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Looking towards policies supporting biofuels and technological change: Evidence from France

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ABSTRACT

The increasing constraints on crude oil resources contribute to the emergence of liquid biofuels as an alternative for road transport fuels. The European Union (EU) Parliament called for a 7% limit on crop-based biofuels by 2030 and proposed increasing the incorporation target for advanced biofuels, within the proposals under discussion in relation to the post-2020 EU Renewable Energy Directive (RED II) by 2021–2030. The main objective of this work is to assess the economic impacts of the EU Parliament's decision concerning first generation biofuels. We also determine the conditions under which advanced biofuels could become available by examining the evolution of oil prices and public subsidies. We employ a recursive dynamic computable general equilibrium (CGE) model calibrated on the French economy. Advanced biofuels are modelled as latent technology and we include biofuel by-products. Our simulations provide guidelines for public decision-makers to design alternative fiscal policies to support biofuels in a context of regulatory uncertainty.

1. Introduction

The increasing constraints on crude oil resources have contributed to the emergence of liquid biofuels as an alternative for road transport fuels. However, first-generation biofuels have been denounced as harmful in terms of their impact on food crop prices, land use changes and ecological damage. As a result, some European Union (EU) governments have decided to redirect public subsidies from crop-based to advanced biofuels made from waste products or non-edible vegetables. However, the large-scale adoption of advanced biofuels remains largely uncertain. Indeed, current trilateral negotiations between the EU Commission, the EU Parliament, and the EU energy ministers have revealed contradictory views about the future of first-generation biofuels.

In September 2013, the EU Parliament 2013 [1] called for a 6% limit on crop-based biofuels by 2020, rather than the 10% objective initially targeted in the 2009 Renewable Energy Directive (RED) (European Parliament and Council, 2009 [2]). The Parliament also proposed a 2.5% binding incorporation target for advanced biofuels by 2020. However, in June 2014 [3], the EU energy ministers came to a quite different agreement, proposing to increase the limit on first-generation biofuels to 7%, and no compulsory objective is defined for advanced biofuels. More recently, in the fall of 2016, the EU Commission proposed to revise the 2009 RED to establish new goals for the 2021–2030 period for renewable energy, energy efficiency, and renewable transportation fuels. This set of proposals, known as the post-2020 EU Renewable Energy Directive (RED II), encompasses a double objective: first, to promote advanced biofuels with a binding mandate, and second to cap the share of first-generation biofuels with a 3.8% maximum incorporation rate in road transport. This new direction of the EU Commission could imply a significant slowing of the biofuels industry in some member states. In this context, Members of the European Parliament (MEPs) decided, in January 2018 [4] to amend some of these proposals. Indeed, the contribution of first-generation biofuels would remain at a 7% limit by 2030. Concerning advanced biofuels, a 1.5% binding mandate has been fixed by 2021, increasing to 10% in 2030. Note that with the 2009 RED, without a compulsory objective for advanced biofuels, member states only had to encourage the transition towards second- and third-generation biofuels, and to respect a minimal incorporation rate of 0.5% in road transport. These lower ambitions resulted from the concerns of the EU biofuels industry and its fears about long-term profitability. Nevertheless, the most recent negotiations seem to be sending a clear message to the biofuels industry about a growth only from sustainable advanced fuels, such as waste-based biofuels, not from food crops. But the competitiveness of biofuels is closely linked to crude oil prices and technological progress. Due to the higher production costs, the substitutability of advanced biofuels in

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place of fossil fuels is particularly challenging. An overview of global biofuel policies is shown in Su et al. (2015) [5].

In this context, the main objective of this work is to assess the economic impacts of first- and second-generation biofuels, and to shed light on the design of policies for sound decision-making with views to the new RED II for 2021–2030. We also determine the conditions under which advanced biofuels could become available earlier, taking into account the evolution of oil prices and public subsidies. For this purpose, we employ a recursive dynamic computable general equilibrium (CGE) model, calibrated on the French economy. France is, together with Germany, the largest biodiesel producer in Europe (EBTP, 2015 [6]). With a capacity of 2.3 Mt/year biodiesel and 1.1 Mt/year ethanol, it produces more than the national biofuel demand and exports the surplus. Thus, our research contributes to understanding the impacts of biofuels policy on the economy of an important producer.

We extend a version of a recently constructed Social Accounting Matrix (SAM) for France, which contains a high level of detail of the energy bundle, specifically, fuel sectors. Our study is one of the first works to include a diesel and biodiesel bundle, a gasoline and bioethanol bundle, and crude oil, separately. Moreover, first-generation and advanced biofuels are differentiated in the analysis. We thus use a CGE model that is designed with detail for the adoption of these alternative technologies. CGE models are sets of numerical equations that capture the characteristics and the overall working of an economy; they are flexible with regard to different technological specifications and capture both the direct and indirect effects of the different economic policy alternatives. These models are useful tools for the simulation of scenarios, as well as for the evaluation of economic and environmental policies.

