Are Smallholder Farmers Better or Worse Off from an Increase in the International Price of Cereals[1]?

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**Abstract**

The effect of agricultural price shocks on household welfare in low-income countries is a major concern for policymakers attempting to reduce poverty rates. This study estimates the impact of an increase in the world cereal price on rural households in Burkina Faso in an agricultural household model framework. We account for imperfect transmission of global prices to local prices as well as supply and demand response of rural households to price signals. The increase in price during the period from 2006 to 2014 is translated to welfare improvement ranging from 0.02 percent for 2006 to 0.06 percent for 2011 for farmers in Burkina Faso.

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## 1. Introduction

In 2008 and 2009, steep increases in international food prices raised concerns about negative welfare impacts on, and the overall poverty rates of, populations in low-income countries. From mid-2007 until mid-2008, the global prices of major cereals increased up to 130 percent with most of these increases passed on to domestic markets (Ivanic and Martin, 2014; Baquedano and Liefert, 2014). Such dramatic changes in food prices may increase poverty rates in developing countries, especially poor ones, where consumers spend most of their income on food and also heavily rely on agricultural production to earn a living (Headey, 2016). In addition, price shocks and the resultant social unrest could sharply increase political instability (Bellemare, 2015). In general, the literature uses three major methods to assess the effect of cereal price increases on household welfare. These are the net benefit ratio (NBR), econometric-based methods and computable general equilibrium models (CGE).

The approach of Deaton's elasticity of the cost of living with respect to the price of a staple good, also known as the net benefit ratio, is an important starting point for evaluating the welfare effect of a price change (Deaton, 1989). As pointed out by Headey (2016), most studies based on the NBR reached consistent conclusions of negative welfare impacts of food price increases since the poor are net consumers of staples (Ivanic and Martin, 2008; De Hoyos and Medvedev, 2011; Ivanic et al., 2012; Badolo and Traore, 2015). However, several critiques of these results have emerged. Recent studies indicate that consumption and production data based upon short-term recall and used to extrapolate to annual estimates suffer from significant downward biases compared to consumption-plus-sales diary methods (Beegle et al., 2016; Deininger et al., 2012).

Another drawback of the NBR approach is the assumption of no behavioral or market response to higher food prices (Headey, 2016). However, rural household engagement in farming provides scope to adjust production during and between cropping seasons in response to higher food prices

(Headey and Fan, 2010, 2008; Magrini et al., 2017a,b). Studies in Madagascar, Malawi, Zambia and Niger have found long-run reductions in poverty and food insecurity following price increases (Headey, 2016; Van Campenhout et al., 2013; Jacoby, 2016; Headey, 2011). Other studies have estimated the impact of price volatility on welfare (Bellemare et al., 2013; McBride, 2015; Magrini et al., 2017a). Previous literature did not relate household welfare to a world price shock in a way that underscores the role played by world price transmission to domestic markets.

The main objective of this paper was to highlight the theoretical and empirical relationship between world price shocks and household welfare for those individuals living in rural areas by taking price transmission into consideration. Based on both the agricultural household model and the law of one price, we extended Deaton's method to account for imperfect price transmission of global prices to local producer and consumer prices. We applied our model to rural households in Burkina Faso using a three-year nationally representative panel survey on expenditures collected using the consumption-plus-sales method. The study considered six major food commodities produced and consumed in rural areas including: pearl millet, maize, rice, sorghum, peanuts and cowpea. Together these commodities occupy more than 80 percent of the cultivated area of food crops in Burkina Faso (MASA, 2004)[3].

Our major contribution was to combine welfare analysis and price transmission literatures to identify household welfare implications of world price shocks. We also examined data collection differences of the NBR by using our own consumption-plus-sales survey method to estimate household annual consumption as opposed to recall-based approaches (Deininger et al., 2012). Finally, we accounted for behavioral responses in household demand and supply when evaluating the welfare effects of price changes.

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Under conditions of price certainty, we found that increases in world prices were associated with an improvement in rural household welfare. This was because the positive producer effect outweighed the negative consumer effect. The increase in price during the period from 2006 to 2014 translated into welfare improvement ranging from 0.02 percent in 2006 (the lowest improvement) to 0.06 percent in 2011 (the highest improvement) of the total purchases. The shocks generated positive welfare impacts for most of the crops, except sorghum and rice. Furthermore, consistent with Baquedano and Liefert (2014), we found that world cereal prices changes are transmitted to consumers and producer prices for almost all the commodities considered in this study. Finally, households had statistically significant behavioral responses to price signals on both the demand and supply sides for the majority of crops.

The remainder of the paper includes information about our conceptual framework, which was based on an agricultural household model to derive the relationship between household welfare and world cereal price changes. Our empirical strategy estimated the welfare effect, including identification of our demand, supply and price transmission elasticities. The three last sections respectively describe our data, the major findings and policy implications

## 2. Conceptual Framework

Consider the classic model of agricultural households (Singh et al., 1986; Deaton, 1989). In each production cycle, households are assumed to maximize their living standard (utility) over agricultural staples, purchased market goods and leisure. Given a farm production technology and an income constraint, the household standard of living is represented as follows:

$$u_h = \psi(w \times T + A + \pi_h(v, w, p^p(p^W)), p^c(p^W)) \quad (1)$$

where the utility of household $h$ ($u_h$) is determined by its income ($I$), composed of the value of its available total time ($WageRate(w) * TotalTime(T)$), the $transfer(A)$ received, profit ($\pi_h$)

from farming or other family businesses, the consumer price ($p_c$ ), and the world price ($p_w$ ). Farm profit depends on input prices ($v$), the wage rate ($w$), producers' price ($p_p$) and the world price. Thus, a price shock will have two effects: first, the change of household welfare through consumption, and second, through production. On the production side, the welfare change is a function of household marginal utility of income ($\frac{\partial \psi}{\partial I}$), sales of home-produced goods or commodities ($y_i$), and the transmission elasticity of world price to the producer price ($\varepsilon_{ip^w,p^p}$). On the consumption side, the welfare change following an international price increase depends on the marginal utility of income ($\frac{\partial \psi}{\partial I}$), purchases ($q_i$), and the transmission elasticity of the world price to the consumer price ($\varepsilon_{ip^w,p^c}$). The effect of a change in the world price of commodity $i$ on household utility[4] is represented by:

$$\frac{\partial u_h}{\partial p^w} = \frac{\partial \psi}{\partial I} y_i \varepsilon_{ip^w,p^p} - \frac{\partial \psi}{\partial I} q_i \varepsilon_{ip^w,p^c} \quad (2)$$

As with the standard agricultural household model, the net effect could either be positive or negative. Our model focused on the bias that can be introduced when differential price transmission elasticities exists ($\varepsilon_{ip^w,p^p} \neq \varepsilon_{ip^w,p^c}$). The welfare effect is trivial if and only if the world price is fully transmitted to producer and consumer prices ($\varepsilon_{ip^w,p^p} = \varepsilon_{ip^w,p^c} = 1$), or equally transmitted ($\varepsilon_{ip^w,p^p} = \varepsilon_{ip^w,p^c}$) or there is no temporal difference in marketing decisions. Using $\frac{\partial u_h}{\partial p^w} = (y_i - q_i)\frac{\partial \psi}{\partial I}$ as a measure of the world price change welfare effect is equivalent to assuming full price transmission to producer and consumer prices, which is empirically implausible under many circumstances. Therefore, the status of household $h$ as a net buyer or net seller is the only driver of the welfare effect following a world price shock.

