Food Policy 51 (2015) 63–73

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

Impacts of ethanol policy on corn prices: A review and meta-analysis of recent evidence

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ARTICLE INFO

Article history:
Received 18 August 2014
Received in revised form 5 December 2014
Accepted 25 December 2014

Keywords:
Ethanol
Biofuels
Renewable fuel standard
Commodity prices
Meta-analysis

ABSTRACT

The literature on the impacts of biofuels on agricultural commodity prices is characterized by contradictory findings. We review studies published between 2007 and 2014 that estimate the effects of U.S. corn ethanol policy on corn prices and find estimates ranging from nil to over 80%. Such divergent results make it difficult to assess the merits of alternative biofuel policies. To bring more clarity to the issue and facilitate comparisons across studies, we assemble a database of over 150 medium-to-long run estimates of the effect of corn ethanol production on corn prices from 29 published studies. We first normalize corn price impacts by the change in corn ethanol volume to control for the large differences in ethanol quantities across scenarios. We then conduct a meta-analysis to identify the factors that drive the remaining variation in corn price impacts across studies. In addition to ethanol volumes, we find that modeling framework, projection year, inclusion of ethanol co-products, and biofuel production from other feedstocks explain much of the differences in price effects. The results indicate that a one billion gallon expansion of the US corn ethanol mandate in the year 2015 would lead to a three to four percent increase in corn prices, with smaller price changes projected in future years.

Published by Elsevier Ltd.

Introduction

During the last decade, there has been more than a fivefold increase in global liquid biofuel production. The U.S., Brazil, and the European Union lead the world in biofuel production, bolstering their biofuel industries with mandates, subsidies, and favorable trade policies. The International Energy Agency (2011) has projected that the share of biofuels in global transportation fuel will increase from two percent in 2010 to 27% by 2050.

The growth in biofuel production has been mirrored by a rise in crop prices. After nearly 30 years of low or decreasing prices, agricultural commodity prices began rising in the mid-2000s, reaching historical highs in 2008 and 2010 (FAO, 2013). The confluence of these two trends has triggered a debate surrounding the tradeoff between food and fuel resources. U.S. biofuel policies have received particular scrutiny because of the U.S.'s role as a leading exporter of agricultural commodities.

Effects of biofuel expansion on agricultural commodity prices have received considerable attention by academics, government agencies, and other organizations. This literature is characterized by contradictory findings and a wide range of estimated impacts. Zhang et al. (2013) find projections ranging from five to 53% for increases in the price of corn by 2015 as a result of biofuel policy, while literature summarized by the National Research Council (2011) on the proportion of the 2007–2009 corn price spike attributable to biofuels includes estimates from 17% to 70%. Such divergent results make it difficult to assess the relative merits of policies that reduce, expand, or otherwise alter biofuel production trends.

Zhang et al. (2013) and the National Research Council (2011) note that the differences across studies make it nearly impossible to compare results or estimate impacts with any accuracy. Unlike

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[2] The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency. In addition, although the research described in this paper may have been funded entirely or in part by the U.S. Environmental Protection Agency, it has not been subjected to the Agency's required peer and policy review. No official Agency endorsement should be inferred. The authors would like to thank John Anderson, Antonio Bento, Ujjayant Chakravorty, Joel Landry, Aline Mosnier, Siwa Msangi, Tran Nam Ahn, Agapi Somwaru, Wyatt Thompson, and Wallace Tyner for providing clarifications or additional data in response to queries about their articles. Jared Creason, Charles Griffiths, Sharyn Lie, Seth Meyer, Wyatt Thompson, and anonymous reviewers provided helpful comments on earlier drafts. All errors are the authors' own.

http://dx.doi.org/10.1016/j.foodpol.2014.12.007
0306-9192/Published by Elsevier Ltd.

previous reviews, we employ several strategies to place studies on more equal footing to facilitate such comparisons. We restrict the scope of our study to a single feedstock—corn—and focus on the effects of U.S. biofuel policy. To control for large differences in ethanol volumes considered across scenarios, we normalize corn price impacts by ethanol quantity to calculate two metrics: the percent change in corn prices per one billion gallon increase in corn ethanol production (a semi-elasticity measure), and the percent change in corn prices per one percent increase in corn ethanol production (an elasticity measure). Looking across studies and scenarios, we find that each billion-gallon expansion in corn ethanol production (or similarly, each ten percent expansion in production) yields a two to three percent increase in long-run corn prices on average.

While these normalized price metrics make for more straightforward comparisons across studies, considerable differences remain. Therefore, we also conduct a formal meta-analysis to parse the contribution of other key assumptions besides ethanol expansion scenario, such as corn yields and oil prices, as well as structural modeling framework. The meta-analysis allows us to relax the assumption of a linear price response per unit of corn ethanol expansion, which the normalization imposes. It also allows us to identify the relative contribution of several key factors driving the large differences in commodity price impacts across studies, though which factors we are able to include is governed by the degree to which they are reported in the literature. We estimate the meta-regression using both random and fixed effects models to address the fact that estimates from the same study and research group are not independent. We find that the modeling framework (partial versus general equilibrium), projection year, treatment of ethanol co-products, and assumptions about non-corn ethanol biofuels are the most important factors explaining the variation in price effects across studies and scenarios.

