Biofuels: Economic and Public Policy Considerations

Antonio M. Bento

Cornell University Department of Applied Economics & Management, Ithaca NY USA

Introduction

Over the last few years, a large number of countries, including the US, Brazil and the European Union, have experienced increases in the production of liquid biofuels, such as ethanol and biodiesel (IEA 2007). Several reasons justify policy public towards the expansion of biofuels' markets including concerns about national security and the dependence on foreign oil from politically unstable countries; concerns about the adverse effects of increased greenhouse gas (GHG) emissions; and the hopes of rural economic development.

This chapter begins by comparing the private costs of producing liquid biofuels against those of regular gasoline. In the absence of government intervention, this comparison dictates the size of (domestic) liquid biofuels markets. I then present evidence for or against each of the arguments for public policy intervention presented and summarize the key features of the most common policies used by different countries. Finally, I present evidence on the effects of alternative biofuels policies for economic welfare and the environment. Most of this evidence is based on recent studies that use either partial or general equilibrium models to measure the effects of various biofuels policies. Before proceeding, it is important to note that most of the economics modeling efforts presented are based on the U.S.; however, such approaches are general enough to be applied elsewhere.

The Private Costs of Liquid Biofuels Production

In a recent paper, Tyner and Taheripour (2008) report a simple break-even analysis that relates fluctuations in corn, crude oil, and ethanol prices with the (private) profitability of the ethanol sector in the U.S. economy. Figure 11.1 plots the break-even line for the ethanol sector. According to the authors, the threshold prices for corn and

Sala, O.E., D. Sax, H. Leslie. 2009. Biodiversity consequences of biofuel production. Pages 195-203 in R.W. Howarth and S. Bringezu (eds) Biofuels: Environmental Consequences and Interactions with Changing Land Use. Proceedings of the Scientific Committee on Problems of the Environment (SCOPE) International Biofuels Project Rapid Assessment, 22-25 September 2008, Gummersbach Germany. Cornell University, Ithaca NY, USA. (http://cip.cornell.edu/biofuels/)

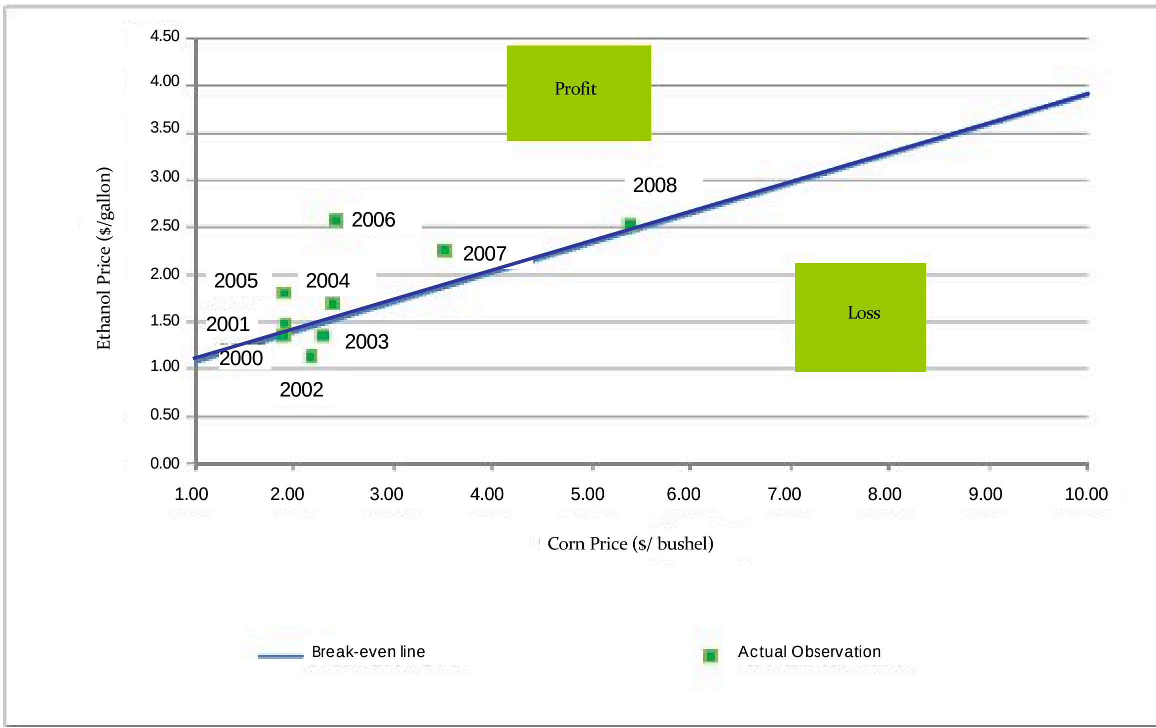
ethanol, at which a representative ethanol plant operates with zero economic profits, is $2.5 USD and $1.55 USD respectively. The authors also note that the level of crude oil prices experienced in 2004 (typically above $100 USD bbl^{-1}), combined with low prices of corn and the $0.51 USD ethanol tax credit, raised the profitability of the industry. However, it is unlikely that the ethanol industry would survive in the absence of tax credits (Yacobucci 2008 and sources cited therein). This raises the natural question: Are there reasons that justify the existence of a tax credit or other policies that promote an industry that would unlikely survive in the absence of government intervention?