In addition to relaxing the assumption that price transmission is equal for consumer and producer

[4] See derivations in the appendix.

prices, we also accounted for supply and demand responses when estimating the welfare impact of a change in world price. We approximated the change in consumer welfare using Compensating Variation (CV), defined as a change in the household expenditure (Irvine and Sims, 1998). Following Irvine and Sims (1998) and Martin and Alston (1997), the change in producer welfare (PW) is derived as a change in the profit function ($\pi$). As a result, the net welfare change is represented as:

$$welfare = e(p^c(p_0^w), u_0) - e(p^c(p_1^w), u_0) + \pi(p^p(p_0^w), u_0, z_0) - (p^c(p_1^w), u_0, z_0) \quad (3)$$

where e(.) is the household expenditure function, and $p_0^w$ and $p_1^w$ are the levels of world cereal price before and after a price shock. Household utility before the price change is $u_0$. We assumed that labor is perfectly inelastic in the short-run causing input price stickiness.

## 3. Empirical strategy

Following Irvine and Sims (1998) and Martin and Alston (1997), second-order Taylor series approximations of the expenditure and profit functions were used to approximate Equation 3[5]. The following equations are used to estimate welfare impacts:

$$CV \cong -\sum_{i=1}^{n} q_i p_i^c \varepsilon_{ip^w,p^c}(\zeta_{p^w}) - \frac{1}{2}\sum_{i=1}^{n} q_i p_i^c \eta_{ii} \varepsilon_{ip^w,p^c}^2 (\zeta_{p^w})^2 \quad (4)$$

$$PW \cong \sum_{i=1}^{n} y_i p_i^p \varepsilon_{ip^w,p^p}(\zeta_{p^w}) + \frac{1}{2}\sum_{i=1}^{n} y_i p_i^p \gamma_{ii} \varepsilon_{ip^w,p^p}^2 (\zeta_{p^w})^2 \quad (5)$$

with $\zeta_{p^w}$ being the relative exogenous price shock[6] in cereal world price, and $\eta_{ii}$ and $\gamma_{ii}$ the Marshallian demand and supply elasticity of commodity $i$, respectively. The price at which households buy and sell crops may be different, mainly due to marketing differences between

[5] See derivations in the appendix A

[6] The relative exogenous price shock stands for the percentage change in FAO cereal price index relative to the base 2002-2004.

purchases and sales. In fact, most crops' sales are conducted during the harvest period when there is an excess of supply. Purchases occur during the lean season for farm households that are net buyers. As a result, production and consumption were considered as different activities and non-separable. Furthermore, $y_i$ and $q_i$ were estimated respectively as the country-level total quantities purchased and sold of all commodities. Our model imposed no cross-price effects, as discussed in the next section. Approximations of market demand ($y_i$) and supply quantities ($q_i$) could be considered to better capture household decisions on food market participation[7]. The survey collected household-level data on quantities of these variables each year in the local unit of measurement.

### *3.1. Estimation of demand and supply elasticities*

Identifying the demand elasticity required isolation of price changes due to supply (demand) shocks. Demand identification was an issue because of the use of unit values as direct substitutes for true market prices. Consumers choose the quality of their purchases, and unit values reflect this choice (Deaton, 1988). This could be less of an issue in our case because our study focused on homogeneous staple commodities. Nevertheless, to check for robustness, we estimated demand equations using two approaches. The first approach used an instrumental variable technique following Roberts and Schlenker (2009) to identify own-price elasticities. In most of the empirical work on demand, weather is considered as an instrument for unbiased identification (Wright, 1928). The reason being that weather events cause a shift in the supply curve unrelated to demand. As a proxy for weather-induced yield shocks, we used the deviation of province yield from the province-specific yield trend for a particular crop. The assumption was that the deviation of province yield from its trend is due to weather shocks[8]. The second approach estimated demand elasticities using

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[7] $y_i$ and $q_i$ are the weighted total of quantity purchased and sold. The weight is attributed to each household to ensure the sample represents the rural population.

[8] Agriculture is rainfed in Burkina and weather explains quite high amount of yield variability (Ray et al., 2015).

the quadratic version of Deaton and Muellbauer's (1980) Almost Ideal Demand System introduced by Banks et al. (1997). This version allowed the budget share to react more flexibly to the log of expenditure while imposing the standard restrictions of demand theory, including adding-up, homogeneity, and Slutsky symmetry. Following Ray (1983) and Poi et al. (2012) we also included a vector of demographic characteristics $z_k$ to control for any changes in the consumption pattern not related to price or expenditure[9].

On the supply side, we used lagged weather-related yield shocks as instruments to identify the supply curves (Roberts and Schlenker, 2013). Past weather shocks affected storage, and consequently expected prices for the upcoming growing season, in the case of smallholder farmers. The supply at the household level was equal to the current production ($Prod_{h,t}$) and the stock ($S_{h,t-1}$) from the previous period: $q_{h,t} = Prod_{h,t} + S_{h,t-1}$. Past weather did not affect current production but affected the inventory demand – a shift in demand for the current period – allowing unbiased and consistent identification of supply[10].

