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## Exploring the determinants of emerging bioenergy market participation



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## ABSTRACT

Individual biomass producers will play a strong role in the emergence of robust and sustainable bioenergy markets. Research on what drives their participation, however, is substantial but fragmented. Despite a recognition of producer heterogeneity, there have also been few comparative analyses of drivers of bioenergy market participation across feedstock types, producer groups, and geographic regions. Through narrative review and network analysis, the following review of the bioenergy market participation literature generates both an increased appreciation of how bioenergy market participation is assessed in existing research and how social network analysis may be further employed as a tool for literature review. Across 41 studies selected for qualitative review and a subset of 22 selected for quantitative review, the analysis reaches two central conclusions. The first pertains to the findings of the literature itself, suggesting that a variety of non-production objectives, structural and social constraints, and market-related attributes influence bioenergy market participation decisions. A second conclusion is that the assessment of these factors varies significantly across the literature for both user group and feedstock type. Further examination of the individual variables within these segments of the literature, as well as of authorship patterns across them, suggests that this variation may rise from differences in the subject matter itself and not from differing perspectives of the researchers undertaking the work. Should disparities in the literature be reflective of actual socio-economic differences in their respective markets, policies or programs targeted to individual feedstock types or user groups may be more effective in encouraging participation than uniform national policy initiatives.

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## 1. Introduction

Despite the strong role of individual biomass producers in emergence of a robust and sustainable bioenergy market, relatively little research exists on what drives their participation [1]. And despite

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a recognition of a wide degree of producer heterogeneity [2], there have also been few comparative analyses of drivers of bioenergy market participation across different producer groups [3,4]. These absences are all the more conspicuous in light of the large contributions bioenergy is projected to play in the U.S. and E.U. economies and the wide array of policies and incentives targeted to increasing their production and use [5]. Compilation of the lessons learned from the existing body of work is a necessary and timely exercise, and is therefore the focus of this review and analysis.

Much of the research that describes aggregate bioenergy supply is generated from the use of economic models such as the Forest and Agricultural Sector Optimization Model with GHGs (FASOMGHG), the Global Trade Analysis Project (GTAP) model, POLYSYS, and others. These models have been used in recent years to assess a vast array of policies and environmental impacts [6–11]. As powerful as these models are, they generally rely on a simplified model of producer participation, that of the profit maximizer. In the case of new or emerging markets like carbon offsets or bioenergy production, profit maximization may be a defensible assumption for larger landholdings or those that are managed for financial returns [12,13]. As programs scale and a broader suite of producers are assessed for participation, however, models based on a singular assumption of profit maximization fail to incorporate the full range of objectives that may be managed for, and in doing so, may generate constrained, misleading, or otherwise incomplete results [13–15]. In particular, they may tend to over-estimate participation rates and supply [16].

A first step in improving our understanding of aggregate market response and thus improve policies through which it may be achieved is to develop a better sense of those factors that influence producer decision-making as it pertains to bioenergy market participation. This is the objective of the review and analysis conducted here. The analysis first surveys the available literature for both identified drivers of and attributes associated with bioenergy participation. In addition to traditional economic measures such as feedstock price or willingness-to-pay, it also assesses factors such as demographic indicators (e.g., age, income, education), biophysical attributes (e.g., soil type, site productivity), and previous participation experience (e.g., conservation program participation, familiarity with easements). Next, social network analysis is employed to further explore trends in the literature with a particular emphasis on how identified factors may vary by region, feedstock, or user group. The analysis concludes with a summary of findings and recommendations for future model and policy development efforts.

### 1.1. Policy to encourage bioenergy market participation

The role of public policy in supporting bioenergy market development has featured prominently in the literature [5,17–19]. In practice, recent years have seen a multitude of policy initiatives implemented with the express purpose of fostering bioenergy market development. These initiatives are characterized by great variability in scope and operation. The literature is replete with approaches for classifying policy instruments [20], but these policies can be broadly categorized for the purposes of this study as one of three types based on their mode of operation: mandate, subsidy, or technical assistance.

An important example within the first policy category – mandates – is the current iteration of the Renewable Fuels Standard (RFS2), which was established by the 2007 Energy Independence and Security Act (P. L. 110-140) and requires a minimum annual contribution of renewable liquid transportation fuels. The minimum quantities established by the RFS2 reduce market uncertainty by ensuring a predictable annual demand for fuel (and by extension, the feedstock to produce it). An example of the second policy type – subsidy – is the Biomass Crop

Assistance Program (BCAP). Created as part of the 2008 Farm Bill (P.L. 110-246), BCAP makes available payments to support the production of specific feedstock types. By focusing incentives in competitively selected project areas that link feedstock suppliers with fuel producers, the program also seeks to address a recurrent “chicken-and-egg” program that heretofore has impeded market development. Examples of the third policy type – technical assistance – abound, and use aid and information to ease or facilitate feedstock producer decision-making and investment. Included within this policy type include feedstock supply assessment programs, publication of technical specifications or guidelines, or direct assistance for practice implementation. Though acting through different mechanisms, these collective policies all in some way rely upon or seek to influence individual biomass producers. Generating a greater understanding of the drivers of bioenergy market participation can therefore improve the potential effectiveness and efficiency of overarching policy.

### 1.2. Observing bioenergy market participation

Bioenergy market participation, defined here as “the direct generation of earnings from bioenergy market activities”, may be observed differently across different parts of the bioenergy market supply chain. Specifically, market participation will mean different things for biomass producers, energy producers, and brokers, processors, and other intermediaries [4]. The focus in this analysis is on bioenergy feedstock producers—farmers and foresters. But even within biomass producers, bioenergy market participation can be observed by way of several different behavioral changes, ordered here by the degree of commitment required or degree of risk exposure (Table 1).

At the most basic level, bioenergy market participation can occur without substantive change in practice. This situation involves only a change “on paper”, whereby there is a shift in feedstock spot or comparable over the counter (OTC) market but not change in product or terms (e.g., corn supplied to an ethanol refinery instead of a feedlot operation). Importantly, this shift may or may not be known to the feedstock producer, depending on harvest arrangements and the presence of aggregators and other market intermediaries. Next, one could undertake a shift in type or terms of contracting to take advantage of bioenergy market opportunities (e.g., establishment of long-term contract to supply an ethanol refinery). Requiring additional levels of commitment are changes in feedstock output undertaken by existing farmers, measured in either a change in harvest scale (e.g., more acres planted) or an expansion of products harvested (e.g., harvesting stover for the first time). Finally come new entrants, or those individuals cultivating and/or harvesting for the express purpose of supplying biomass feedstock, thus requiring the purchase of new equipment and/or the establishment of new crops.

These differences in commitment or exposure suggest that the factors underlying market participation may differ by feedstock. And as targeted feedstocks are not universal across space or industry, one could also expect to see differences in factors associated with market participation by region and user group, as well. These hypothesized differences form the theoretical basis of the following review and frame the central research question of the analysis herein: does the available literature on bioenergy market participation vary by feedstock, region, and/or user group?

## 2. Materials and methods

Previous efforts to assess the factors contributing to particular land management decisions [21], social perceptions of new technologies [22], GHG and environmental effects [23–25], and productivity [26,27] have employed meta-analytic approaches of

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