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Weather and international price shocks on food prices in the developing world

Molly E. Brown[a,*], Varun Kshirsagar[b]

[a] Department of Geographical Sciences, University of Maryland, College Park, MD 20740, USA
[b] Independent Consultant, Washington, D.C. 20002, USA

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ABSTRACT

In the context of a changing climate, there is an urgent need to better understand the impact that weather disturbances have on food affordability in the developing world. While the influence of international markets on local food markets has received considerable attention, in contrast, the potential influence of weather disturbances on local food markets has received much less attention. In fact, local weather disturbances may have an adverse impact on the poorest households in developing countries. Here we quantify the short-run impact of both weather disturbances as well as international price changes on monthly food prices across 554 local commodity markets in 51 countries during the period between 2008 and 2012. We find that almost 20% of local market prices were affected by domestic weather disturbances in the short run, 9% by international price changes and 4% by both domestic weather disturbances and international price changes during the period. An improved understanding of the magnitude and relative importance of weather disturbances and international price changes on rural economies will inform public policies that are designed to mitigate the impact of adverse weather disturbances.

1. Introduction

In the context of a changing climate, there is an urgent need to better understand the impact that weather anomalies have on food security in the developing world. As Feng et al. (2013) document, increasing variability in seasonal rainfall is more pronounced in the tropics. Our analysis is not representative of the developing world but includes markets in Africa, South Asia, and Latin America—regions that contain large segments of the world's poor. Tropical food insecure countries are also characterized by poor transport infrastructure and are among the least able to trade and offset weather risk (Brown 2014; World Bank 2014). The poor smallholder farmers in these regions are also more likely to engage in subsistence agriculture (Barrett, 2008b); (World Bank 2008) and are more likely to face the risks associated with climate-related domestic weather disruptions.

Despite the large literature that has examined local food prices in developing countries, there is limited systematic evidence on the relationship between domestic weather disturbances and local food prices (Baffes and Dennis 2013; Bradbear and Friel 2013; Garg et al., 2013; Hazell 2013; Headey and Fan 2008; Trostle et al., 2011; ul Haq et al., 2008; Von Braun 2008; Webb 2010). These studies involve household surveys that cover two or three time periods, or use simulated data instead of observations. Here we examine 60 months of price data for each of the 554 markets in order to quantify the impact of weather disturbances on food prices.

Lack of access to food due to affordability is a primary cause of food insecurity in urban areas, therefore it is important for policy makers to understand how domestic weather disturbances affect local prices (FAO, 2012). In the aftermath of the 2008 crisis, international organizations including the International Food Policy Research Institute (IFPRI), the World Bank Group, the UN's Food and Agricultural Organization, and the Group of 20 (G20) assumed that local prices in developing countries rose in response to large increases in international commodity prices (Swinnen and Squicciarini 2012). In competitive, efficient food markets, local weather shocks should have no influence on local prices (Samuelson 1965). We find that local weather disturbances do affect food prices because the assumptions of the underlying economic theory are unrealistic. If local production is affected by weather disturbances, do international commodity prices matter more to local market prices? Quantifying the influence of international commodity price changes simultaneously with

* Corresponding author.
E-mail addresses: mbrown52@umd.edu (M.E. Brown), varun.kshirsagar@gmail.com (V. Kshirsagar).

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domestic weather on local markets during this period is one of the goals of this paper.

In agricultural economics there is a large literature on market integration (Barrett 2008a; Cook 1999; Ihle et al., 2011; Zant, 2013). Taken together, this literature has not quantified the mechanisms that prevent food markets in developing countries from being better integrated. Further, we are not aware of a study that examines the influence of domestic weather disturbances across large set of countries and markets, although the influence of weather disturbances on local food markets is widely acknowledged. Consequently, and in contrast to studies that have examined food market integration across a large set of countries (e.g., Minot (2011), our study focuses on quantifying impacts of both weather disturbances and world food prices as drivers of local food prices. This will help clarify the mechanisms that drive local food price movements. Further analysis could attempt to bridge our approach with the food market-integration literature.

We categorize local food markets as being influenced by domestic weather disturbances, international commodity shocks, or both. We are aware that many other influences affect local food prices, including regional markets, distance to ports, informal trade, currency and exchange rates, degree of engagement in the international market and many other factors. We take a minimalist approach in order to enable analysis and response by international organizations such as Famine Early Warning Systems Network and the World Food Program who have a lot of local qualitative intelligence about the functioning of food markets, but need a way to analyze food affordability across multiple regions at the same time. Absent policy interventions, markets influenced by domestic weather disturbances are more vulnerable to increasing rainfall variability (Byerlee et al., 2006). To measure weather disturbances in a way that is comparable across agro-ecosystems and continents, we use a widely used satellite-derived vegetation index that integrates rainfall and temperature impacts on biomass and enables comparability across countries and ecosystems (Becker-Reshef et al., 2010; Pettorelli et al., 2005; Pfeifer et al., 2014). A similar approach is used by the Group on Earth Observation's Global Agriculture Monitoring Initiative (GeoGLAM) sponsored by the Group of Twenty (G20), whose objective is to monitor food production across all major agricultural production zones.