Hendricks et al. (2014) shows that using the lagged yield shock as an instrument is not necessary when the supply equation includes pre-planting futures prices and controls for the current yield shock. In our setting, a futures price in Chicago, Illinois, USA may be a poor representation of prices facing producers in Burkina Faso. We utilized data on the actual price received by farmers, but this price is endogenous since it reflected actual supply conditions, rather than expectations of supply, as needed for the case of a futures price. Therefore, we expected producer prices to be endogenous in our setting. Consequently, we estimated the supply and demand equations using standard two-stage least squares. The estimated supply and demand equations are as follows:

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[9] The reader can find an extended development and estimates of this model in the online appendix.
[10] Farmers' behavior regarding price expectations follow either naive expectations (Ezekiel, 1938); adaptive expectations (Nerlove, 1958); or rational expectations (Muth, 1961). Our approach in this paper assumed naive expectations since planting decisions were made using actual prices faced by the producer.

$$Supply = \begin{cases} \log(y_{h,t}) = \alpha_p + \gamma \log\widehat{(p^p_{h,t})} + \beta W_{h,t} + u_t \\ \log(p^p_{h,t}) = \rho + \phi W_{h,t} + \delta W_{h,t-1} + \lambda_h + e_t, \end{cases} \quad (6)$$

$$Demand = \begin{cases} \log(q_{h,t}) = \alpha_c + \eta \log\widehat{(p^c_{h,t})} + v_t \\ \log(p^c_{h,t}) = r_0 + r_1 W_{h,t} + \lambda_h + \epsilon_t, \end{cases} \quad (7)$$

where $\log(p^p_{h,t})$ and $\log(p^c_{h,t})$ are the logarithm of producers price and consumers price, $\lambda_h$ are province fixed effects, $W_{h,t-1}$ and $W_{h,t}$ are the lagged and current yield shock, and $y_{h,t}$ and $q_{h,t}$ are respectively household $h$ acreage and consumption in period $t$. The parameters to be estimated include $\alpha_p, \gamma, \beta, \rho, \delta, \lambda, \alpha_c, \eta, r_0$ and $r_1$. The error terms, $u_t$, $v_t$, $e_t$ and $\epsilon_t$ are assumed to be normally distributed, and $u_t$ included the effects of policies and non-policy distortions including marketing margins found to be significant in affecting the supply response to price signals (Magrini et al., 2017b). Including the current yield shock ($W_{h,t}$) in the second stage equation for supply alleviated two concerns about the validity of the lagged yield shock as an instrument. First, weather may be serially correlated so that lagged yield shocks are correlated with current production. Second, a household may have yields systematically below the district-level trend so the lagged difference of household yield from the district-level trend is correlated with current production. By including the current yield shock as a control, these concerns were mitigated.

### 3.2. *Estimation of price transmission elasticities*

The empirical analysis of price transmission relies upon the law of one price. This law states that once transaction costs are adjusted, and no policy intervention distorts the transaction, the price for a homogeneous commodity in two different markets should be the same. We examined this causal relationship between world cereal prices and domestic prices in an error correction framework following (Baquedano and Liefert, 2014). This framework allowed us to measure and separate long- and short-run effects on domestic prices from an exogenous change in world prices. Based on the law of one price, we defined the data generating process for the relationship between the domestic and world border price as:

$$p_{ijt}^{d} = \alpha_0 + \alpha_1 p_{ijt-1}^{d} + \beta_0 p_{ijt}^{b} + \beta_1 p_{ijt-1}^{b} + \varepsilon_t \quad (8)$$

where $\varepsilon_t$ represents the error term, $p_{ijt}^{d}$ and $p_{ijt}^{b}$ represent domestic (consumer or producer) and border prices in real terms in country $i$ of a homogenous commodity $j$ at time $t$, respectively. However, with the border price equal to the world price in foreign currency, multiplied by the exchange rate, equation 8 is also equivalent to equation 9. In addition, by breaking $p_{ijt}^{b}$ into two parts, dropping the subscript of country $i$ and commodity $j$, and manipulating we have:

$$\Delta p_t^{d} = \alpha_0 + \delta p_{t-1} + \lambda_0 \Delta wp_t^{f} + \lambda_1 \Delta wp_{t-1}^{f} + \theta_0 \Delta e_t + \theta_1 \Delta e_{t-1} + \varepsilon_t \quad (9)$$

where $wp_t^{f}$ and $e_t$ represent the real-world price of the commodity in terms of foreign currency in natural log, and the exchange rate between the domestic currency and that of the rest of the world. The coefficients $\lambda_n$ and $\theta_n$ measure the effect on the domestic price ($p_t^{d}$) of an immediate and lagged change in the world price ($wp_t^{f}$) and exchange rate ($e_t$), respectively. In the case of countries with market power, where domestic and world prices are endogenously determined by each other, price fluctuation in both series would be better modelled with approaches proposed by Johansen (1988). These approaches rely on systems of equations in the form of vector auto-correlation and were not relevant in our case.

Our model assumed that causality runs from world prices to domestic prices. Burkina Faso has no market power over the world market because of its small size with regards to the commodities under consideration. This unidirectional causal relationship is modelled relying on single equation error correction model (SEECM) instead of on the Engle and Granger (1987) two-step procedure considered as the standard approach when dealing with unidirectional causal relationship of co-integrated series. The choice of SEECM was motivated by two main advantages. First, as noted by

Baquedano and Liefert (2014), the SEECM does not require that all the related series have a unit root to attempt to model their long run relationship in an ECM framework. Second, SEECM provides less biased parameter estimates and more robust tests compared to the Engle and Granger (1987) approach (De Boef and Keele, 2008; Banerjee et al., 1998). As a result, the estimated SEECM is as follows[11]:

$$\Delta p_t^d = \alpha + \beta \Delta wp_t^f + \rho \Delta e_t + \delta(p_{t-1}^d - \gamma wp_{t-1}^f - \varphi e_{t-1}) + \varepsilon_t \quad (10)$$

where $\varepsilon_t$ represents the error term, $\beta$ and $\rho$ represent the short-run price transmission elasticities for the world price and exchange rate respectively, $\delta$ represents the error correction term coefficient and measures the speed at which the domestic price ($\Delta p_t^d$) returns to its long-run equilibrium relationship following a world price or exchange rate shock. Its sign is expected to be negative as it shrinks the gap between the series in each subsequent period (Baquedano and Liefert, 2014). The long run elasticities of transmission are $\gamma$ and $\phi$ for the world price and the exchange rate respectively.

To simultaneously estimate long-term relationship elasticities and standard errors for $wp_t^f$ and $e_t$, we used equation 9 and relied on Bewley's (1979) transformation. The estimation method considered is the generalized least-squares with serially correlated error term structure. We tested our assumption that the error terms follow an autoregressive process of order one. The long-term world price transmission elasticities derived were used to simulate the welfare effect due to the world cereal price increase.

## 4. Data

Data used to estimate the elasticities is taken from the *Enquête Permanente Agricole (EPA)*, the "Continuous Farm Household Survey" of Burkina Faso. These data are collected by the *Direction Générale des Études et des Statistiques Sectorielles* (DGESS) of the Ministry of Agriculture and was

[11]See Baquedano and Liefert (2014) for a step by step derivation of equation 8 from equation 7.

used by Haider et al. (2017) in their study on fertilizer adoption in Burkina Faso. The EPA is used to estimate farm input use, production, area, and yield of crops; it also provides information about livestock holdings and expenditures of rural households. We utilized data for the 2007-2008, 2009-2010 and 2010-2011 cropping seasons (three survey years) in this analysis as these were the last years for which clean data was available[12]. The survey was a two-stage design with Probability Proportional to Size (PPS) sampling. The units in the first stage were the villages in each province and the unit of the second stage were farmers.