Reasons for Government Policies in Biofuels Markets

Energy Security. One reason for government intervention in biofuels production relates to energy security. The premise of the argument is that an increase in biofuel production domestically can reduce the dependence on foreign oil from politically unstable countries. Several countries, including the US, have introduced trade barriers to promote and protect domestic production of biofuels.

Critics argue that many countries are unable to displace a significant share of their oil consumption, and as a result, are unable to control the fluctuation in fuel prices. The U.S. and the European Union, for example, can displace 10% of their gasoline consumption with biofuels by allocating 30% and 70% of their croplands respectively. Such a diversion of cropland would be very difficult to achieve without causing serious costs in terms of food independence. Brazil, which can meet 10% of its fuel demand with just 3% of its cropland, is the exception (discussed in

Figure 11.1 Break-even corn and ethanol prices compared with actual observations (Reprinted from Tyner and Taheripour 2008).



detail in chapter 4 (Connor and Hernandez 2009).

In addition to being unable to control fuel prices, as energy demand continues to grow (due to increases in income and population), more land will be needed to assure the same percentage of fuel coming from biofuels. This fact implies that, unless coupled with policies that manage the overall demand for energy, biofuels policies alone will quickly become extremely costly and unsustainable.[1]

GHG Emissions Mitigation. Much government intervention to expand the biofuel production is based on the assertion that biofuels will contribute to an overall reduction in GHG emissions. Therefore, in order to justify the economic costs associated with increased biofuels policies, one must carefully investigate the extent of GHG emissions savings. This section briefly summarizes a growing body of literature that extends standard life-cycle analysis (LCA) of biofuels with rather contradictory results. The following section aims to highlight the underlying assumptions of these models that lead to inconsistencies.

As the literature on the LCA of biofuels matures, consensus points to a rather small greenhouse gas emissions savings from corn-based ethanol. The most cited study is Farrell et al (2006), which, after conducting a meta analysis based on over a dozen previous studies, concluded that corn-ethanol provides ~ 13% savings relative to fossil fuels. However, the estimates in the literature range between a -50% to a +50% savings, suggesting that, there is still a lot of uncertainty related to GHG emissions impacts. Several underlying assumptions of LCA models explain this large range including system boundaries and co-product allocation, as described in chapter 5 (Menichetti and Otto 2009). Furthermore, it is important to recognize that the LCA method suffers major shortcomings.

