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Methodological and Ideological Options

Automatic Responses of Crop Stocks and Policies Buffer Climate Change Effects on Crop Markets and Price Volatility

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ABSTRACT

Climate change has the potential to affect crop prices and price volatility. However, the economic models used in prior assessments largely do not include known, automatic, stabilizing factors. Crop storage can stabilize prices and U.S. crop policy tends to provide support that moves opposite prices. We quantify effects of circa 2050 climate forcing on the inter-annual variability of U.S. Corn Belt corn and soybean yields using statistical crop models and climate scenarios from regional and global climate models. Climate change generally reduces mean yields and increases the inter-annual variability of yields in the Midwestern U.S. Using these yield impacts and an economic model with automatic market stabilizers, we find only modest increases in price volatility. Although individual producers and states are negatively affected by the yield reductions, the aggregate effect for all corn and soybean producer returns can be positive because of price increases. Moreover, agricultural policies based on price levels or revenue variation offset some of the impacts of market variation on farm income. Our results differ from other recent results and temper concerns that increasing climate instability necessarily translates to greater uncertainty about agricultural commodity uses, including as food and biofuels, in the near future.

1. Introduction

Climate change might have critically important consequences for crop yields and markets, land use, and food security. Climate change has been projected to increase yield volatility by as much as 50% (Chen et al., 2004; Diffenbaugh et al., 2012; Urban et al., 2012), suggesting potential impacts on crop market volatility. Attention has been given mostly to yield changes, farm- or region-specific response, or to yield-induced price level changes, but most studies have not explicitly represented crop stocks or policies that respond automatically to changing market conditions thereby buffering effects of climate variability or other environmental shocks on markets and producer revenues (e.g. Adams et al., 1995; Attavanich and McCarl, 2014; Barnwal and Kotani, 2013; Calzadilla et al., 2013; Campbell et al., 2006; Kandulu et al., 2012; Mearns et al., 1997; Sandford and Scoones, 2006; Tack et al., 2012).

We represent the impacts of climate change on crop yields in a key growing region and on market volatility, taking into account automatic policy and market responses that have not yet been represented in this literature. Historical data show inverse correlations between corn price and stocks, and corn price and related government expenditures (Fig. 1). Crop stocks are defined as the amount in storage at the end of one marketing year for use in later years. Holding grain stocks is not free, incurring costs of the facilities and delaying receipts from sales, yet is a key mechanism for smoothing consumption over time despite production fluctuations (Westhoff, 2010). Stocks are held from the harvest to be used throughout the remainder of the marketing year and also held for sales in the subsequent marketing year in the event the

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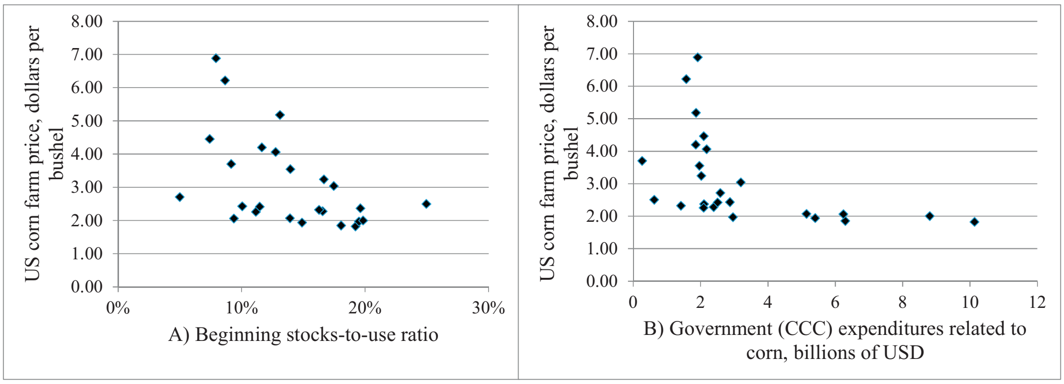

Fig. 1. Inverse relationship of United States corn price with stocks and policy expenditures.
Sources: USDA NASS (*www.nass.usda.gov*) for corn price, ERS data (*www.ers.usda.gov/data/* feedgrains) for quantity data that are used to calculate stocks-to-use ratio, and FSA CCC Budget Essentials (*http://www.fsa.usda.gov/about-fsa/budget-and-performance-management/budget/ccc-budget-essentials/index*) for expenditure data.

next harvest is poor. Grain stockholding has motivations and costs that might not be present in the cases of some other agricultural products. For example, livestock products like meat and butter require refrigerated storage facilities and can be produced throughout the year, in most cases, whereas crop storage is not refrigerated and also relates to the surges of production at harvest time as well as uncertainty about the next harvest.