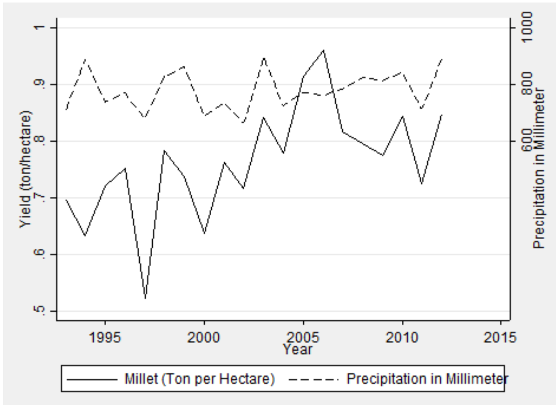
To capture household food availability and utilization, EPA uses the consumption-plus-sales approach and establishes a food balance sheet spanning the period of October 1 of the previous year and September 30 of the current year for each household and each rainfed food crop. Food supply information is collected on the beginning stock and primary sources of food inflows such as production, gifts and purchases. On the utilization side, information is collected on the primary sources of the food outflows at the household level, such as consumption, sales, gifts and ending stocks. All information is collected as quantities and in value, which allows for the derivation of the implicit price of each crop at the household level. Crop quantities are obtained in the local unit of measure and converted into a common unit. We estimated the household-level producer and consumer prices ($p^p$ and $p^c$) for each commodity $i$ by dividing total value of production (consumption) by quantity of production (consumption).

The survey collected information on 25 commodities with millet, maize, rice, sorghum, peanuts and cowpea as the primary products since they are widely grown by 81 percent of farmers across the country. In order to comprehensively analyze the crops produced at the household level, the remaining crops were recorded as "others", while red and white sorghum were recorded as "sorghum".

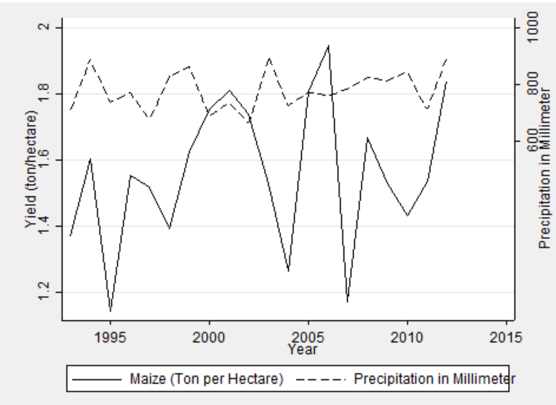
Using province-level yield data available for the period 2002 to 2012, yield shocks were calculated by taking the difference between household yield and the province-level linear yield

[12]This survey was not collected in 2010, mainly due to the agricultural census that was on-going.

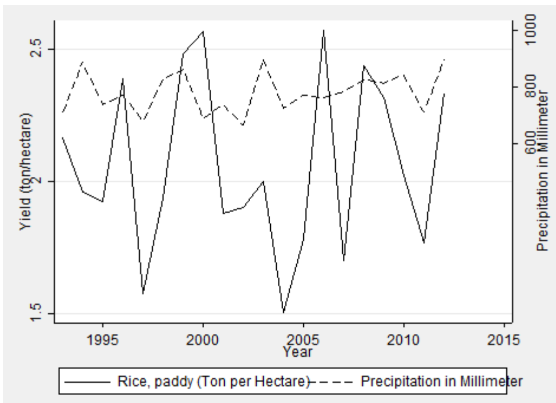
trend. The province-level yield data were from The Ministry of Agriculture and Food Security. Figure 1 plots the national level yield versus the rainfall for each commodity. National crop yield estimates were obtained from FAOSTAT (2017b) and rainfall data are from World Bank (2017a). The yields vacillated around their trend in a pattern similar to the rainfall suggesting that a deviation of yield around its trend is mainly due to the level of rainfall. This pattern also is likely observed at the province level. Thus, we have reasonable evidence to consider that the deviation of the province yield from its trend is more plausibly due to weather and is an adequate instrument to identify demand and supply curves. Furthermore, we highlight that during the three years the data are collected, no severe plague was reported.



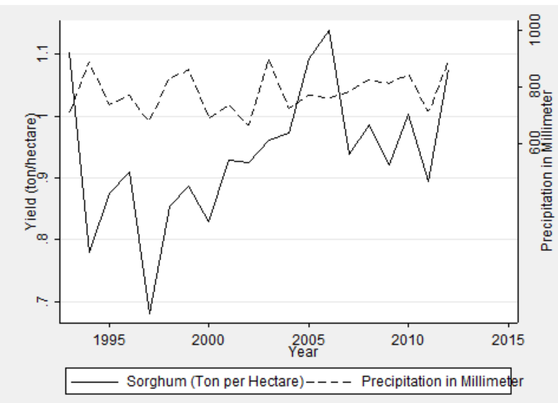

(a) Millet



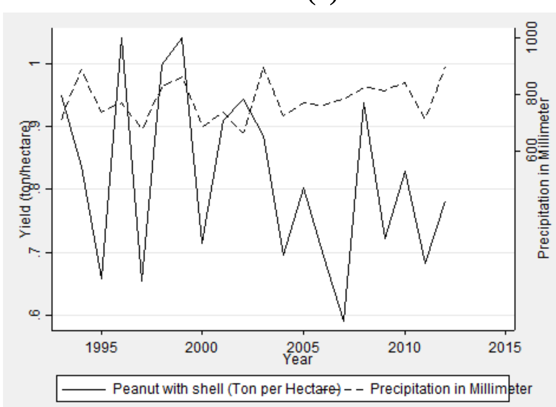

(b) Maize



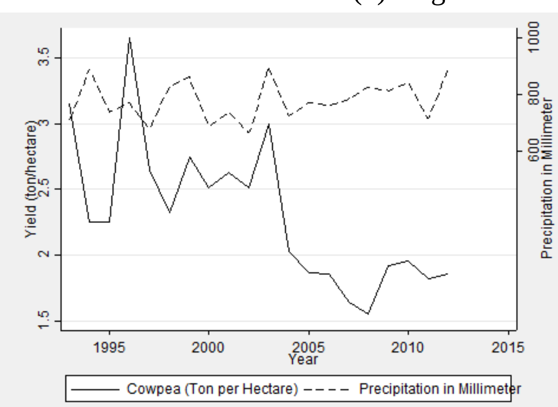

(c) Rice




(d) Sorghum




(e) Peanuts




(f) Cowpea

Figure 1: Yield of major commodities (tone per hectare) and rainfall (Meter) in Burkina Faso from 1994 to 2014.

