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# Policy mixes towards sustainability transition in the Italian biofuel sector: Dealing with alternative crisis scenarios

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ABSTRACT

In this paper, we present an empirical analysis in order to identify and recommend the most effective policy combinations to steer a sustainable energy transition under alternative crisis scenarios (i.e. crisis worsening vs. crisis reduction). Specifically, focussing on a green energy niche – namely the Italian biofuel sector – we perform a fuzzy inference simulation by means of a two-step investigation. Firstly, we identified the concepts surrounding the investigated sector by means of a specifically designed questionnaire and the related literature. Secondly, we interviewed a pool of experts to map the casual effect relationships among the concepts. Then we used this map to develop the two alternative scenarios and the related most suitable policy mixes to foster the sector development. As expected, our findings show that the most effective policy mixes vary across the scenarios and according to different pursued objectives. This is particularly evident in the case of the job creation' goal, when the policy mix in the crisis-worsening scenario differs considerably, both in terms of ranking and composition, from the policy mix in the crisis-reduction scenario. Therefore, our evidence supports the need for going beyond a simple one-fits-all approach to deploy the synergistic effect of the policy drivers' interaction.

## 1. Introduction

Biofuels are liquid, solid, or gaseous fuels derived from renewable biological sources (such as food crops, crop residue, wood waste and by-products, and animal manure); they include ethanol and other alcohol-based fuels, pyrolysis oils, gasification fuels, and biodiesel. They are supposed to provide a relevant alternative to fossil-based fuels, and expected to create new job opportunities in manufacturing, plant servicing, and fuel harvesting and transport [1]. Biofuels are receiving a great deal of attention from policy makers worldwide [2]. In this fashion, EU Commission is promoting the development of a large biofuels market by committing all the Member States to a 10% renewable fuel mix by 2020 [3].

However, despite the emphasis towards their potential, biofuels are subject to considerable criticism, due mainly to the possible negative externalities associated with them, mainly in terms of soil and water degradation [4], increased water demand [5], biodiversity loss [6], and uncertain net reductions in greenhouse gas (GHG) emissions [7]. This is giving rise to a wide policy and sustainability contention of biofuel among practitioners and academics [8,9]. In particular, they emphasize the importance of also taking into account sustainability criteria in biofuel production for achieving a green energy transition, including environmental (e.g. energy consumption and GHG emissions related to biofuels), economic (e.g. increase in crop prices and food costs), and social related issues (e.g. the social acceptance of the new biorefinery plants).

Building on the sustainability transition literature [10–12], another aspect to consider is represented by the pressures coming from structural and transformational system failures, as in the case of the recent economic crisis that has affected most economies on a worldwide level.[1]

In this respect, policy mixes are meant to be the main route of dealing with these structural failures [13]. The relevance of this tool in fulfilling the socio-technical needs, including the decarbonization of the energy system, has also been recently acknowledged by the OECD [14]. In this context, several investigations have been provided in order to design and appraise policy mixes for addressing sustainability transition [15–18].

In this paper, we stress the complexity of the relationship between the transition towards low-carbon systems and the economic crises, which should be addressed by a comprehensive approach capable of identifying well-tailored policy mixes. To this end, we present an

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[1] A summary of the contributions to the topic concerning the link between sustainability transitions and economic crises is provided in Table A1 in the Appendix A.

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empirical analysis aimed at identifying and recommending the most effective policy combinations to steer a sustainable energy transition under alternative crisis scenarios (i.e. crisis worsening vs. crisis reduction). The investigation focusses on the case of the Italian biofuel sector, and employs a fuzzy inference approach that allows the treating of the complexity phenomenon under investigation.

The remainder of the paper is structured as follows: Section 2 presents the literature review; Section 3 describes the context of the analysis; Section 4 deals with the methodology; Section 5 reports the results; Section 6 ends with some concluding remarks.

## 2. Literature review

The importance of a policy mix for addressing the decarbonization of the energy system has been largely recognized in the literature [19]. According to the pure neoclassical perspective, policy mixes are required for such sustainable transition in order to push firms to undertake socially efficient levels of innovative activity. Indeed, when the social returns to innovation exceed the private returns, innovations might be lacking; this results in the necessity of 'internalizing' externalities and correcting for such market failures [20]. In contrast, from the innovation system perspective, the foundation for a combination of different policy instruments to drive sustainable energy transitions originates from the need to correct for multiple market failures, such as underinvestment in R & D or negative environmental externalities of greenhouse gas emissions. However, it can also orginate from structural and transformational system failures, such as institutional failures or failures regarding the direction of a transformation process [10]. These new practice-oriented views allow for the combination of long-term aims with short-term actions (so as to complement traditional policy intervention) through a process of experimenting, learning and stakeholder involvement [21]. In this fashion, policy mixes can contribute to sustainability transitions by providing public support for infrastructure, helping companies to cope with technological changes, generating incentives for new technologies or technological systems, overcoming barriers created by the prevalence of incumbent technologies, and monitoring and assessing the performance of regulatory and policy systems [13].