A cursory examination of global corn production and use shows that year-to-year fluctuations in production do not cause similar variations in consumption (Fig. 2). At times when production is higher than usual, prices are typically pushed down and stocks grow. In years when production is low, prices are pushed up and existing stocks are drawn down without being replenished. Thus, although weather and other factors cause production to swing from one year to the next, changes in stocks allow consumption to follow a more stable path. If stock holding were not possible, then global consumption would have to equal global production. In this hypothetical case, grain price is the factor that would drive consumption up or down: in a low production year, price would have to rise until enough consumers are discouraged from buying the grain that no more is consumed than produced; and in a good year the price would have to fall until consumers are induced to buy as much as is consumed. An economic model that omits automatic stock responses would tend to over-estimate market price volatility impacts of climate variability. Yet, some important models used in climate impacts studies do not represent stocks or policies explicitly and therefore could err in projections of future market volatility.

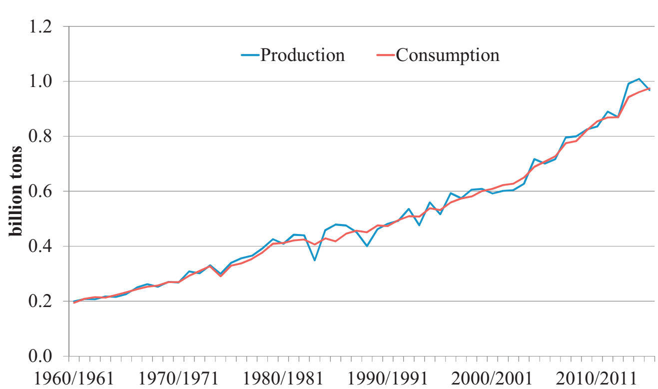

Fig. 2. World corn data show greater year-to-year variation in production than in total consumption because of stocks.
Source: USDA/FAS PSD View (http://apps.fas.usda.gov/psdonline/psdhome.aspx).

At the same time, many U.S. agricultural policies are tied to market events: some pay out only if market prices fall below trigger levels and others might pay if returns or prices decrease. Therefore, these policies can have different effects in the context of a large price decrease as compared to a large price increase (Fig. 1). Moreover, studies of market volatility induced by climate change to date have not examined producer revenue impacts taking into account yield, price, and subsidy changes.

A ground-breaking study assessed climate volatility impacts by using downscaled regional climate change estimates to project corn yield changes in the U.S. Corn Belt that, in turn, were used to adjust stochastic yield variation in a model that generates price effects (Diffenbaugh et al., 2012). The model, Global Trade Analysis Project (GTAP), typically combines commodities into broad aggregates, solves at less than annual frequency, and represents most policies as constant price wedges without the actual connections to market conditions (Narayanan et al., 2012). Diffenbaugh et al. (2012) adjust GTAP to represent annual markets and endogenous policy with significant modifications yet do not explicitly include crop stocks and this omission could bias volatility estimates (Diffenbaugh et al., 2012). Many other modeling approaches relating to climate change or other environmental factors also ignore stocks and consequently would be inappropriate tools for assessing the impacts of changing market variation, as well as the consequences for prices and producer receipts (Brouwer et al., 2008; Dellink et al., 2011; Freire-González et al., 2017; Gallai et al., 2009; Ianchovichina et al., 2001; Melathopoulos et al., 2015; O'Ryan et al., 2005; Salami et al., 2009).

We argue that assessments of climate change impacts on agricultural markets should ideally take into account stabilizing stock responses to prices, and assess the combined impact of yield, price, and government support responses on crop producer revenue. Here we use a market model that includes automatic stock and policy responses to estimate how U.S. Corn Belt corn and soybean yield changes driven by circa 2050 climate change affect the level and variability of corn and soybean market prices and quantities. First, we estimate climate change effects on the average and variance of corn and soybean yields for the mid-21st century. Second, we introduce these yield changes into a stochastic economic model to estimate market impacts, taking automatic responses of stocks and policy intervention into account. Our methods expand the possibilities of conducting economic analysis of climate change across multiple crops simultaneously, and provide estimates of the role of climate impact buffering due to crop storage and government support. Our results highlight the importance of crop stocks and policies in assessments of climate change impacts on crop price variability and agricultural producer receipts.