We used a second data set to estimate price transmission because a more detailed time series of prices was needed, yet the household survey provided only three years of data. We used the monthly cereals world price index from FAOSTAT (2017a) as a proxy of world price. For domestic prices, we used the monthly consumer and producer prices data from *Institut National de la Statistique et de la Demographie* (the National Institute of Statistics and Demography).

We computed consumer and producer price indices by dividing the price $P_t$ of a year $t$ by the average of the period 2002-2004 considered as the base price to coincide with the base of producer price index provided by FAOSTAT. Figures 2 and 3 plot the producers' and consumers' price index against world price, respectively. Producer prices and the world price index had the same general pattern with a matching of the peaks and trend suggesting a correlation between the two set of prices. The world cereal price reached its highest peaks in 2008, 2011 and 2012 with an increase of 132 percent, 141 percent, and 136 percent, respectively. On the other hand, the consumer price index (except for rice) did not display a clear pattern compared to the world cereal price (Dawe et al., 2015).

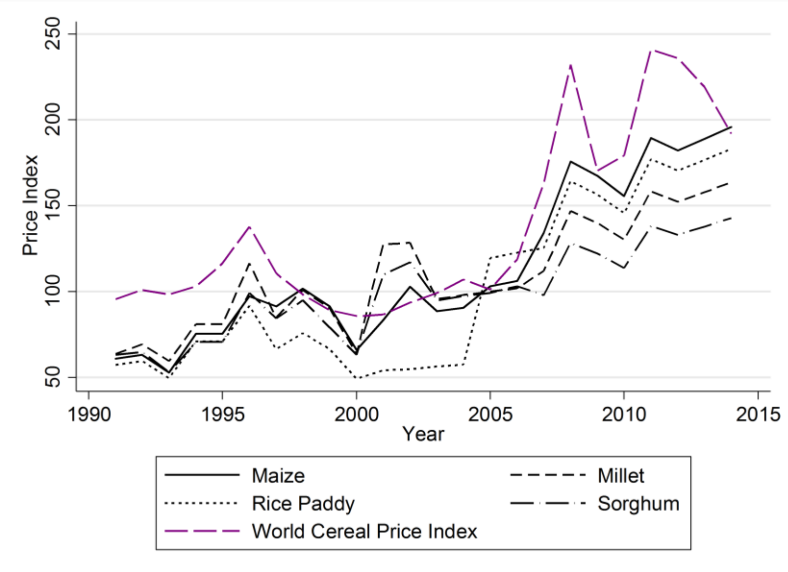



Figure 2: Relationship between world cereal price index and producers price index between 1991-2014.

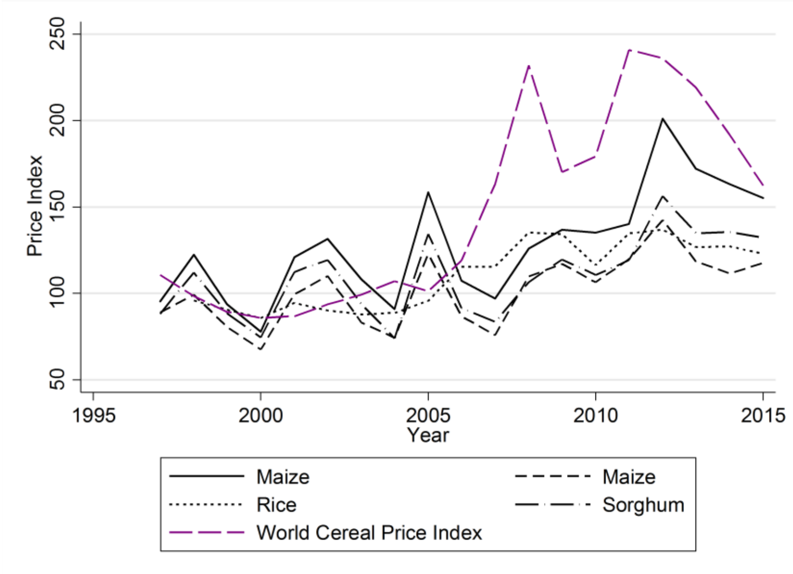



Figure 3: Relationship between world cereal price index and consumers price index between 1996-2014.

## 5. Results

### *5.1. Descriptive statistics*

Table 1 shows rural households' socio-economic and demographic characteristics. Most household heads are males (94 percent). The average household's size (eight persons) is the same as what was reported by the official statistics in 2014. The head of household age ranges from 17 to 99 years old with the average being 50 years old. The average age seems high when considering that 65 percent of the population is more than 24 years old. Nevertheless, the high average age is partly due to the nature of the multinuclear household type that includes different generations. Moreover, most households are headed by the eldest male of the household. In addition, a high rate of illiteracy (75 percent) characterizes the sample, similar to the 76.6 percent of the rural illiteracy level reported in 2014 (INSD, 2014).

Households are involved mainly in crop and livestock production. Millet, maize, rice, sorghum, peanuts and cowpea are the most produced food crops. On average, sorghum has the highest acreage (0.98 hectare) followed by millet (0.66) and maize (0.43). The lowest acreage is allocated to rice

(0.04 hectare), partly because rice production is constrained by biophysical constraints (biotic and abiotic). Sorghum is also the most produced and self-consumed crop. With the exception of peanuts and cowpeas, households self-consume most of their produced food crops. This is in line with the subsistence agriculture system that characterizes rural households.

Even though the primary activity remains agriculture or farming, the economic activities in rural areas involve different sectors. For instance, about 93 percent of households combine crop production with livestock rearing. Few households are involved in secondary activities such as gardening during dry season (2.5 percent), handicrafts (7.5 percent), or foraging (18 percent). About 98 percent of the sampled households own their farmland, and most of them are involved in agriculture during the rainy season.

