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Biofuel-related price transmission literature: A review☆

Teresa Serra [a,*], David Zilberman [b]

[a] Centre de Recerca en Economia i Desenvolupament Agroalimentaris (CREDA)-UPC-IRTA, Parc Mediterrani de la Tecnologia, Edifici ESAB, C/ Esteve Terrades 8, 08860 Castelldefels, Spain
[b] Department of Agricultural and Resource Economics, University of California, Berkeley, USA

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ABSTRACT

In this article, an extensive review of the rapidly growing biofuel-related time-series literature is carried out. The data used, the modeling techniques and the main findings of this literature are discussed. Providing a review of this flourishing research area is relevant as a guidepost for future research. This literature concludes that energy prices drive long-run agricultural price levels and that instability in energy markets is transferred to food markets.

1. Introduction

The growth of global biofuel production during the first decade of the new millennium has been mainly led by government policies that target different objectives such as adding to domestic energy security, promoting rural economic growth, addressing global warming, or reducing fossil fuel prices (Hochman et al., 2010).[1] World ethanol production reached roughly 20 billion gallons in 2009, with the United States (US), Brazil and the European Union (EU) representing about 54%, 34% and 5% of this production, respectively (RFA, 2011). World biodiesel output is dominated by the EU that produced 9 million tons in 2009, 65% of global output (EBB, 2010).

Currently commercialized biofuels are, by and large, first-generation biofuels based on food crops.[2] Ethanol is mainly produced from coarse grains (representing 51% of global ethanol output by feedstocks in 2008–2010), specially corn, and sugarcane (accounting for 29% of global ethanol output in the same period) (OECD-FAO, 2011). Biodiesel is mainly produced from vegetable oils (rapeseed oil in Europe and soybean oil in the US). About 20 million hectares (1% of worldwide agricultural land) were committed to grow biofuel feedstocks in 2008 (Scarlat and Dallemand, 2011). In 2008–2011, around 11% of global coarse grain production, 13% of vegetable oil production and 21% of sugar cane production were used to fuel cars (OECD-FAO, 2011). These average figures however disguise significant differences across countries and commodities. The proportion of US corn production transformed into alcohol for fuel reached 40% in 2010–2011 (USDA, Economic Research Service, 2011). In Brazil, 55% of sugarcane was distilled into ethanol in the same period (Valdes, 2011).

Subject to mandates, tax exemptions, subsidizations, or technical restrictions in different countries, biofuels are usually consumed blended into gasoline and diesel, but also in pure form (Chang et al., 2011). The share of ethanol in total US gasoline consumption was 5.5% in 2009 (RITA, 2011), below the US blend wall of 10% of ethanol in gasoline.[3] In Brazil ethanol displaced around 50% of gasoline used for transportation in the same year (REN21, 2010). In the EU, biofuels represented 4% of all transportation fuels in 2009 (EurObserv'ER, 2010).

More recently, skepticism around the benefits of promoting biofuels has grown as these have been blamed for being one of the causes of the

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* Corresponding author. Tel.: +34 935 521 209; fax: +34 935 521 121.
E-mail address: teresa.serra-devesa@upc.edu (T. Serra).

[1] As noted by a referee, the fact that biofuels usually require government support to be competitive, casts doubts on their actual contribution to fuel price declines.

[2] While cellulosic sources are projected to supplement biofuels from food crops sometime in the future, they are still at a research or demonstration stage and are not expected to be commercialized before 2020 (Sims et al., 2010).

[3] As explained by Abbott (2012), the blend wall has not been a binding constraint over the short-run, but it is expected to be more binding in the longer-term through its influence on investments on ethanol plants.

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2007/08 and the 2010/11 global food crises, having negative environmental and social impacts, etc. This has led many governments to reconsider support to biofuels. One of the most important effects of the growing biofuel production has been the change in the nature of the link between agricultural commodity and energy markets that has spurred the food versus fuel debate. While this link was traditionally weak (Taheripour and Tyner, 2008) and mainly supply driven (i.e., through input costs, specially through energy intensive agricultural inputs), a wide range of analyses have reported a stronger connection since the increase in the biofuel industry demand for food commodities. Though much of the interest among the press and the academic world has been on the implications of biofuels for food prices, some research papers also investigate how biofuels affect fossil fuel prices (Whistance and Thompson, 2010).

An overwhelming majority of analyses studying the biofuel impacts on food and energy prices have focused their interest on price levels. Price volatility has received much less attention. The recent 2007/08 crisis, however, has stimulated research in the area of commodity price volatility. While there is not a single definition of price volatility, it is generally characterized as a directionless price variability that cannot be predicted by market fundamentals (Prakash, 2011). Episodes of prolonged and/or relevant volatility have been shown to have important economic impacts (they can lead to reduced investments in R&D and in physical and human capital, unemployment, income fluctuations, etc.) that can bring on social and welfare costs, increased poverty, reduced social peace and cohesion, etc. (Prakash, 2011).

