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The impact of different energy policy options on feedstock price and land demand for maize silage: The case of biogas in Lombardy

A. Bartoli [a,*], D. Cavicchioli [a], D. Kremmydas [b], S. Rozakis [b], A. Olper [a]

[a] Department of Economics, Management, and Quantitative Methods, University of Milan, Italy
[b] Department of Agricultural Economics and Development, Agricultural University of Athens, Greece

HIGHLIGHTS

- We investigate biogas production in Lombardy under two alternative policy scenarios.
- We model the biogas sector using a partial equilibrium approach.
- Past legislation significantly increases maize demand and its market clearing price.
- New incentive system favors manure based plants (130 kWe) decreasing maize demand.
- Wider, new policy mitigates past distortions and negative effects on maize price.

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ABSTRACT

The growing demand of maize silage for biogas production in Northern Italy has triggered an intense debate concerning land rents, maize prices and their possible negative consequences on important agri-food chains. The aim of this work is to quantify the extent to which the rapid spread of biogas raised the maize price at regional level, increasing the demand of land for energy crops. For this purpose we applied a partial-equilibrium framework simulating the agricultural sector and the biogas industry in Lombardy, under two alternative schemes of subsidization policy. Results show that policy measures implemented in 2013 – reducing the average subsidy per kWh – may contribute to enforce the complementarity of the sector with agri-food chains, decreasing the competition between energy and non-energy uses. Compared to the old scheme, maize demand for biogas would decrease, lessening the market clearing price (as well as feed opportunity cost for livestock sector) and reducing land demand for energy purposes.

1. Introduction

Biogas production from energy crops has strongly grown over the last years in Italy, as a consequence of the subsidization policy. Despite the biogas policy scheme concerns the whole Country, in Italy biogas plants are mainly concentrated in regions of the Po Valley (i.e. Lombardy, Piedmont, Emilia-Romagna and Veneto), whose agricultural systems are highly productive and urban areas are densely populated. With one of the highest concentrations in Europe, Lombardy is the region with the highest share of biogas plants in Italy (361 at the beginning of 2013, equal to 40% at national level, Peri et al., 2013).

However, as many biogas plants use maize silage, such emerging activity has been accused to increase maize demand with two main consequences: i) pushing up (locally) land rent price and ii) raising its opportunity cost as livestock feed in a region where, before the proliferation of biogas plants, animal production represented about 60% of the value of agricultural production (Cavicchioli, 2009). According to such criticism, in Italy maize area devoted to biogas plants has grown sharply between 2007 (below 0.5% of arable crop mix) and 2012 (10% of arable crop mix), covering more than 18% of arable land in Lombardy (Mela and Canali, 2014). Therefore this competition may put under pressure agri-food supply chain, among which some important Protected Designation of Origin (PDO), such as Grana Padano and Parma ham.

As pointed out by Carrosio (2013), the huge expansion in the number of biogas plants has been mainly driven by dedicated subsidization schemes. In particular the feed-in tariff (FIT) introduced in

* Corresponding author.
E-mail address: andrea.bartoli@unimi.it (A. Bartoli).

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Italy in 2009,[1] has boosted agricultural biogas production between 2009 and 2012 (Fig. 1) shaping the technology adoption by farmers (Chinese et al., 2014). Under such scheme, all plants with an electric capacity up less than 1 MW electric (MWe) were entitled to receive the all-inclusive feed-in tariff of 0.28 €/kWh for 15 years,[2] leading the majority of biogas plants to build a capacity slightly less than 1 MWe in order to maximize subsidies (Carrosio, 2013).[3] Such incentive system has oriented the majority of biogas plants toward the exclusive production of electric energy, rather than cogeneration (production of electricity and heat) even if the latter would be more efficient in terms of biogas utilization (CRPA, 2008; Mela and Canali, 2014).

This consideration is in line with previous studies (e.g. Haas et al., 2011; Britz and Delzeit, 2013) pointing out the distortive effect of subsidization mechanism for renewable energies, like the FITs. this payment scheme assures a higher profitability, associated to a diminished level of risk, charging taxpayers with associated additional costs (Chinese et al., 2014). As a result, the level of public support to renewable energy has been put under discussion (Galeotti, 2012), leading to a new biogas subsidization structure in 2012,[4] more in line to those adopted in other European Countries (Hahn et al., 2010). The new support scheme applied from January 2013 and provides, with respect to previous policy, a payment reduction in absolute terms and new criteria more favourable for smaller plants (see Table 1). Moreover, in order to encourage the utilization of manure and by-products instead of energy crops, the subsidies have been related to the type of feedstock used in the blend (Gaviglio et al., 2014). In the present paper the two different incentive systems described above will be hereafter referred to as *pre* 2013 and *post* 2013 renewable energy policy system.