Table 1: Rural households' socio-economic and demographic characteristics in 2011 at the national level.

| VARIABLES | Mean | Standard error | Min | Max |
|---|---|---|---|---|
| **Household socio-demographic** | | | | |
| Male | 0.945 | 0.003 | 0 | 1 |
| Female | 0.055 | 0.003 | 0 | 1 |
| Household size (# of individuals) | 8.000 | 0.037 | 2 | 20 |
| Age of household head (years) | 50 | 0.197 | 17 | 99 |
| Not literate | 0.757 | 0.006 | 0 | 1 |
| **Household economic characteristics** | | | | |
| Plot owners | 0.981 | 0.002 | 0.000 | 1.000 |
| Livestock owners | 0.934 | 0.003 | 0.000 | 1.000 |
| Involved in rainfed agriculture | 0.956 | 0.003 | 0.000 | 1.000 |
| Involved in counter-season agriculture | 0.025 | 0.002 | 0.000 | 1.000 |
| Involved in handicraft | 0.075 | 0.003 | 0.000 | 1.000 |
| **Acreage (hectare)** | | | | |
| Millet | 0.661 | 0.482 | 0.079 | 2.499 |
| Maize | 0.431 | 0.452 | 0.001 | 1.579 |
| Rice | 0.036 | 0.041 | 0.000 | 0.181 |
| Sorghum | 0.979 | 0.400 | 0.326 | 1.901 |
| Peanuts | 0.219 | 0.138 | 0.000 | 0.734 |
| Cowpea | 0.061 | 0.046 | 0.000 | 0.173 |
| **Production (kilogram)** | | | | |

| | | | | |
|---|---|---|---|---|
| Millet | 442.693 | 790.203 | 0.000 | 14580 |
| Maize | 609.565 | 1370.463 | 0.000 | 23460 |
| Rice | 77.328 | 412.575 | 0.000 | 25010 |
| Sorghum | 748.966 | 834.942 | 0.000 | 15660 |
| Peanuts | 113.953 | 220.195 | 0.000 | 3146 |
| Cowpea | 108.340 | 175.048 | 0.000 | 3926 |
| **Own-consumption (kilogram)** | | | | |
| Millet | 443.954 | 820.775 | 0.000 | 14094 |
| Maize | 527.200 | 1070.181 | 0.000 | 20062 |
| Rice | 64.722 | 183.997 | 0.000 | 5000 |
| Sorghum | 692.800 | 763.974 | 0.000 | 12256 |
| Peanuts | 38.265 | 89.120 | 0.000 | 2502 |
| Cowpea | 68.880 | 122.193 | 0.000 | 3918 |
| **Observations** | 5849 | | | |

Source: Authors' calculations

Table 2 presents the patterns of rural household market participation. The results highlight the presence of net buyers and sellers for all the crops considered. The proportions of net buyers ranged from 8 percent (peanuts) to 38 percent (rice) while the proportions of net sellers ranged from 9 percent (rice) to 44 percent (peanuts). In general, legumes exhibited the highest proportion of net sellers because they are grown mainly for cash purposes, as the own-consumed quantities were the lowest reported in Table 1. Among the grains, rice had the highest proportion of net buyers. Rice was not cultivated by the majority of households and was produced in only a few regions as highlighted earlier. Notably, Table 2 also shows a high percentage of autarkic households which supports the subsistence status of most rural economy. This percentage was high for millet (68 percent), sorghum (65 percent) and maize (71 percent), for which most of the production was self-consumed. The case of millet and sorghum especially may suggest that most households were self-sufficient, and the crops were for subsistence. Maize was grown mainly in four regions; Boucle du Mouhoun, Haut-Bassins, Comoe and Sud-Ouest and was not a staple food for the majority of households in rural areas. Finally, households participating in the market were typically either buyers or sellers. Few households were both buyers and sellers, with their proportion ranging from two percent for rice to six percent for peanuts.

Table 2: Market participation in rural Burkina Faso.

| | Millet | Maize | Rice | Sorghum | Peanuts | Cowpea |
|---|---|---|---|---|---|---|
| Percent net buyers | 0.16 | 0.16 | 0.39 | 0.13 | 0.08 | 0.10 |
| Percent net sellers | 0.16 | 0.13 | 0.09 | 0.21 | 0.44 | 0.34 |
| Autarky | 0.68 | 0.71 | 0.52 | 0.65 | 0.48 | 0.57 |
| Total | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Percent buying only | 0.15 | 0.15 | 0.38 | 0.12 | 0.07 | 0.09 |
| Percent selling only | 0.15 | 0.11 | 0.07 | 0.19 | 0.39 | 0.30 |
| Percent buying and selling | 0.03 | 0.02 | 0.02 | 0.04 | 0.06 | 0.04 |
| N = 13593 | | | | | | |

Source: Authors' calculations

### *5.2. Regression models estimates*

Estimates from equation 6 and 7 are used to derive the elasticities of demand and supply, respectively, for the six commodities (Table 3). We performed Wu-Hausman tests for exogeneity and F-tests for instrument relevance. Wu-Hausman tests showed evidences of endogeneity for maize and peanuts at demand side and for millet at supply side. A weak instrument problem is recorded for peanuts at demand side and millet at supply equations. F-statistics for the remaining equations suggests no problem of a weak instrument. We followed the approach of Stock et al (2012), which suggests that the F-statistic should exceed 10 for inferences to be reliable under 2SLS estimation including one endogenous regressor.

Overall, point estimates of the demand response (Table 3 upper panel) were highly significant for maize, rice, peanut, and cowpea. The point elasticities range from -1.738 (peanuts) to -0.487 (maize) with all the cereals having inelastic demand. This steeper demand curve was likely guided by rural household's rigid preferences for staples. Households in rural areas may be attached to their traditional dishes in a way that they are less willing to substitute among staples following a price increase below a certain threshold.

In addition, biophysical constraints of crop production – supply – dictated the availability of close substitutes for final consumption in a specific area. Maize and rice were predominantly grown in four regions (Boucle du Mouhoun, Centre-Sud, Cascades and Sud-Ouest). These two crops are not staple in the rural areas of other regions as argued by Traore et al. (2016).

Finally, even with the availability of substitutes, the characteristics of the alternatives such as processing time could limit crop substitutability. For example, maize and rice may not be close substitutes for millet and sorghum because of the higher processing time that they require. More time-constraining crops for final consumption may have higher response following a price increase. Point elasticities estimates were higher for rice and maize than for sorghum and millet. As such, after a price increase of millet and sorghum, consumers were more willing to reduce their consumption as compared to millet and sorghum.