The academic literature has extensively relied on partial and general equilibrium models as a methodological approach to characterize the economic impacts of biofuels. These models have however been widely criticized for not being sufficiently validated against historical data and perform poorly (Beckman et al., 2011). Further, since they are usually calibrated using annual data, they are unable to assess short-run price dynamics. Given that volatility is intuitively a measure of the extent to which prices jitter, volatility assessments gain from using data at high frequencies, both because high frequency volatility is easier to predict and because it has proven useful to forecast at longer horizons (Andersen et al., 2003). The time-series econometrics literature studying the economic impacts of biofuels has been growing in parallel with the availability of biofuel time-series data.

Reviews of the literature investigating the economic impacts of biofuels have paid special attention to structural models (Kretschmer and Peterson, 2010; Rajagopal and Zilberman, 2007). Some recent articles have presented non-exhaustive reviews on the biofuel-related price transmission literature (Janda et al., forthcoming; Zilberman et al., in press). In this article, an extensive review of the time-series literature addressing the impacts of biofuels on food and/or fuel prices is carried out. The data used, the modeling techniques and the main findings are discussed. Providing a review of this rapidly growing research area is relevant as a guidepost for future research.

The paper is organized as follows. In the next section, a discussion of different price modeling approaches, as well as some general time-series properties and how they should be modeled is presented. The third and fourth sections are devoted to review price level and volatility studies, respectively. A summary of research results and a list of still open research questions conclude the article.

2. General modeling issues

The economics profession's ability to accurately understand and forecast commodity prices has been widely questioned (Deaton, 1999; Hamilton, 2009). Recent progressive dismantling of public commodity price stabilization mechanisms, leading to increased dependence of prices on global markets may have complicated the task. The relevance to obtain accurate forecasts cannot be understated given the influence of expected prices on the decisions taken by economic agents.

Attempts to theoretically model food-energy price links are relatively new (Ciaian and Kancs, 2011a) and mainly focus on assessing price level patterns. In contrast, price volatility interactions receive little attention (Wright, 2011). Price links have been usually defined using partial equilibrium models that differ in terms of sophistication and underlying assumptions. de Gorter and Just (2008, 2009a, 2009b) use a partial equilibrium model of corn, ethanol and oil markets to show that consumers' willingness to pay for ethanol establishes a long-run link between crude and ethanol prices, while supply forces lead to an equilibrium between feedstock and ethanol prices. Ciaian and Kancs (2011a) extend de Gorter and Just's (2008) model to allow for agricultural commodities other than feedstock and for the indirect input channel through which energy can affect agricultural prices. As opposed to the competitive structure generally assumed, Saitone et al. (2008) and Hochman et al. (2010, 2011a, 2011b) allow for market power. Hochman et al. (2011b) and Carter et al. (2012) include corn inventories in the assessment of the impacts of biofuels on corn prices. A strand of literature stresses the relevance of considering policy regulations to better understand food-energy price links (Abbott, 2012; Carter et al., 2012; de Gorter and Just, 2008, 2009a, 2009b; Tyner, 2010). While theoretical structures generally allow for energy-agricultural price causality links to flow in both directions, more attention has been paid to quantify the increase in food prices as a result of the influence of biofuel markets. Hochman et al. (2010)'s literature review places these increases between 3 and 75%.

In spite of the progress made in theoretical modeling of food–energy price relationships, there is no widely accepted model that explains food price volatility (Wright, 2011).[4] Speculation in futures markets, stocks, changes in food and fuel demand, weather conditions, changes in world population, policy regulations, or macroeconomic conditions (exchange rates, interest rates, monetary policy, etc.) can alter food and energy prices and their links (Balcombe, 2011; Cooke and Robles, 2009; Gilbert, 2010; Headey and Fan, 2008; Meyers and Meyer, 2008; Mitchell, 2008; Wright, 2011). However, no comprehensive theoretical framework embracing all these elements has been developed, which makes it difficult to predict the sign and relative magnitude of their impact.

Time-series models hardly impose any theoretical structure and mainly focus on empirical investigation of price links. They have the advantage of not requiring as much data as structural models. Many price transmission models are based on price data alone, which is usually available at relatively high frequencies that are suitable to investigate price volatility issues. In being non-structural models, however, time-series models do not allow distinguishing price patterns under alternative theories (Miller and Hayenga, 2001). Their results should thus be interpreted with care. Abbott (2012) and Headey and Fan (2010) criticize time-series analyses for being rather inconclusive regarding the influence of biofuels on commodity prices and for failing to provide substantial economic insight into price behavior patterns.

Caveats being made, time-series models are relevant instruments to characterize price behavior. When relevant market events are in place and if we, social scientists, wish to be relevant, "we do not have the luxury of waiting for the evidence needed for formal testing of hypotheses (…)" (Wright, 2011; p.42). In this regard, an empirical non-structural assessment can shed light on the patterns followed by the relevant economic indicators. Some general statistical properties of time-series dynamics such as nonstationarity, co-movements, nonlinearity and time-varying clustering volatility, should be considered to provide refined price forecasts (Deaton and Laroque, 1992; Myers, 1994; Stigler, 2011). Nonstationary time series tend to have a high degree of persistence or autocorrelation, implying that both their mean and variance change over time. While empirical proof of the presence of a unit root

[4] Alghalith (2010) developed a theoretical model assessing joint oil and food price uncertainty in a small producing country. The model, however, does not allow to a priori predict the sign of the impacts of oil price, price uncertainty and production on food prices.