The evolution of Italian biogas market and incentive policy has been examined in some recent papers.[5] Carrosio (2013) proposed an analysis based on the neo-institutional lens. In particular, he argued that the incentive system associated to technology uncertainty led to a non-competitive market structure, resulting in one prevalent model of biogas production (999 kWe plants fed with a blend of energy crops and livestock manure), with low efficiency in energy use and environmental outcomes. Chinese et al. (2014), used a linear programming approach to study the effect of *pre* 2013 and *post* 2013 Italian biogas incentive systems on plant dimension, input bend and profits. Such a simulation makes assumptions on maize supply, using cultivation and harvesting cost as a proxy for input price. Main results show that the *post* 2013 new regulation would make the system to shift toward smaller plant size, mainly fed by manure, and so reducing the pressure induced by energy crop-based plants.

Building upon and extending existing literature, the aim of this paper is to analyse the impact of biogas production in Lombardy on maize silage demand, price and, in turn, on potential competition with other agri-food supply chains in terms of opportunity cost for maize silage. To do so, we build up a partial equilibrium framework, by explicitly modelling and integrating demand-side biogas industry and supply-side agricultural sector. Using such a modelling framework we perform a comparative-static exercise, deriving market clearing price and quantity for maize silage under *pre* and *post* 2013 support scheme. This integrated model allows then to emphasize the differential effects[6] of alternative energy policies for biogas production on maize silage equilibrium price and, in turn, on the related outcomes, such as energy production, biogas plant profitability and allocation of land devoted to biogas production.

This paper is the first application to the Italian biogas sector of a partial equilibrium framework, firstly developed by Delzeit (2010) and Delzeit et al. (2012) for the German biogas sector. In particular, we applied this method in different areas and under different policy schemes. From this perspective, our contribution to the literature is twofold. Firstly, we can assess the suitability of the proposed methodology when applied to a specific reality. Secondly, from the modelling exercise we can draw important policy implications for the Italian agro-energy subsidization schemes.

Moreover, we add to the existing literature on similar topics in Italy (i.e. Chinese et al., 2014) contributions in terms of *equilibrium displacement effects* under different renewable energy policy options, through: i) the comparison of market clearing price for maize before (actual) and after (simulated) the introduction of biogas sector, and under *pre* and *post* 2013 biogas energy policies; ii) the estimation of differential biogas energy production and profitability; iii) the related differential demand of land for maize silage.

The structure of the paper is the following. Section 2 briefly reviews the relevant literature on bioenergy modelling, describes models used to build up our partial equilibrium framework, and motivates our methodology. Additionally, data and models parameters are described. In Section 3 we illustrate and explain the model results under alternative policy scenarios. Section 4 summarizes the main findings and draw policy implications.

2. Methods

2.1. Modelling framework for biogas production

Agricultural biogas production uses bulky biomass inputs (energy crops, manure and/or by-products), with localized demand and high transportation costs (Delzeit, 2010). This demand, in turn, influence regional markets for bioenergy feedstock (Mertens et al., 2014) and will interact with the market for crops devoted to non-biogas uses. Such "side-effects" call for a comprehensive assessment of all these inter-linked markets. The impact of alternative agricultural and bioenergy policies has been assessed using different approaches like micro-economic and multi-criteria methodology (Rozakis et al., 2013), partial-equilibrium framework (Delzeit et al., 2012), mixed integer linear programming (Chinese, 2014), nonlinear programming (Stürmer et al., 2011), survey information and farm-household mathematical programming (Bartolini and Viaggi, 2012), Positive Mathematical Programming integrated models (Donati et. al, 2013), dynamic mathematical programming (Bartolini et al., 2015), multi-agent modelling approach (Mertens et al., 2014) or using approaches based on geographical information systems (Delzeit et al., 2009a; Fiorese and Guariso, 2010; Sorda et al., 2013).

In the present study, we apply a partial equilibrium model on two areas of Lombardy Region in order to assess the impact of Italian subsidies for biogas production on energy and agricultural markets, using a demand-side biogas industry model and a supply-side agricultural model.

[1] See Law 99/23 July 2009.

[2] With the introduction of the Law 99/23 July 2009, biogas plants up to 999 KWe, were entitled to receive a single payment (feed-in tariff, FIT) of 0.28 €/kWh, ensured for 15 years. The same time span of subsidization was assured to plants bigger than 1 MWe, under the *Green Certificates* system.

[3] According to the Law 99/23 July 2009, FIT, more profitable than the *Green Certificates* incentive mechanism, was available only for plants below the threshold of 1 MWe. Within this category, plants that better maximize the profits were those with capacity slightly less than 1 MWe (999 kWe), more efficient and able to produce more energy compared to smaller plants (e.g. 250 kWe).

[4] Decree of the Ministry of Economic Development of 6 July 2012.

[5] More in general, many studies analyzed the agro-energy sector in Italy from different view point. For example, Donati et al. (2013) investigated the water requirements of energy crops production in Emilia Romagna. Bartolini and Viaggi (2012) and Bartolini et al. (2015) studied how different Common Agricultural Policies (i.e. CAP 2014–2020 reform) affect the adoption of agro-energy production in Emilia Romagna and Tuscany, respectively.

[6] Such simulated differential effects are not free of potential distortions due to assumptions made to render the modelling exercise tractable, as explained in Section 2.2.2.