The key problem of LCA studies is the complete omission of any price responses to biofuels expansion, which in turn may seriously alter the overall GHG emissions resulting from biofuels. In essence, LCA is a useful tool if one wants to know the energy savings for the 'first' unit of ethanol produced, but estimates simply do not hold for large-scale levels of production. At commercial scales, price adjustments and responses by agents in the economy start to have impacts, which LCA does not consider. Two price-driven effects that need to be carefully examined (Bento and Landry 2008) are land-use adjustments – both at the intensive and extensive margins - that occur in response to changes in crop prices due to increased biofuels production (domestically and abroad) and changes in transportation decisions due to changes in fuel prices.

Recognizing the potential for biofuel policies to generate land use changes, Searchinger et al. (2008) use the GREET model to examine the land use effects resulting from a 56 billion liter increase of corn-based ethanol in the US. The GREET model is a multi-country general equilibrium agricultural model developed at Iowa State University, which has been used frequently to evaluate the impacts of trade policies on agricultural commodity prices. Searchinger et al. (2008) main argument is that the allocation of cropland in the US for the production of biofuels translates in an overall reduction on US corn exports. As a consequence, it is likely that other countries will increase their corn production to fill the gap created in the market. To the extent that these additional corn acreages come from land that was previously in forest or grassland, greenhouse gas emissions could actually increase. According to Searchinger et al.

(2008), in order to accommodate an increase of 56 billion liters of corn-based ethanol in the US, an addition 10.8 Mha of land elsewhere would be needed, doubling carbon emissions over a thirty-year period. The Searchinger et al. (2008) results, however, have stirred much debate and should be taken with caution. Several critics have taken issue with the underlying assumptions of the study (Sylvester-Bradley 2008 and sources cited therein) including failure to account for higher protein concentrations in co-products for livestock feed and potential conversion of marginal or fallow lands land (i.e. CRP land).

In on-going research, Bento and Landry (2008) develops a complete general equilibrium model of the U.S. economy to study the GHG emissions results from increased corn-based ethanol to meet the 2007 Energy Bill mandates. Bento and Landry's (2008) framework is novel in that it combines a detailed transportation model - in which individuals make decisions in terms of vehicle miles traveled and fuel economy - with a land use model. Unlike Searchinger et al. (2008), the Bento and Landry (2008) model considers the intensification margin of adjustment that comes from changes in rotation and tillage practices used in agricultural production. In addition, the authors consider the possibility of land conversion from the CRP and other land uses. Bento and Landry (2008) increases corn production to accommodate 56 billion liters of ethanol and ignores the impact of this increase in other countries. This is because the US increase in corn-ethanol comes primarily through a shift to continuous corn rotations and some conversion of CRP land. The deforestation numbers presented in Searchinger et al. (2008) do not occur, since the increased corn production is completely accommodated in the US, without any major land use change. In fact, in Bento and Landry (2008) U.S. corn exports remain roughly constant throughout the policy experiment, thus not creating a pressure for additional land use conversion abroad. Thus, Bento and Landry (2008) implicitly believe that some of the deforestation results presented in Searchinger et al (2008) may have been overestimated. This is an area for which further research is needed[2], as it will ulti-mately determine whether GHG savings from corn-ethanol occur. Still, one should question whether there are future opportunity costs of using corn for biofuels. Even if the US corn production can theoretically be fully utilized for domestic use without generating land use effects on other continents, the problem is that coarse grain demand is growing strongly every year and indirect land use effects will arise if the US forgoes future corn exports.

