time.

The output from the energy part of the model is an important determinant of the level of demand for biofuels. An attempt is made in the model to separate the demand for biofuels into three distinct categories:

i. Demand for biofuels that comes from sources such as public fleets where vehicles will always be operated on biofuels as a policy decision. Demand is very inelastic with respect to changing prices in this market.
ii. Markets where biofuels compete directly with fossil fuels (mostly with the aid of tax incentives), such as in the E-85 or B-100 markets, or when a blending rate decision is made based on relative competitiveness. This market will be more elastic than (i).
iii. Mandatory incorporation or blending rates imposed by the member states or by the EU in the case of the Renewable Energy Source Directive. Here demand is very inelastic, though in practice in the model there is a small response in that higher biofuel prices will lead to an increase in the weighted fuel price and therefore a drop in the demand for total fuels. This is small given the low elasticity for total transport energy usage and the small role that biofuels take in meeting that demand.

A simplified diagram of the demand for biofuel is given in Figure 3. In practice the demand equations are made more complicated by the diverse policies operated at a member state level. Italy, for example, only operates a tax incentive that is subject to a quota, so the demand for fuels is either at that level if the tax incentive makes the fuel cheaper than the fossil equivalent, or zero if it doesn't. The schemes in operation in the UK and France operate like a mandatory level that is binding for a range of biofuel prices, but if the biofuel price drops very low demand may be higher than this. If biofuels prices rise to a very high level then the limits under the RTFO and TGAP will not be binding. The different demand equations for the countries attempt to take this heterogeneity into account.

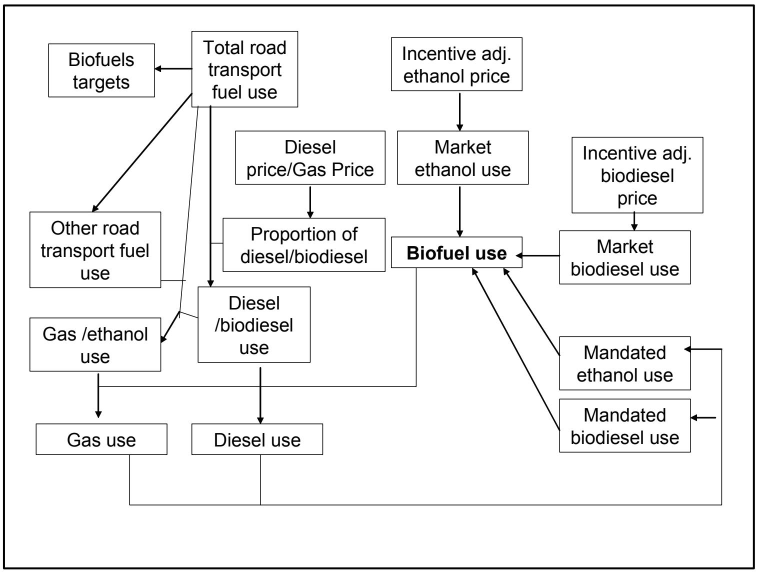

Figure 3: Biofuel demand in the model.

The equations for the demand component of the biofuel model can be summarised as:

$BDTOTC_i$ = f(max((biodiesel/diesel pump price, biodiesel/diesel refinery price), country level mandated volume, EU mandated volume)))

$ETTOTC_i$ = f(max((ethanol/gasoline pump price, ethanol/gasoline refinery price), country level mandated volume, EU mandated volume)))

$BDTOTC_i$ = biodiesel transport energy usage, $ETTOTC_i$ = ethanol; transport energy usage

The specific structure of the country or regions model differs, but in each case several markets are assumed to operate. The lack of data for these different markets makes the calibration of this part of the model difficult, but there is some historical and ad hoc data on which to base assumptions. As most countries switch to some sort of mandatory use or blending rate approach the need to segregate the markets like this becomes less important.

The production component of the model is based on the approach that has been taken by FAPRI in their US modelling system. In this approach, shown in Figure 4, the capacity of the industry is first estimated, and then capacity utilization, which together give production. Separating production into these two components allows for a greater range of behaviour to be exhibited and more closely approximates to the way that the industry actually works than just modelling production itself.

