



Original research article

# The political economy of bioenergy in the United States: A historical perspective based on scenarios of conflict and convergence



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## ABSTRACT

The paper analyzes the historical evolution of the production of liquid bioenergy in the US on the basis of the political economy of fuels for road transport, largely determined by the dynamics of the opportunity cost that arises from the connection between energy and agricultural markets. We have developed an analysis framework to build a set of scenarios suitable to explain the evolution of biofuel markets in the historical period analyzed. These scenarios, strongly associated with conditions of convergence and conflict between the regulatory state and the agro-industry, have then been statistically verified using an interrupted time series analysis. The analysis shows that the evolution of governance, institutions, and markets around bioenergy have been determined not just by the political goals of the US regulatory state, but also by private economic drivers related to agro-industry. This suggests that bioenergy transition in the US can be understood as the agricultural dimension of the political economy that underlies the socio-technical regime of energy for transport in the US, characterized by institutional inertia and technological lock-in.

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## 1. Introduction

The process of energy diversification in road transport has been more complex and difficult than in other sectors. This is largely due to the low availability of competitive substitutes to liquid fossil fuels, which in great extent is the result of the road transport technology and infrastructure development, characterized by inertia and technological lock-in. This has represented a technological barrier to the use of other alternative energy products [1].

Biofuels can be considered as a feasible alternative for energy diversification in road transport, especially first-generation bioethanol and biodiesel, which represent the biggest share of total production in the US, Brazil and the EU. Unlike sugar cane Brazilian bioethanol, US bioethanol is obtained mainly from corn, a product traditionally oriented to food markets. The multidimensional nature that surrounds this industry necessarily imposes unravel the historical logic of economic and political phenomena, whose impact on the development of bioenergy for road transport seems to have been decisive.

In this paper, we argue that market development of biofuels can be explained as the result of a complex relationship between the

regulatory state<sup>1</sup> and the private agro-industry sector. We choose the US as a benchmark because it is the main biofuel producer in the World and because of its long record as a significant biofuel market, which reduces the likelihood and impact of possible external influences. Anyhow, the building blocks of the model are rather general, so it is possible to adapt it in order to explain the evolution of other major markets, especially those with huge agricultural endowments and an active agricultural policy. The main point is that, while it is true that biofuels have been closely related to energy policy applied to fossil fuels for transport, the variability of commodities markets as well as the institutional game rules in the agricultural sector have exerted an important influence on the development of biofuels industry development. Hence, the aim of this work is to contribute to grasping the political economy of the industry in the US, trying to explain how political, economic and institutional endowments related to the energy use of corn have interacted along the time, and how this dynamic relationship is connected to the historical development of biofuels.

To this end, the first part of this article presents an analysis framework that can be used to explain the political economy behind the historical evolution of biofuel industry in the US, while the

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<sup>1</sup> Due to the historical approach and the origins and evolution of the regulation in the US since the late XIX, we refer to the regulatory state as the public intervention in firm's decisions and in markets outcomes.

second part puts this framework in chronological perspective, building a successive chain of explanatory scenarios on the basis of historical milestones and setting specific testable hypotheses for each period. In the third part, the proposed hypotheses have been tested using interrupted time series analysis. The applied methodology is novel to the extent that it draws attention to the effective and real balances resulting from private and public interest in each period, applying elements of analysis from a variety of disciplines.<sup>2</sup> Finally, the conclusions section presents a summary of the findings and the relevance of the approach to grasping the implications of the political economy that underlies bioenergy evolution in the US.

## 2. Analysis framework

From a historical approach, the use of biofuels can be considered to have been influenced by political and economic decisions adopted by the main actors in the frame of certain institutional and technological endowments that are part of the socio-technical regime of the energy sector. The term socio-technical regime in the energy sector rises from the notion of interdependence between society and technology [2]. The assemblage of institutions, markets and other attributes of a society interacts dynamically with the restrictions that technology imposes on human behaviors, influencing choices at different levels of decision-making, which led to a non-linear process of co-evolution [3].

Thus, the decisions around liquid bioenergy have been determined by the influence of the related markets (energy and agricultural markets) as well as by its institutional structure, including embedded Institutions, institutional environment, and institutions that govern economic transactions [4]. On the basis of that historical information, an analysis framework has been developed to study the evolution of the biofuel industry, which is formally shown as a result of a dynamic relationship of convergence or conflict between private and public agents regarding the production and consumption of biomass as a renewable source of energy for road transport. It describes the persistent institutional tensions and contradictions that arise from the different degrees of institutionalization of competing energy sources along the time, as well as the stability of the system and the potential for change [5].