The topic of policy mixes for the promotion of energy transitions has gathered increasing attention among policymakers and scholars involved in the emerging field of innovation and sustainability transitions theory. Initially, emphasis was placed on the interaction of different policy instruments for a successful policy outcome [22,23], and on the policy processes concerning the designing of such a mix of instruments [24]. In particular, the active involvement of local stakeholders represents a relevant aspect in designing policy mixes, mainly in contentious contexts where social acceptability is crucial, such as in biofuel production [25]. Indeed, designing an effective mix of policy instruments for driving the transition towards a biofuel-based regime involves a significant amount of changes in behaviour and practices that, in turn, requires the cooperation of local stakeholders [26]. From this point of view, the base assumption is that members of local communities are a depository of embedded knowledge about processes and mechanisms at the local level and, therefore, they represent a significant source of information for policymakers in shaping policy mixes [27].

Recently, a wider conceptualization of the policy mix concept arose in order to provide an holistic framework for analysing the link between policy and technological change. This new trend is rooted in the need for redirection and acceleration of technological change, for which polices' interaction play a significant role in moving towards a more sustainable energy system. Policy mixes therefore embody complex arrangements of several goals and means, usually developed over many years; these involve both traditional technology push and demand pull instruments, as well as mission-oriented policy instruments [28,29,16]. The rationale of using a broad policy mix conceptualization is justified by the identification of multiple aspects outdoing a single policy instrument in terms of instrument' combinations, long-term policy objectives, and the other policy mix aspects such as consistency, comprehensiveness, credibility and stability [30,31,15,18].

A quite recent contribution, provided by Reichardt and Rogge [29], has extended the debate on the link between policy mixes and technological change in the context of sustainability transitions theory in two main points. Firstly, the authors provide a broadened view of the policy mix that considers the intricacy and dynamics of real-world policy mixes, going beyond the interacting instruments and strategies for long-lasting objectives, but also embracing the underling policy processes aimed at shaping policy mixes. Secondly, they offer an integrating analytical framework that could help empirical analysis by looking at previously disregarded facets so as to enable more specific policy recommendations. In the same vein, Quitzow [17] proposes a comprehensive framework for comparative policy appraisal, focussing on specific challenges related to the promotion of environmentally friendly innovations. In doing so, the author revises the concept of a "policy strategy", developing it further from the literature on the governance of environmental innovation and technological change. In particular, the suggested concept of "policy strategy" not only embodies the objectives, measures, and processes characterizing a certain mix of policy, but also the normative dimension of policy making, such as value judgements, political opportunities and pressures. This implies that an ultimate sustainable transition, through the achievement of effective policy strategies for the promotion of environmental technologies, lies in the debate concerning the trade-offs among socio-political and techno-economic concerns. Indeed, the identification and tackling of such trade-offs seems to be, in practice, the most critical task in order to develop and implement policy strategies for a transition towards sustainability.

Focussing on the recent policy mix and sustainability transitions contributions, Kivimaa and Kern [16] suggest a framework for the analysis of policy mixes considering, alongside policies for the development of a specific technology-innovation system, all policies that possibly move towards sustainable transitions. Thus, transitions imply not only the creation or diffusion of innovations, but also a wider shifting of the whole socio-technical system. In other words, the authors recognize the importance of policy mixes designed for radical changes within an industry by means of a simultaneous breakthrough of new energy innovations niches; this is in addition the mere destruction and replacement of the dominant sociotechnical system.

In this article, we complement the recent empirical interest on policy mixes for sustainable transitions (see [17,16]) by investigating the mix of policies that can contribute to drive the sustainability transition of the Italian energy industry. To this end, we try to enrich the literature by providing a new empirical framework of analysis, a policy fuzzy inference simulation, in order to identify and recommend the most effective policy combinations to steer a sustainable energy transition under alternative scenarios (i.e. crisis worsening vs. crisis reduction). This could help to fill the gap concerning the overall lack of attention to mix of the policies capable of directly promoting a transition towards energy sustainability [16].

## 3. The context of analysis

In accordance with EU energy policy, Italy is trying to achieve a sustainable and reliable energy supply. In particular, much effort is being devoted to meeting the goals set by Directive 2009/28/EC; this Directive establishes the 17% target of final energy consumption from renewable sources by 2020 (raised to 20% from the 2010 Italian Renewable Energy Action Plan). The directive also aims to accomplish the 10% goal of renewable energy in the transport sector by the same year.

To this end, Italy is increasingly supporting the renewables industry, with a particular focus towards the development of a modern and