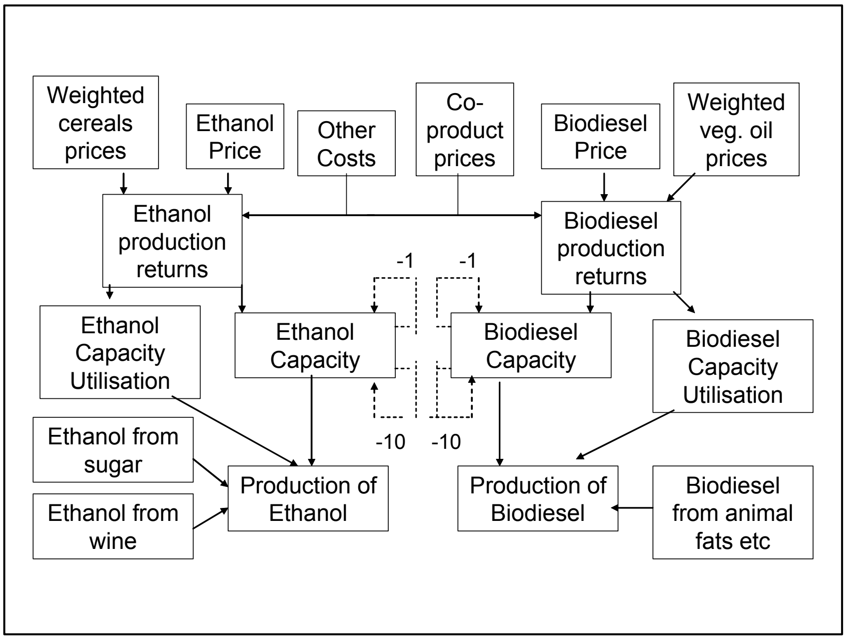

Figure 4: Production of biofuels in the model.

The equations of the model can be summarised as:

$BDCAP_i = BDCAP_i(-1) - 0.05*BDCAP_i(-10) + f(BDNRT_i/GDPD_i \text{ (lag 0 – lag3)})$

$BDUCRO_i = f(BDNRT_i/GDPD_i)$

$ETCAP_i = ETCAP_i(-1) - 0.05*ETCAP_i(-10) + f(ETNRT_i/GDPD_i \text{ (lag 0 – lag3)})$

$ETUCRO_i = f(ETNRT_i/GDPD_i)$

$BDCAP_i$ = biodiesel capacity, $BDNRT_i$ = biodiesel net returns, $ETCAP_i$ = ethanol capacity, $ETNRT_i$ = ethanol net returns

The capacity in the current period is therefore determined by the capacity in the previous period minus some loss in capacity that is assumed to become obsolete, plus additional capacity (which could be zero) based on a set of lagged returns to the industry. The coefficients on these returns in the equations are weighted to represent the fact that it takes several years to plan and build capacity. Utilization is based on current period returns and is defined between 0 and 100%.

Returns are the key variables in these equations and it is difficult to obtain comprehensive data on the costs and profits of the industry. The returns that are used in this simulation come after a review of the various published estimates of returns that are available in the public domain (such as International Energy Agency, 2004; FAS/USDA, 2003). At present in the model virtually identical returns are used for each of the countries (differing only by the different cereals prices produced for each country by the GOLD model), and are based on producing ethanol from wheat and biodiesel from rapeseed. This is an area where greater access to data will improve the model significantly.

Once the volume of ethanol produced is determined then that is converted into cereal equivalents. The cereal demand is divided up into demand for wheat, barley and maize on the basis of historical use. Some substitution between the cereals is allowed on the basis of relative prices. Biodiesel comes from either rapeseed, soybean or palm oil (or an "other" category). Limited substitution is allowed but overall the fact that there are technical restrictions on the type of biodiesel that is used is respected and most of the biodiesel comes from rapeseed in both the baseline and the scenario below.

At present non-cereal sources of ethanol are determined outside of the biofuels model. There is no wine model and ethanol from that source is assumed exogenously. Ethanol from sugar is determined in the sugar model, and there is feedback between that model and both the rest of the agricultural sector through crop returns and the biofuels model through the price of ethanol, which together determine the amount of non-quota beet that is produced. All non-quota beet is assumed to be converted to ethanol.

Production and consumption are estimated at the country/region level detailed above but the model is solved for prices at an EU-25 level. At present in the model stocks are ignored due to lack of data and the model is balanced on net trade. The net trade equations are simplified as:

BDNED25 = f(preferential agreements, world ethanol price/EU ethanol price)

ETNED25 = f(preferential agreements, world ethanol price/EU ethanol price)

BDNED25 = biodiesel net trade for the EU-25, ETNED25 = ethanol net trade for the EU-25

Net trade is estimated using the volume imported under trade agreements and then on the basis on the relationship between the world price and the EU price comparison taking into account the cost of transportation and tariffs. As alluded to above, this is a key part of the model but also one of the most difficult to specify. Firstly biofuels can be imported in a variety of forms such as B-100, B-99, or B-5 in the example of biodiesel and these face different tariff restrictions. Although as far as the EU targets are concerned imported biofuels count, in some cases imported fuels may not receive the same benefits as domestically produced fuels in terms of tax incentives, and may also be hindered by the variety of different standards that are applied across the EU. Import demand, therefore, may be a lot less elastic than just a comparison of the relative prices and tariffs might indicate. Additionally, in the case of biodiesel, the countries most likely to export to the EU are the US, Brazil and Argentina who are likely to make their biodiesel from soybeans.