Perhaps even more important is that Bento and Landry (2008) find large effects of biofuels policies via the transportation sector. In particular, the presence of tax credits for ethanol production tend to lead to an overall increase of vehicle miles traveled and a delay in the adoption of more fuel-efficient cars. This effect can seriously exacerbate the GHG emissions resulting from the expansion of the biofuels sector. On the other hand, when biofuels mandates bind, that is, when fuels blenders are forced to meet the mandate, fuel prices go up and, as a consequence, there will be some GHG emissions reductions that are associated with reductions in VMTs and increases in fuel economy. Thus, unless biofuels policies act like a 'hidden' gasoline tax and promote a reduction in overall fuel consumed, it is unlikely that biofuels will generate any GHG emissions savings. Therefore, one should also compare the costs of biofuels policies against the costs of other policies aimed at reducing overall fuel consumption. Not surprising, because fuel taxes will be broader, the costs of achieving similar emissions reductions would be much cheaper. The issue is how increases in the corporate average fuel economy (CAFE) standards or subsidies to promote the purchase of cleaner vehicles compare to increased biofuels mandates.

Rural Economic Development. The prospects of increased farm income and rural economic development, primarily in the less developed countries, can justify some degree of government intervention to promote the increase of biofuels production. However, government intervention without a strong governance infrastructure may actually threaten development. In developed countries, increases in rural income are offset by higher costs and not equally distributed across agricultural sectors.

In the United States, the expansion of the ethanol sector has created additional demand for crops and empirical evidence suggests some increase in overall farm income. According to the recent USDA Outlook Report (2008), farm income in 2007 was approximately $86.8 billion USD. This is 42% about the 10-year average of $61 billion USD. Part of this increase in farm income is explained by the boost in corn prices, which reached $6 USD per bushel in 2008.

While, at a first glance, it appears that biofuels expansion increases farm income, several additional issues should be taken into consideration. First, like commodity prices, biofuels expansion promotes the increase of other inputs, including fertilizers. To the extent that over time fertilizer prices can increase, farm income resulting from biofuels expansion will be partially offset. More important, although it appears that there has been an absolute increase in farm income, the risk associated with farm investments has also gone up, due to the increase in input prices. Therefore, a bad yield year, due to any exogenous shock, could represent a serious loss of income. While such shocks can easily be mitigated by government-subsidized insurance, there will still be welfare losses associated with exogenous shocks. Second, it is important to note that the distribution of benefits from biofuels expansion will not be even across all sub-sectors of the agricultural sector. In particular, there is a concern that, in response to the costs of fuel and corn, feed prices will go up, reducing livestock farmers' income[4].

There is a potential for developing countries to specialize in bio-energy crops, crops that can be produce in poorer soils and adverse climatic conditions (IFPRI 2005). According to IFPRI (2005), 80 developing countries can grow and process sugarcane. The removal of trade barriers against these countries could represent an expansion of the cultivated area of sugarcane, as well as an increase in intensification of production of bio-energy crops. To the extent that there are substantial yield gaps to be explored in these countries, increased biofuels production can be partially achieved through intensification of existing cultivated areas. In turn, this will represent increases in farm income. The use of marginal lands in developing countries, where several second-generation biofuels could grow, could also translate into an increase of rural income. According to the IFPRI (2005), for example, India has 30 million hectares available to produce Jatropha.

One should note that the developing countries' comparative advantage in the production of biofuels feedstocks comes from the lower opportunity costs of land. In the U.S., for example, where yields are not expected to increase, an expansion of biofuels production will be very costly and the environmental consequences of such expansion need to be properly quantified. From a public policy perspective, this suggests that policy makers should seriously consider the removal of all trade barriers against biofuels production elsewhere and should also consider revising the current level of ethanol tax credits and mandates. Only the reform of such policies will moves towards the optimal location and type of feedstock. On the other hand, moving to the optimal land (defined based on a narrowly economic criteria) might mean making land grabs in developing countries. Therefore, traditional market-based instruments may have to be complemented with regulatory schemes that differentiate land based on its ecological potential to prevent the conversion of land that can have adverse environmental consequences.

