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AGRO-INDUSTRIAL AND REFINING MODEL INTEGRATION FOR DECISION MAKING PURPOSES CONCERNING BIO-FUEL TAKE-OFF

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Overview

During 2004, France incorporated less than 1% of bio-fuels in conventional fuels. In recent years, the French government has set public policies on bio-fuel development to respect Kyoto commitments of 5.75% bio-fuel blending in 2010. To evaluate those measures, a complete representation of the bio-fuel production system was necessary. In order to achieve this target, a French partial agro-industrial equilibrium model was coupled to a French refinery optimisation model, both based on linear programming. This coupling procedure allows simultaneous consideration of three bio-fuel production chains (VOME, bio-ethanol and ETBE) that compete for agricultural, agro-industrial and refinery production factors. Such a systemic analysis gives accurate information on agents' economic interest for bio-fuels. Using marginal analysis we can evaluate, public policies on various economic and environmental criteria in a flexible way. In this paper French bio-fuel development plan has been evaluated considering microeconomic information such as regional bio-fuel crops production, bio-fuel production, total budget cost of tax exemption for regulators, total costs of producing bio-fuels, economic agent surpluses and gas emissions from seed to final use.

Methods

In order to evaluate public policy on bio-fuels, an original tool was created. An agro-industrial model and a refinery model were coupled to represent all the bio-fuel production chains. In this way, each economic agent's interest (farmers, agro-industrials and refiners) for one of the three bio-fuels under consideration can be evaluated. Vegetal oil methyl ester (VOME), bio-ethanol and ethyl-tertio-butyl-ether (ETBE) are the bio-fuels studied in this work.

The agro-industrial model OSCAR[1] is an economic surplus optimization model for renewable agricultural fuels. It is a French regional partial equilibrium model based on linear programming. It is also a sequential model representing European agricultural policy evolution from 2002 to 2012 [Sourie & al., 2001].

The refining model OURAR[2] is a linear programming model which optimizes the production plan of a mono-refinery representing the whole French refining activity [Saint-Antonin, 1998].

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[1] Developed by the French National Institute for Agricultural Research (UMR Economie Publique, INRA Grignon)

[2] Developed by the French Petroleum Institute (IFP) from original OURSE™ (Division des Etudes Economiques, IFP)

The obvious complementarity between the agro-industrial and the refining models to give a realistic representation of all the chains at the present time and in possible evolutions was at the origin of the coupling procedure[3]. In a fist stage, the agro-industrial part of the OSCAR model was improved by updating agro-industrial data on transformations and costs, taking into account bio-fuel unit economies of scale in OSCAR by means of integer programming. Then, the OURAR model was adapted to enable the refiner to incorporate fixed rates of bio-fuels, to benefit from tax exemption when buying bio-fuels and to perform modelling of physical properties of bio-fuel and fossil fuel mixes, i.e. non linear ethanol volatility in gasoline in OURAR using integer variables [Rozakis & al., 2005].

Finally an iterative coupling procedure was developed to evaluate public policies on bio-fuel development in France. The aim of the procedure is to determine for a given bio-fuel target production, the minimum tax exemption the government should set up. Models are driven by quantities (As a matter of fact, French government assigns maximum capacity to investors based on global target quantities dependent on earmarked budget for bio-fuels).

The iterative procedure consists in:

1. Running OURAR to obtain the refinery marginal cost of production to reach a given quantity of bio-fuels. The model also gives information on the pollutants emitted by the refinery (CO_2, SO_2, PM_{10}) when producing bio-fuel in comparison with conventional fuel production.
2. Running OSCAR to obtain the agro-industrial marginal cost of production to reach the same quantity of bio-fuels. The model also gives the total quantities of rapeseed, wheat and sugar-beet to be produced nationally and by region to reach the bio-fuel quantity targets and the sequestrated carbon due to this production.
3. Then using both previous results, we can obtain for each production chain the agricultural and industrial surplus and what should be the minimum tax exemption for each production chain. The total budgetary cost and the total production chains CO_2 economy.

An important contribution of this systemic and integrated approach is the consideration to real agents' interest for bio-fuels. The minimum exemption from tax represents the difference between the agro-industrial bio-fuel production cost and the refiner's willingness to pay and not the average market price of fossil substitutes. Considering the refiner's willingness to pay, we integrate bio-fuel in the production plan of the refinery in accordance with the real need of the refiner for this product. This information allows the determination of an accurate minimum tax exemption.

Beyond the previous results, the important advantage of these coupled models is the flexibility it offers. Indeed we can operate on prices of the crops, fossil fuel and bio-fuel demand, crude provisioning, incorporation rate obligations for each bio-fuel and exemption from tax on bio-fuel units. So, it makes it possible to evaluate different possible evolutions or bio-fuel opportunity cost sensibility to crude oil price or competition between food use and energy use of agricultural crops.

Results

In this article we explore for French case the European commitments to promote bio-fuel reaching 3.5% bio-fuel blending in 5.75% in 2010. To be more accurate we considered some announced and possible evolutions such as specification evolution of sulphur (10 ppm sulphur in fuels from 2009), crude oil provisioning changes (high quality crude oil provisioning reduction from 2010), agricultural policies changes (decoupling from 2006). In addition, several oil crude medium prices were considered (34$/b and 64$/b).

Preliminary results of the coupling procedure are presented in the next tables.

[3] Collaboration in the frame of the scientific interest group 'Agriculture for chemistry and energy' (AGRICE).

Table 1 & 2 : some OSCAR, OURAR and coupling procedure results

	units	**2007**	**2010**
Q ethanol *	kt	0.314	0.525
Q ester *	Kt	1.012	1.927
Refinery eth.Price	€/l	201.968	11.863
Refinery est Price	€/l	343.731	345.32
Q rapeseed	Mt	2.530	4.817
Q wheat	Mt	0.568	0.950
Q sugar-beett	Mt	1.988	3.324
Refinery SO2 emissions	Mt/an	0.053	0.11
CO_2 economy	Mt/an	2.954	5.638

* Input of the model

	2007	**2010**
	Budgetary expense share	
Agricultural surplus	11%	12%
Ethanol Industrial surplus	12%	4%
Ester Industrial surplus	39%	37%
Budgetary cost	***61%***	***53%***
	Current tax exemption share	
Minimum Tax exemption ethanol_ex_wheat	61%	71%
Minimum Tax exemption ethanol_ex_sugar-beet	71%	97%
Minimum Tax exemption ester	45%	48%

It seems that policy incentives are mainly intended for industries which catch a larger part of the surplus compared with agricultural sector. Furthermore, a huge part of budgetary expense is lost (deadweight loss).

The main CO_2 economy is obtain in transforming-refining-final use of bio-fuel productions, CO_2 sequestration when producing crops comparing to other land uses represent less than 2% of the total CO_2 economy.

Conclusions

A methodological tool combining the French refinery activity and the agro-industrial activity and representing all the French bio-fuel production chains has been proposed to evaluate public decision-making considering relevant economic and environmental information such as total budget cost for regulators of tax exemption, total costs of producing bio-fuels, economic agent surpluses and gas emissions from seed to final use. It allows a large representation of the different economic agents involved in those chains (farmers, agro-industrials and refiners) and a flexibility to take into account or not government measures, new specifications, and new development constraints. On this basis French bio-fuels promotion plan was evaluated.

References

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