The article is structured as follows. The next section discusses trends in U.S. biofuel policy and corn prices. Section 3 reviews 29 studies of the impact of U.S. corn ethanol production on corn prices published since 2007. Because many studies examine several scenarios, we include a total of 157 estimates in the meta-analysis. We discuss policy implications of the results from the meta-analysis before concluding in a final section.

Recent biofuel policy and crop price trends

Ethanol is the primary biofuel produced in the United States, with corn ethanol comprising more than 90% of domestic ethanol production (U.S. DOE, 2011). From 2000 to 2012, U.S. ethanol production increased by more than 700%, from 1.6 billion gallons to 13.3 billion gallons. The percentage of the U.S. corn harvest diverted to ethanol production steadily increased from less than ten percent to over 40%.[3] Over the same period, the real corn price received by farmers more than doubled (USDA, 2013).

A particularly rapid increase in agricultural commodity prices from 2006 to 2008 coincided with a dramatic expansion of the U.S. Renewable Fuel Standard (RFS), highlighting the blending mandate as a potential contributor to price trends. The 2005 Energy Policy Act established the RFS, mandating the blending of 7.5 billion gallons of renewable fuel with gasoline annually by 2012. The Energy Independence and Security Act (EISA) of 2007 expanded these requirements, setting a target of 36 billion gallons of biofuels to be produced or imported by the United States annually by 2022. Corn ethanol can be used to satisfy up to 15 billion gallons of the biofuels mandate starting in 2015.

Unless crop production is perfectly elastic, diverting some portion of the corn harvest for use as biofuel feedstock is expected to put upward pressure on crop prices, other market fundamentals held equal. However, a correlation between biofuel production and crop prices is not sufficient to infer a causal relationship or to parse the magnitude of the contribution of biofuels to crop price increases.

A slew of studies from the peer-reviewed and gray literatures in 2008 and 2009 contributed to the debate about rising crop prices (Timilsina and Shrestha, 2010). While the potential role of biofuels garnered considerable attention, the literature also highlighted higher population and income levels in developing countries, drought in major exporting countries, trade restrictions, devaluation of the U.S. dollar, historically low grain inventories, speculation in commodity markets, and oil prices (Abbott et al., 2009; Collins, 2008; Mitchell, 2008; Trostle, 2008; Baffes and Haniotis, 2010).

Despite some agreement about the factors responsible for increasing agricultural commodity prices in 2008, the literature has yielded wildly disparate estimates for the magnitude of the effect caused by biofuels. The National Research Council (2011) presents estimates from 17% to 70% for the contribution of biofuels to the increase in corn prices during 2007–2009. These estimates are based on different analytic approaches, policy instruments, geographic coverage, and even timeframe within the 2007–2009 period. These factors, as well as assumptions about demand and supply elasticities and whether indirect effects are included, may have a large effect on the results (Baier et al., 2009).

Another review examines the potential reasons why nine studies of biofuel expansion scenarios predict such a wide range of estimated crop price impacts (Zhang et al., 2013). The authors identify several differences, including modeling structure, international trade, co-products, land supply elasticity, and energy market assumptions. However, they stop short of any quantitative analysis to parse the relative importance of these factors in driving the results.

A more recent review by Persson (2014) undertakes a systematic assessment of over one hundred published and unpublished studies reporting price impacts of biofuels on multiple agricultural commodities and over short- and long-run timeframes in the US, EU, and other world regions. Persson finds a wide range of impacts across studies even after normalizing by the change in biofuel demand and attributes the bulk of the variation to the elasticities of demand and supply implied by different models. The author also acknowledges but does not quantify the importance of modeling structure, co-products, and international trade assumptions. We build on the work of Zhang et al. (2013) and Persson (2014) by conducting a formal meta-analysis that allows us to make these types of relative comparisons, while highlighting a more focused set of studies examining the medium- to long-run impacts of U.S. corn ethanol on corn prices.

Much attention has been paid in the popular press to the potential for biofuel policies to drive up consumer food prices (e.g., Rosenthal, 2011). However, in the U.S., crop price increases do not translate into commensurate changes in retail food prices: a 20–40% rise in corn prices results in only a one to two percent increase in the retail price of grocery food items (National Research Council, 2011). That said, higher food prices can lead to higher rates of food insecurity among low-income households in the US (Gregory and Coleman-Jensen, 2013). Welfare impacts of biofuels and associated higher crop prices for developing country consumers and producers have been addressed in other literature (e.g., Ewing and Msangi, 2009; Cororaton and Timilsina, 2012; Tyner, 2013).

[3] The fraction of the corn harvest devoted to ethanol shrinks from 40% to about 27% after accounting for the use of distillers dried grain co-products in the animal feed sector.