Table 3: Two-stage least square model estimates of demand and supply response by commodity.

| | Millet | Maize | Rice | Sorghum | Peanuts | Cowpea |
|---|---|---|---|---|---|---|
| **Demand** | | | | | | |
| Elasticity | -0.682** | -0.571*** | -0.633*** | -0.487* | -1.738*** | -0.749*** |
| | (0.342) | (0.209) | (0.0667) | (0.256) | (0.280) | (0.129) |
| Province dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 6,666 | 7,414 | 5,364 | 8,145 | 5,959 | 6,437 |
| Tests | | | | | | |
| 1st-stage F-demand | 24.68 | 22.07 | 36.6 | 12.87 | 2.99 | 13.9 |
| Wu-Hausman p-value | 0.2006 | 0.9115 | 0.001 | 0.6078 | 0.000 | 0.1826 |
| Supply | | | | | | |
| Elasticity | 0.520** | 1.107*** | 1.215*** | 1.009*** | 0.792*** | 0.862*** |
| | (0.253) | (0.212) | (0.191) | (0.0997) | (0.154) | (0.128) |
| Province dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1,813 | 2,079 | 1,465 | 2,237 | 1,623 | 1,749 |
| Tests | | | | | | |
| 1st-stage F-supply | 2.32 | 14.12 | 27.14 | 10.49 | 13.95 | 17.20 |
| Wu-Hausman p-value | 0.0217 | 0.7861 | 0.1635 | 0.5813 | 0.7924 | 0.6687 |

Standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.
Source: Authors' calculations

Supply response elasticities in Table 3 (lower panel) were highly significant for all crops. Supply response was elastic for cereal (except millet) and inelastic for legumes. This suggests more important extensive margin (an increase in farm size) in the case of cereals than legumes. The strong supply response is in line with Headey (2016) in their study on less-developed countries including countries from sub-Saharan Africa.

Rice exhibited the highest supply elasticity (1.215) followed by maize (1.107), and sorghum (1.107). Given that farmers in Burkina Faso are primarily cereal growers, a price increase prior to land preparation, is likely to induce land reallocation in favor of a specific cereal, resulting in more elastic supply. The supply of peanuts and cowpea was inelastic even though both commodities are primarily grown for market purposes. It is most likely that peanut and cowpea require a higher price increase to experience a supply change. Therefore, the price change might need to be strong enough to induce an acreage response. Agricultural land constraints faced by farmers may cause a primary allocation in favor of staples. In addition, this phenomenon may occur because the households' limited storage capabilities in rural areas. In any case, the number of substitutes for these commodities is limited, which makes it difficult for consumers to shift from one crop to another. Overall, farmers' responses to a price change may have thresholds that vary across commodities, which is beyond the scope of this analysis.

Table 4 shows the estimates of producer and consumer price transmission elasticities. Our results for millet, maize, rice and sorghum showed that local consumers and producers' prices have a long-term, co-integrated relationship with world cereal prices. For all four-cereal crops, both the parameter on error correction term and world price were significantly different from zero, except for millet consumer price. As results, consumer and producer price for those commodities in Burkina Faso were integrated with world cereal prices; however, the results indicated that transmission of the changes from world price to local price is not high. The average of the long-term price transmission elasticities –over maize, rice, and sorghum – was 0.25 and 0.38, respectively, for consumers and producers. On the consumer and producer side, maize had the highest world price transmission elasticity. Sorghum had the lowest price transmission on the consumer side, while rice had the lowest price transmission on the producer side. Furthermore, on the producer's side, sorghum had the second-highest price transmission elasticity, which could be explained by its higher percentage of net sellers compared to other cereals, as indicated by Table 2. Our results did not show any significant findings for peanuts and cowpea, which may be due to the small sample size for those two crops. Policy intervention and market failures may also be reasons for lower price transmission elasticity.

Our findings of market integration and higher price transmission elasticity for maize and rice on the consumer side was consistent with Baquedano and Liefert (2014). They use an approach similar to ours to examine market integration and price transmission in consumer markets of developing countries. They find that on the consumer side, on average, the most traded crops (maize and rice) have a higher transmission elasticity than lesser or untraded goods (sorghum). Their results also reveal market integration and price transmission elasticity for maize equaling 0.12. In addition, these findings are in line with price transmission elasticities reported by Zorya et al. (2012). They find that the spatial transmission of world price change is imperfect in developing countries and ranges from 0.20 to 0.70, and they propose that once global prices are transmitted to local consumers, price signals are passed further to producers, or conversely from production market to the consumer market depending on when the shock occurred. Notably, we found that the magnitude of the transmitted world price shock was asymmetric, with the transmission to the producer price higher than to the consumer price.

Table 4: Long-run world price and exchange rate transmission elasticities by commodities.

| | Error Correction Term [a] | World Cereal Price | Real exchange rate | Obs.[c] | Adj.R2[d] | DW[e] |
|---|---|---|---|---|---|---|
| ***Consumer*** | | | | | | |
| Millet | -0.0853** | -0.102 | -0.666 | 106 | 0.00401 | 1.286 |
| | (0.0361) | (0.118) | (1.012) | | | |
| Maize | -0.189*** | 0.357*** | 0.750*** | 106 | 0.590 | 1.181 |
| | (0.0538) | (0.117) | (0.196) | | | |
| Rice | -0.0861*** | 0.246*** | 0.897*** | 106 | 0.589 | 1.969 |
| | (0.0266) | (0.0757) | (0.148) | | | |
| Sorghum | -0.105** | 0.206* | 1.015*** | 106 | 0.432 | 1.289 |
| | (0.0417) | (0.107) | (0.200) | | | |
| Peanuts | -0.484 | -0.0717 | 0.685 | 10 | 0.542 | 1.228 |
| | (0.875) | (1.091) | (4.112) | | | |
| Cowpea | -0.879 | 0.623 | 0.666 | 10 | 0.542 | 1.228 |
| | (0.955) | (2.458) | (0.911) | | | |
| ***Producer*** | | | | | | |
| Millet | -0.0961** | 0.293* | 1.008*** | 106 | 0.582 | 1.616 |
| | (0.0387) | (0.151) | (0.291) | | | |
| Maize | -0.218*** | 0.557*** | 0.514** | 106 | 0.691 | 1.557 |
| | (0.0583) | (0.158) | (0.254) | | | |
| Rice | -0.101*** | 0.246** | 0.948*** | 106 | 0.650 | 2.090 |
| | (0.0367) | (0.123) | (0.204) | | | |
| Sorghum | -0.145*** | 0.412** | 0.791*** | 106 | 0.582 | 1.648 |
| | (0.0476) | (0.162) | (0.265) | | | |
| Peanuts | -0.824 | -0.393 | 0.362 | 10 | 0.542 | 1.228 |
| | (0.771) | (1.451) | (3.621) | | | |
| Cowpea | -0.514 | 8.897 | 35.62 | 10 | 0.542 | 1.228 |
| | (0.922) | (17.64) | (62.86) | | | |

Robust Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
[a] represents the coefficient of error correction term
[b] the real exchange rate in US Dollars
[c] the number of observations used in the regression
[d] the Adjusted R-Squared
[e] Durbin Watson statistic

We attributed this asymmetry to a behavioral adjustment of middlemen, intermediaries such as collectors, wholesalers and processors providing a marketing role. Following a price shock, the derived inventory demand by intermediaries, at the producer level, shifts to the right. In addition, some of the final price of consumer products includes value-addition from post-primary production activities, such as transportation, processing, and retail sale, which is not affected by the change in the world cereal price (Baquedano and Liefert, 2014). Transmission of the world price to the domestic consumer price will therefore be less than price transmission to the producer price. Conversely, there is a lag in the transmission of the world price variation to consumer price mainly because of the existence of inventory and the policy interventions such as price floors or buffer stocks.