This relationship emerges from the interaction of the opportunity costs related to the use of food biomass as a renewable energy source for transport. On one side, the US regulatory state, able to intervene and to not intervene in the market according to its objectives or political interests; on the other side the agro-industry linked to the energy use of biomass, whose decisions affects the level of production of biofuels. Following this logic, we have identified three main types of scenarios, characterized by positive convergence, negative convergence, and conflict. Table 1 shows the possible underlying relations upon which the historical evolution of first generation biofuels in the US can be explained.

The main vectors that have affected the political opportunity cost of the regulatory state related to fostering liquid bioenergy have been historically linked to the expectancy about the price of oil. Being this the main factor, studying environmental and agricultural policy has been relevant to explain the nuances of the public intervention's cost in the fuels markets. Thus, when the price of oil is relatively high, the opportunity cost to support alternative energy sources such as liquid bioenergy decays and vice versa. This, in turn, has historically reflected the expectations about diverse variables as the domestic reserves (e.g. conventional or unconventional tight oil), the cost of dependency on energy imports, the

strategic behavior of the international oil companies and the host-countries, the technology improvements (e.g. hydraulic fracturing) or the negative externalities. As regards the opportunity cost of the agro-industry, it is mainly affected by different variables such as the fluctuations of prices in the international food markets, the level of protection embedded in the agricultural policy, the technology, the favorable environmental policy or the level of support to liquid bioenergy itself or to local feedstocks, many of them expressed in environmental regulations, bans, commodity pricing policies, tariffs, tax breaks, subsidies or international trade rules. All of these vectors interact dynamically leading to certain sort of scenarios of conflict and convergence characterized by diverse institutional and non-institutional conditions, which can be favorable or unfavorable to the development of liquid bioenergy (Table 2).

Based on the conditions for each scenario, the impact on market development can be identified as expansion (moderate or strong) or contraction (moderate or strong) (Table 3).

Influenced by a series of vectors of economic, political and institutional nature, the opportunity costs of the different stakeholders tend to increase or decrease in time, and the resulting underlying relationship becomes essentially a dynamic process. Because of this dynamic nature, the relationship can be synchronous or asynchronous, and its evolution can be understood as a sequence of scenarios of convergence and conflict that have affected bioenergy transition over time.

Consistent with this formulation, we suggest as a general hypothesis that the historical evolution of biofuel industry in the US is not determined by the state action alone or by private sector decisions adopted in an autonomous manner, but by complex scenarios of convergence and conflict influenced by vectors that emerge from within and outside the socio-technical energy regime, which have determined the governance patterns and markets development of liquid bioenergy. In this context, governance is understood as the numerous processes through which a group of people sets and enforces the rules needed to enable that group to achieve desired outcomes [6]. The governance structure is composed of a number of institutions with certain features of resilience and adaptability, which are part of the socio-technical regime of the energy sector [7].

## 3. Scenarios of convergence and conflict, and the evolution of bioenergy for road-transport in the US

In our approach, the different combinations of opportunity costs are what determine the successions of convergence and conflict scenarios. On the public sector side, the opportunity cost is affected by the cost of energy and by the institutional endowments around biofuels governance. In a broad scope, that includes national laws and regulatory policies, as well as international rules and third countries policies related to energy, agriculture, or environmental dimensions of bioenergy. On the private sector side, the opportunity cost is related to the historical evolution of agricultural and energy markets as well as the institutional protection of the agro-industry. As noted above, even when we can observe key regulatory milestones along the development of biofuels in the US, the liquid bioenergy industry evolution in the US can be better understood as a sequence of convergence and conflict underlying relationships.

### 3.1. First period: from early 20th century to the end of World War II. Conflict scenario for liquid bioenergy expansion: (–) regulatory state (+) agro-industrial sector

During the early years of the 20th century, agriculture was a labor-intensive industry employing about 41% of the workforce in a large number of small, diversified farms located largely in rural

<sup>2</sup> The suggested methodology and the obtained results may help deal with some of the challenges posed by Sovacool [40], especially those related to institutions and energy governance, and sociology and history of technology.

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