Whether in the developed or developing world, one should note that while farm income can increase and rural development can occur, one should also consider the potential welfare losses that come from increased food prices. To date, there is no consensus amongst academics and policy-makers of the exact impact of biofuels expansion on food prices. In part, food prices are also increased due to overall population and income growth. Empirical studies suggest that biofuels contribute to 10-15% of food prices increases. If this is the case, it is likely that the benefits from rural economic development will still dominate the unintended impacts due to increased food prices[5].

Public policy intervention in biofuels is motivated by very different concerns and such concerns have rather different scales. While national security and rural economic development can be considered local concerns, reducing GHG emissions is a global concern. Depending on how different governments weigh these each concern, some policy interventions will make more sense than others. For example, if the chief goal of biofuels expansion is the reduction of GHG emissions, then it is important to learn about “where”, “how much” and “what type” of biofuels to produce. In this case, the presence of tax credits or trade barriers, which tend to promote corn-based ethanol should be revised and potentially removed. In the next section, we further discuss some of these issues and outline the most common public policies used.

Current Policies and their Effects

Excise Tax Credits. If the goal is to make biofuels competitive against fossil fuels, fuel excise tax credits are the most direct and widely used instrument. Because most countries tax the consumption of gasoline, the excise tax credit effectively lowers the cost of biofuel relative to gasoline, and thus promotes its expansion up to the point where the blender is indifferent between using gasoline and biofuels (Bento and Landry 2008). The US, for example, started its current subsidization of the use of ethanol in motor fuel in 1978 as part of a policy response to the 1970s disruptions in petroleum supplies from the Middle East. The subsidy of $0.51 USD per gallon of ethanol used, takes the form of tax credits to energy companies as opposed to payments to ethanol producers. Producers of corn, by far the predominant source of U.S. fuel ethanol, see this policy as beneficial to them.

It is important to note that the tax credit does not adjust to changes in oil prices and has no cap on production. Therefore, when oil prices are relatively higher, this tax credit may constitute a burden for the government (or more precisely a ‘waste’), as it will be optimal for the blender to combine larger amounts of ethanol with regular gasoline independently from the subsidy. It is important to note that the tax credit represents foregone taxes. This means that, in order for the government to face normal expenditures, some other tax will need to increase. While measuring the costs of tax credits, one needs to develop general equilibrium models that assume government budget balances.

Gardner (2007) presents back-of-development calculations related to the costs of this tax credit. According to this study, the cost of the US government to sustain 5 billion gallons of ethanol is $2.6 billion. To date, the literature has pointed to the potential perverse effects of the ethanol excise tax credit. Degorter and Just (2008) and Bento and Landry (2008), for example, point out to the fact that the excise tax effectively lowers the overall cost of the fuel, and, at the margin, creates incentives for increases in vehicle miles traveled. As a result, a potential perverse result associated with the tax credit is the increase in the externalities associated with driving, including local air pollution, GHG emissions, congestion and accidents.

Bento and Landry (2008) also suggests that the excise tax may delay in the introduction of cleaner ethanol technologies and the tax credit may make corn based ethanol producers more competitive over time, through learning-by-doing externalities. That is, as producers of corn-based ethanol continue to experience with their production processes, they are likely to become more competitive over time, thus delaying the potential penetration of a cleaner technology.

So the question is: Should excise tax credits be removed all together? From an overall efficiency perspective the answer is yes. However, because the profitability of ethanol producers is directly related to the price of crude oil (which is not controlled domestically), one can imagine situations where, in response to a drop in oil prices, ethanol plants will have massive losses in profits and would run out of business. In this case, one should worry about the losses related to investment decisions (e.g. capital costs associated with the ethanol facility itself) Thus, there may be a reasons to justify a variable excise tax credit to smooth out the profitability of ethanol prices (Taheripour and Tyner 2007).

Renewable Fuel Standards and Mandatory Blending. While the tax credit discussed above is an incentive-based approach, mandatory blending is essentially a command-and-control regulation. Economists have for a long time made a serious case against such regulations by pointing to the fact that the costs of achieving the same outcomes are substantially higher than with market-based instruments.