In line with the existing literature, advanced biofuels are usually modelled as latent technology. In this context, our paper contributes an original approach, modelling latent technology within a dynamic CGE model in order to simulate the times when advanced biofuels become available. For this, we assume that the implementation of advanced biofuels in the economy from 2010 to 2040 is low at the beginning, with a temporal progression characterized by an intermediate acceleration and smooth growth after a certain number of periods. We propose a novel method with a logistic schedule to capture this gradual adaptation.

Additionally, we pay special attention to include biofuels by-products in the analysis following methodological aspects for first and second-generation biofuels presented in Saladini et al. (2016) [7]. Technological improvements are also modelled, and the oil price variation is taken into account in our simulated scenarios. In this context, alternative fiscal measures to provide guidelines for public decision makers to support advanced biofuels hand-in-hand with economic, social and environmental impacts are addressed. Thus, our research aims to go beyond the specific case study, offering some insights into how we may model advanced biofuels and the potential effects of both first and second-generation biofuels to shed light on alternative fiscal policies. It provides guidelines for decision makers on a topic that is a matter of continual discussion.

The remainder of the paper is organized as follows. Section 2 introduces a brief review of biofuel-related CGE models. In Section 3, we introduce the sources of information used to obtain a Social Accounting Matrix (SAM) for France. Section 4 presents the outline of the model, its calibration, and the approach to incorporate the second generation of biofuels. Section 5 describes the scenarios and results obtained, and Section 6 shows the results of a sensitivity analysis. Finally, Section 7 provides a discussion of policy insights and closes the paper with a summary of our main conclusions.

2. Review of the literature

In recent years, a number of CGE models for biofuels have been published, specifically working on first-generation biofuels, to assess their economy-wide impacts. Our work benefits from the prior research in this area and previous results obtained. Banse et al. (2008a) [8] evaluate the global implications of the EU Directive on biofuel use for the first generation, observing that EU targets on biofuels will not be reached in 2020 without additional policies to stimulate them. Then, Banse et al. (2008b) [9] assess the global and sectoral implications of policy initiatives in a global economy and suggest the study of the second generation of biofuels to reduce environmental impacts. Rosegrant et al. (2008) [10] investigate the interaction of biofuel demand with the demand and production of food and feed crops, and observe that adverse impacts require a renewed focus on crop breeding for productivity improvement in wheat, maize, and the sugar crop. Ogg (2009) [11] indicates the importance of considering the ecological and food price effects of likely scenarios for worldwide biofuel expansion. For developing countries, Arndt et al. (2012) [12] conclude that producing biofuels enhances economic development in Tanzania whenever public investments are provided, Wianwiwa and Asafu-Adjaye (2013) [13] study the implications of promoting biofuels in Thailand and discover that biofuels do not result in increased food prices (and thus do not put food security in jeopardy), and Cansino et al. (2013) [14] evaluate the economic impacts derived from constructing biodiesel plants in a Spanish region (Andalusia). Other works present studies to improve materials and methods to analyse biofuel policies, such as Birur et al. (2008) [15] that improves the GTAP-E model to study biofuels in a global economy, and explains the detailed specifications that are required in a CGE model, and Taheripour et al. (2011) [16] present a detailed explanation of how including first- and second-generation biofuels in the GTAP data base is used as a guide for preparing the data. Additionally, environmental impacts are evaluated in Taheripour and Tyres (2014) [17], who show that induced land use emissions could be reduced with the extraction of corn oil through alternative measures to estimate emissions. In this context, our study improves the development of the database and model used in Doumax et al. (2014) [18] to analyse the impacts of first-generation biofuels. In comparison with these works, our biofuels-related CGE model proposes a detailed substitution within the energy bundle, with a high level of disaggregation of renewable and non-renewable fuels, and includes a logistic schedule to model advanced biofuels.

Earlier works have also analysed advanced biofuels. For instance, Gurgel et al. (2007) [19] introduce land as a productive factor and model second-generation cellulosic biomass used in electricity generation. Reilly and Paltsev (2007) [20] incorporate biomass production technologies, estimate biomass production in different scenarios of greenhouse gas emissions abatement, and point out that cellulosic technology has fewer direct effects on commodity prices. Boeters et al. (2008) [21] find that biofuel targets to reduce emissions are preferred to increases of excise taxes on transport fuels, because the high level of the existing taxes already distorts the transport market. Melillo et al. (2009) [22] explore scenarios for cellulosic biofuel production and find that it could contribute substantially to future global-scale energy needs, but with significant unintended environmental consequences. These authors caution policy-makers that cellulosic biofuels must be deployed carefully, so as not to jeopardize biodiversity, compromise ecosystems services, or undermine climate policy. Finally, the work of Kretschmer and Peterson (2010) [23] presents various techniques for introducing bioenergy technologies into CGE modelling frameworks, and is used as a guide in the development of our model.

In this context, our paper is, to the best of our knowledge, the first study to evaluate the gradual adaptation of advanced biofuels using a logistic evolution. Logistic curves provide S-shaped patterns, which have been widely used in the literature to model different processes of innovation diffusion (Mansfield, 1961 [24]; Mahajan and Peterson, 1985 [25]; Kijek and Kijek, 2010 [26]) and gradual technological change (Philip et al., 2014 [27] and Duarte et al., 2018 [28]). We use these functions to approximate the date at which advanced biofuels become available, low-level at the outset, with a temporal progression