The international community responded to the 2007/8 international food price spike by channeling considerable resources into the agricultural sectors of developing countries (Swinnen and Squicciarini 2012). The rationale for these actions was predicated on the assumption that higher global food prices engendered a large poverty increase across the developing world (Swinnen and Squicciarini 2012). In fact, a growing literature provides evidence that international food price shocks exert a muted impact on food prices in developing countries (Headey 2013; Minot 2011) Here we show that, for our sample of 554 local food markets, there are many more markets in the developing world that are influenced in the short run by local weather disturbances (23.2%) than those that are influenced by international food price shocks (12.4%). Consequently, our results speak to the urgent need for greater policy emphasis on understanding and mitigating local weather disturbances—regardless of the frequency and occurrence of international food price spikes.

Since food staple food demand shifts are rarely large, significant increases in local prices typically indicate local or regional shortages. In lower income households that are food insecure, this results in lower than optimal food consumption and poor nutrition outcomes (Golden et al., 2011; Handa and Mlay, 2006). Therefore, food prices are often the most accurate and timely indicators of changes in both local food scarcity and food insecurity. Local staple food prices can be collected for representative markets on a regular basis and at a reasonable cost, providing insight on the food security of local communities (Garg et al., 2013). Information on food prices also allows systematic comparisons across time, agro-ecological food systems, and political boundaries.

1.1. Model assumptions and structure

Given our hypothesis that domestic weather and changes in the international price of commodities will affect local food prices, we develop a set of models is compared against a random walk benchmark. Samuelson (1965) was one of the first to demonstrate that under certain conditions (including rational expectations and behavior) price series would exhibit random walk behavior (Samuelson 1965). These ideas were further developed in seminal work by Fama (in particular, (Fama, 1965, 1970; Malkiel, 1973). At the same time, an influential literature developed a theory of commodity price dynamics that rested on harvest shocks and competitive storage with profit maximizing intermediaries (Gustafson 1958; Newbery and Stiglitz 1981; Wright and Williams 1991). An ambitious research program undertaken by Deaton and Laroque tested this theory using commodity price data (Deaton and Laroque 1992, 1996).

While Deaton and Laroque's program could explain commodity price spikes, they concluded that the autocorrelation of the price time series was not consistent with the competitive storage model. Further, none of their methods explicitly measured weather disturbances. Food price changes in developing countries exhibit pronounced seasonal behavior (Sahn, 1989). This is due to inadequate storage and transportation. It is also worth noting that, even for stock prices that are traded in the most sophisticated markets in the developed world, it has been shown that price dynamics may not be random (Lo and MacKinlay, 2011). Food markets in developing countries are characterized by a wide-range of inefficiencies (World Bank, 2008) and likely to be far less efficient than financial markets in developed countries.

In this context, here we test other specifications against a benchmark model that is a random walk (augmented to adjust for seasonality). Given the market inefficiencies mentioned above, it is possible that lagged weather and world price shocks will influence local food price dynamics. Therefore, we allow for three other possible data generating processes. First, that food prices may be influenced by domestic weather disturbances. Second, that food prices may be influenced by prices at which food commodities are traded on international markets. And finally, a data generating process in which food prices may be influenced by both international prices and weather disturbances. These three models are described below in Section 3.

2. Data

2.1. Vegetation index data and pre-processing strategy

We use the vegetation index measure derived from remote sensing observations as a proxy for yield changes. Vegetation index data have long been used to examine changes in agricultural production due to changes in plant biomass from abiotic stresses (Becker-Reshef et al., 2010; Fensholt 2004; Hoefsloot et al., 2012; Karnieli et al., 2010; Vrieling et al., 2011). A review of the NDVI-crop literature given by Funk and Budde (2009) focuses on the strong relationship between vegetation indices and crop yields in tropical countries such as the Sahel, where 93% of the variation in yields could be detected in semi-arid ecosystems (Rasmussen 1992). Using vegetation index from NASA's moderate resolution imaging spectroradiometer (MODIS), Funk and Budde (2009) were able to estimate variations in crop production in Zimbabwe in a period