3. Results of the simulations

In this paper the results of a simple scenario are presented to give further insight into the model. The scenario is designed to give some insight of the consequences of adopting a 10 percent target for transport fuels. All that was incorporated was to implement a binding mandate for biofuels in transport that rises to 7.5 percent in 2016. It does not therefore constitute an analysis of the Renewable Energy Source Directive, where the target for 2016 will differ, and includes a number of other provisions that will have an impact on the actual outcome of the policy.[4] It is important to note that in the model no estimate is made for the output of biofuels from other sources, in particular second generation biofuels such as ethanol from cellulosic material.

The results of the analysis for the biofuels sector are presented in Table 1. The scenario is modelled as being that ethanol and biodiesel each must make up a total of ethanol and gasoline and diesel and biodiesel respectively, so there is no opportunity to switch between sources of biofuels as a result of their relative price change. The impact on the energy sector is small and so is not presented.

	Baseline	Scenario	Difference	% Change
Ethanol		thousand tonnes		
Production	4,883	9,475	4,593	94.1%
Capacity	8,475	12,753	4,277	50.5%
Utilisation	58%	74%		
Consumption	5,240	10,583	5,343	102.0%
Net exports	-358	-1,107		
		euro/m3		
Price	539	755	216	40.2%
Biodiesel		thousand tonnes		
Production	8,572	17,673	9,101	106.2%
Capacity	13,162	20,058	6,896	52.4%
Utilisation	65%	88%		
Consumption	8,724	18,229	9,505	108.9%
Net exports	-152	-556		
		euro/m3		
Price	835	1,343	508	60.9%
Biofuels of total fuel	3.57%	7.39%		

Table 1: Impact of 10% mandate on biofuels sector, 2016.

It is important to consider the baseline when examining the results. Under the baseline the biofuels share of total transport fuel is below even the 2010 target of 5.75 percent even in 2016. That is because only actual member state policies such as tax exemptions and mandates were included in the baseline (which would differ again from the stated targets in response to the Renewable Fuels Directive). In the baseline both ethanol and biodiesel capacity utilisation is low, at 58 percent and 65 percent respectively.

In the scenario both ethanol and biodiesel production approximately doubles, which comes about as capacity for both industries rises by about 50% and capacity utilization increases. There is an increae in the net imports of both ethanol and biodiesel, with the latter lower for the reasons outlined above. The price of the biofuels increases to levels that spur sufficient production to fill the remaining

[4] Not least of these is the fact that the Renewable Energy Source Directive also includes targets for non-transport energy from renewables which may further drive up agricultural prices through the use of palm oil for electricity generation for example.

mandates. The price has to rise higher for biodiesel as the price of its feedstock increases more as discussed below.

The key to the results for the biofuels part of the model, is the responsiveness of trade. Although the changes in imports look large here in relation to the baseline, they are not big in comparison to the likely global capacity at that date and the simulation does include a divergence in European and global biofuels prices. If imports were very elastic, then there could be a situation where much of the increase in demand is met by imports, which would still drive up the costs of feedstocks to similar levels as they are driven by global demands. This could lead to lower returns for the EU biofuels producers and therefore lower utilisation rates.

The impact on the agricultural sector is presented in Table 2. The impact of the mandate on the ethanol feedstock market and the biodiesel feedstock market is different. Vegetable oil prices rise much more rapidly than cereals prices in response to a similar shock in demand for product. This is because, for rapeseed in particular, biofuel demand comprises a much larger part of overall demand than for cereals. Vegetable oil prices rise over 40 percent in the scenario whereas the cereals price rise is less than half of that.

	Baseline	**Scenario**	**Difference**	**% Change**
		thousand hectares		
Rapeseed area	6,735	7,581	846	12.6%
		thousand tonnes		
Rapeseed oil imports	1,673	7,604	5,932	354.7%
		euros/tonne		
Rapeseed oil price	750.0	1073.8	324	43.2%
		thousand hectares		
Wheat area	23,100	23,411	312	1.3%
		thousand tonnes		
Wheat net exports	3.07	0.98	-2	-68.1%
		euros/tonne		
Wheat price	137.2	162.9	26	18.7%

Table 2: Impact of a 10% mandate on the agricultural sector.