The U.S. Energy Policy Act of 2007, for example, mandates the production of 15 billion gallons of corn-based ethanol by 2015. The European Union Biofuels directive issued in 2003 requires member states to set national targets to ensure a minimum proportion of biofuels and other renewable fuel use domestically.

Unlike the tax credit, the effect of the increase in the mandates of blending is to drive up the price of fuel. However, to the extent that the mandate creates an (sub-optimal) excessive production of biofuels, there are serious economic costs associated with it. From the government perspective, a mandate is revenue neutral. Indeed, in response to fuel prices consumers will typically drive less and search for more fuel efficient vehicles (Bento and Landry, 2008). Producers of the feedstock to meet the ethanol production will benefit, as they experience an increase in the overall price of the feedstock. Whether there are GHG emissions savings depends on whether the reduction in driving compensates for potential GHG emissions from land use.

Trade barriers. Several countries impose forms of trade restrictions on both biofuels and feedstocks. For example, the US has currently an import tariff on Brazilian sugarcane ethanol in order to protect corn ethanol producers in the US.

If the overall goal of Biofuels policies is to reduce GHG emissions, trade liberalization increases global welfare in the long run, as it allows countries to produce the optimal amount of biofuels from the different feedstocks.

Energy Tax or Carbon Tax. So far, we have discussed policies to increase the overall production of biofuels, however, if the goal is to reduce overall GHG emissions, economists often advocate increases in carbon taxes, as opposed to sectoral policies, such as biofuels. A major argument in favor of broader based carbon taxes (or cap-and-trade programs) relative to sectoral biofuels policies is that such instruments tend to have dynamic effects such as encouraging investment in clean technologies and inducing behavioral changes such as energy and resource conservation. As a result of an increased in the price of carbon, if biofuels are part of the optimal solution, biofuels production will naturally emerge in the economy and the size of the ethanol sector vis-à-vis other renewables will be optimal. With mandates, we can be forcing the economy to produce a sub-optimal quantity of biofuels and impose extra costs in the economy. Furthermore, carbon taxes (or cap-and trade programs) generate revenues that can be used to cut pre-existing distortions in the economy and reduce the overall costs of taxation (Bento and Jacobsen, 2007).

Conclusions

The combination of high crude oil prices and a variety of government policies – including the volumetric tax credit and import tariffs – have sustained the rapid increase of the US biofuels industry. Such an increase has foster changes in the relative prices of food and feed crops, leading to unintended land-use changes in US and abroad. This chapter surveyed the economics literature that examined the effects of alternative biofuels policies. Whether some biofuels policies are justified depends ultimately on its goal; and the chapter argues that because different goals have different scales, they can actually be in conflict. In addition, while we suspect that biofuels policies will continue to be at the forefront of public policy debates, as energy demand continues to grow (due to increases in income and population), more land will be needed to assure the same percentage of fuel coming from biofuels. Unless coupled with policies that manage the overall demand for energy, biofuels policies alone will quickly become extremely costly and unsustainable.

Notes

1 The discussion here focused primarily on gasoline. However, gasoline is not the only energy source that should be considered under an energy security perspective; in fact, at least in the EU there are concerns related to natural gas supplies.

2 Of course the increased in corn production in the US has its consequences as well. There are potential major environmental impacts that result from loss in CRP lands, including significant carbon losses and local pollution that comes about from the increased intensification of corn production

4 While rising costs of feed will translate in reductions in income for livestock farmers, one can argue that if feed prices go up and passed into higher beef prices, individuals will eat less meat. As a consequence, methane emissions can be reduced as well as other environmental and health impacts associated with meat consumption

5 One should note that the discussion here has focused primarily on efficiency issues. However, distributional considerations can be equally, if not, more important. It is important to recognize that the combined effect of the impacts of increases in food prices and rural incomes on welfare depends on whether the income increases actually go to the population for whom food is a large portion of their budget. If increases in income go mainly to large farmers and food insecurity increases among small farmers and poor urban dwellers, even if total welfare increases, this outcome may not be acceptable for policy-makers.