Given the fact that only a small part of the additional demand for biodiesel is met through imported fuel for the reasons outlined above, and that the ability of area to expand to produce more oilseeds is limited (given the high area in the baseline, and the fact that cereals prices are rising too, albeit more slowly) then the bulk of the increase in biodiesel production must be supported by imported feedstocks. In the model, most of this is in the form of rapeseed oil, with a smaller increase in rapeseed itself. It must be remembered at this stage that GOLD is linked only to a reduced form of the world model, and therefore the world price rises in response to this demand on the basis of the elasticities that were calculated through simulation of the global modelling system of a magnitude much less than this.

For cereals, the EU is still a net exporter of wheat and barley in the baseline. The result of this scenario is that the EU is barely self sufficient in wheat and barley, and net imports of maize increase. There is an increase on area and therefore some increase in domestic cereal production. A greater increase in ethanol imports than for biodiesel, coupled with the smaller share of gasoline in overall fuel usage the impact on the cereals sector is smaller.

The results that are presented here are significantly different than those produced by the Commission in their analysis of a 10% obligation. For example, the Commission analysis has smaller impacts on prices, and has the EU as a significant net exporter of wheat and rapeseed oil even after the obligation. In part the different results reflect a different set of assumptions used regarding the policy, and also may be due to important omissions from our model that are discussed below. In general our conclusions would be that there would be a greater impact on agricultural markets, particularly for rapeseed, than in the Commission report.

4. The further integration of biofuels into the model

The model outline presented in section 2 of this paper represents the first attempt to incorporate the biofuels sector into the EU modelling system. It is hoped that as more data becomes available that the model can be improved. The main areas that are a priority are:

i. A more detailed understanding of the trading restrictions and possibilities is paramount, not only for modelling in the context of the EU, but also for the global modelling system where the EU is a key market, and the leading market for biodiesel.
ii. At present there is no feedback in the model for the byproducts from ethanol production, which are fed to livestock. Rapeseed meal is incorporated into the model, with all the meal being fed. This may not be an accurate representation of reality since some of this is burnt for energy.
iii. Incorporation of second generation fuels. At present it is impossible to project what production of these fuels will be in five or ten years time. Some consideration of biofuels from products not currently modelled, like jatropha may also be necessary.

In addition to these improvements work in ongoing at FAPRI on US and global models for biofuels and so it is hoped that FAPRI will be in a good position to analyse changes in biofuel policy in the future.

5. Conclusions

The modelling of the biofuels market is a complex task. In order to model the sector properly one must consider both the energy markets that are the outlet for the product, and the agricultural markets that are the source of the inputs. For the EU analysis is complicated by a large number of policies that influence the sector, some of them set by the Commission in the form of targets or through standards pertaining to the composition of fuels, and some of them set by the member states themselves. The member state's policies generally differ from country to country and are themselves often a combination of mandates and tax exemptions. The policies are regularly revised.

Biofuels themselves can, and currently are, produced from a variety of inputs, with different technical processes, sourced both domestically and internationally. The byproducts of biofuel production will themselves have an impact on agricultural markets. All of these considerations mean that to model the sector properly significant amounts of data are needed, some of which is not readily available. The fast growing nature of the sector means that long time series of data sets are largely not available or not useful meaning that econometric estimation is not possible.

In this paper one approach is proposed, that is largely shaped on the data that is available. The model must be able to reflect some of the complexities of the system, but also fit into and interact with the existing model of agricultural markets. The model is validated partly by running simple scenarios, one of which is presented here, where the EU is assumed to impose a mandated level of biofuels consumption on the way to meeting a 10 percent target. The result of this is to greatly increase the demand for vegetable oils and cereals. To meet the extra demand for biodiesel the EU has to look to imports of either oilseed, vegetable oil or biodiesel and the impact on world prices is significant. For the cereals sector the extra demand can in part be met by the EU becoming a net importer in cereals.

In recent years there have been many significant analyses for agricultural economists in the EU to examine with CAP reform and enlargement at the forefront. The results that are presented here indicate that the impact of biofuels policies, especially when they are considered in conjunction with other policies in other countries around the globe that are increasing the demand for biofuels, are likely to have a bigger impact on agricultural markets than even those most significant of developments. Incorporating biofuels into policy models for agriculture is therefore necessary for those models to retain their relevance.

References

EurObserv'er, *Biofuels Barometer*, various issues.

European Commission, 2003. *Biofuels Directive.* Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport (OJ L 123, 17.5.2003).

European Commission, 2007. Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Renewable Energy Sources.

FAS/USDA, 2003. *EU: Biodiesel Industry Expanding Use of Oilseeds*.

Hanrahan, K, 2000. GOLD manual.

International Energy Agency, 2004. *Biofuels for Transport, An International Perspective*.

Kavalov, B. and S. D. Peteves, 2004. *Impacts of the increasing automotive diesel consumption in the EU*. European Commission, Joint Research Centre.