References

Bento, A. and J. Landry. 2008. Economic costs, land use adjustments and the GHG emissions of increased US biofuels production. *Appl. Econ. & Mngmt*. working paper.

Bento, A. and M. Jacobsen. 2007. Ricardian rents, environmental policy and the double dividend hypothesis. *J. of Env. Econ. & Mngmt*. 53 (1): 17-31

Connor, D. J. and C. G. Hernandez. 2009. Crops for biofuel: current status, prospects and limitations for future. In R. W. Howarth and S. Bringezu (eds), Biofuels: Environmental Consequences and Interactions with Changing Land Use. Report of the International SCOPE Biofuels Project. Cornell University, Ithaca NY, USA. (http://cip.cornell.edu/biofuels/)

De Gorter, H. and D. Just. 2008. The welfare economics of a biofuels tax credit and the interaction effects with price contingent farm subsidies. *Amer. J. of Agric. Econ.* (forthcoming).

ERS (Economic Research Service) 2008. Farm Income and Costs: 2009 Farm Sector Income Forecast. U.S. Department of Agriculture ERS (http://www.ers.usda.gov/Briefing/FarmIncome/nationalestimates.htm)

Farrell, A., R.J. Plevin, B.T. Turner, A.D. Jones, M. O'Hare and D.M. Kammen. 2006. Ethanol can contribute to energy and environmental goals. *Science* 311: 506-508

Gardner, B. 2007. Fuel ethanol subsidies and farm price support. *J. Agric. & Food Ind. Org.* 5 (2): article no. 4

IEA. 2007. World Energy Outlook 2007. OECD Publications, Paris.

IFPRI (International Food Policy Research Institute). 2005. The Promises and Challenges of Biofuels for the Poor in Developing Countries. IFPRI, Washington D.C., USA.

Menichetti, E. and M. Otto. 2009. Energy balance and greenhouse gas emissions of biofuels from a product life-cycle perspective. In R. W. Howarth and S. Bringezu (eds), Biofuels: Environmental Consequences and Interactions with Changing Land Use. Report of the International SCOPE Biofuels Project. Cornell University, Ithaca NY, USA. (http://cip.cornell.edu/biofuels/)

Petersen, J. 2008. Energy production with agricultural biomass: environmental implications and analytical challenges. *Eur Rev Agric Econ (forthcoming)*

Searchinger, T., R Heimlich, R.A. Houghton, F. Dong, A. Elobeid, S. Tokgoz, D. Haynes, T. Yu. 2008. Use of Croplands for biofuels increases greenhouse gases through emissions from land use change. *Science* 319: 1238 - 1240

Sylvester-Bradley, R. 2008. Critique of Searchinger et al (2008) and related papers assessing indirect effects of biofuels on land use change. A study commissioned by AEA Technology as part of the Gallagher Review for Renewable Fuels Agency. ADAS UK Ltd., Cambs UK

Taheripour, F. And W.E. Tyner. W. 2007. Ethanol subsidies, who gets the benefits? Paper presented at the Farm Foundation/ USDA conference, 12-13 Apr. 2007, St. Louis MO, USA (http://www.farmfoundation.org/projects/documents/TaheripourandTyner_St_Louis.pdf)

Tyner, W.E. and F. Taheripour. 2008. Biofuels, policy options, and their implications: analyses using partial and general equilibrium approaches. *J. of Agric. & Food Ind. Org.* 6(2): article no. 9

Yacobucci B.D. 2006. Alternatives fuels and advanced technology vehicles: issues in congress. U.S. Congressional Research Service IB10128 2006, Washington, D.C.