### *5.3. Welfare effect of price change*

Using the estimated value of crops sold and purchased (Table 5), Equations 4 and 5 and parameters found in Tables 3 and 4, we evaluated country level net welfare effects due to changes in world prices from 2006 to 2014. As shown by Equations 4 and 5, country level quantities purchased and sold by commodity were used to evaluate welfare change. As a result, the average value in US dollars (USD)[13] of sales and purchases over the years 2008, 2009, and 2010 are respectively USD 1,064 and USD 490 million. In 2008, which is a year of important price spikes, these values are USD 1,406 million for sales and USD 619 million for purchases. These respectively represent 45 percent and 20 percent of the agricultural GDP, which amounts to USD 3,097 million (World Bank, 2017b). Comparatively, in 2010, the values of sales and purchases were 41 percent and 20 percent of agricultural GDP, respectively, estimated at USD 2,922 million (World Bank, 2017b). The reduction in the agricultural GDP was partly due to bad weather because of a late rainy season in 2010. In 2011, the values of sales and purchases were the lowest, which seems counter-intuitive since the data show a price and agricultural GDP increase, leading to higher value crop sales. Nevertheless, over the three years, the two most-purchased crops by rural households were rice and sorghum, while the two most-sold crops were peanuts and cowpea in 2008, and peanuts and sorghum in 2010 and 2011.

[13] To convert the total value of 2008, 2010, and 2011 from FCFA to USD, we used the exchange rate of the World Development Indicator database (World Bank, 2017b). The exchange rate in 2008, 2010, and 2011 for one dollar was 447.8, 495.3, and 471.9 FCFA, respectively. The extrapolation was done using the sampling weight available in the database.

The other parameters of the welfare estimates included the exogenous change in the world cereal price, the world price elasticity of transmission to consumers and producers price, and the demand and supply elasticities. The contribution of the second-order terms to the welfare change (Equations 4 and 5) were negligible due to the behavioral factors that dampen the magnitude of the effect. Therefore, demand and supply elasticities played a small role in the welfare change. The aggregate welfare change, derived from the estimated parameters, is presented in Table 6.

Table 5: Estimated total value of crops purchased and sold by rural households in millions of USD.

| | 2008 Purchase | Sale | 2010 Purchase | Sale | 2011 Purchase | Sale | Average Purchase | Sale |
|---|---|---|---|---|---|---|---|---|
| Millet | 94.9 | 152.7 | 81.4 | 100.8 | 35.2 | 55.5 | 70.5 | 103.0 |
| Maize | 92.5 | 147.6 | 76.7 | 152.8 | 32.8 | 49.8 | 67.3 | 116.7 |
| Rice | 108.5 | 85.1 | 103.2 | 119.9 | 61.2 | 40.1 | 91.0 | 81.7 |
| Sorghum | 279.1 | 265.7 | 294.8 | 258.4 | 121.6 | 164.5 | 231.8 | 229.5 |
| Peanuts | 29.3 | 402 | 13.9 | 379.6 | 8.8 | 162.3 | 17.3 | 314.6 |
| Cowpea | 15.7 | 352.8 | 14.6 | 183.3 | 6.4 | 117.8 | 12.2 | 218.0 |
| Total | 620 | 1406 | 584.5 | 1194.9 | 266.1 | 590 | 490.2 | 1063.6 |

Source: Authors' calculations

We estimated the welfare effects considering equations 4 and 5, where the international price change was transmitted to the local commodities price according to our estimates in Table 6. Subsequently, we performed a sensitivity analysis to highlight how the elasticities of transmission affected the relative welfare change (Figure 4). The exogenous price change, $\zeta_{p^w}$ , as stated earlier, is the change in the world cereal price index relative to the base period of 2002 to 2004. The world price shocks were 132 percent in 2008, 141 percent in 2011 and 136 percent in 2012.

Table 6: Change in welfare relative to total purchase per commodity and year.

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| World Price Increase ($\uparrow\zeta_{p^w}$) | 19 | 63 | 132 | 70 | 79 | 141 | 136 | 119 | 92 |
| Millet | 0.08 | 0.27 | 0.56 | 0.30 | 0.34 | 0.60 | 0.58 | 0.51 | 0.39 |
| Maize | 0.12 | 0.39 | 0.81 | 0.43 | 0.49 | 0.86 | 0.83 | 0.73 | 0.56 |
| Rice | 0.00 | -0.01 | -0.03 | -0.02 | -0.02 | -0.03 | -0.03 | -0.03 | -0.02 |
| Sorghum | -0.04 | -0.13 | -0.28 | -0.15 | -0.17 | -0.30 | -0.29 | -0.25 | -0.20 |
| Total | 0.01 | 0.03 | 0.05 | 0.03 | 0.03 | 0.06 | 0.05 | 0.05 | 0.04 |

Source: Authors' calculations

Overall, the increases in the world cereal price from 2006 to 2014 was translated into net welfare improvement for farmers. This improvement ranged from 0.02percent in 2006 to 0.06 percent in 2011. Among the six crops considered, the relative gain in welfare improvement resulted from millet and maize while rice and sorghum induced welfare loss; cowpea and groundnuts had no effect because of insignificant parameters. Maize dominated the welfare effects over all the other crops with an increase of the welfare ranging from 0.12 percent in 2006 to 0.86 percent in 2011. This was largely due to two factors: maize had the highest price transmission elasticities and the producer's price transmission elasticity was greater than that of consumers.

Second, maize sales exceeded purchases by a greater margin than any of the other crops (Table 5). The welfare gain from millet stemmed from the lack of transmission of the world cereal price to the consumer price resulting in the welfare gain equivalent to producer's surplus. Rice and sorghum generated welfare losses following a world price shock. The result for rice was consistent with the findings of Badolo and Traore (2015). The world price transmission to domestic rice market hurt farmers due to the fact that they were often net buyers. Similarly, there was a welfare loss from sorghum because purchases exceeded sales. As a result, any sorghum price increases adversely affected overall farmer welfare.

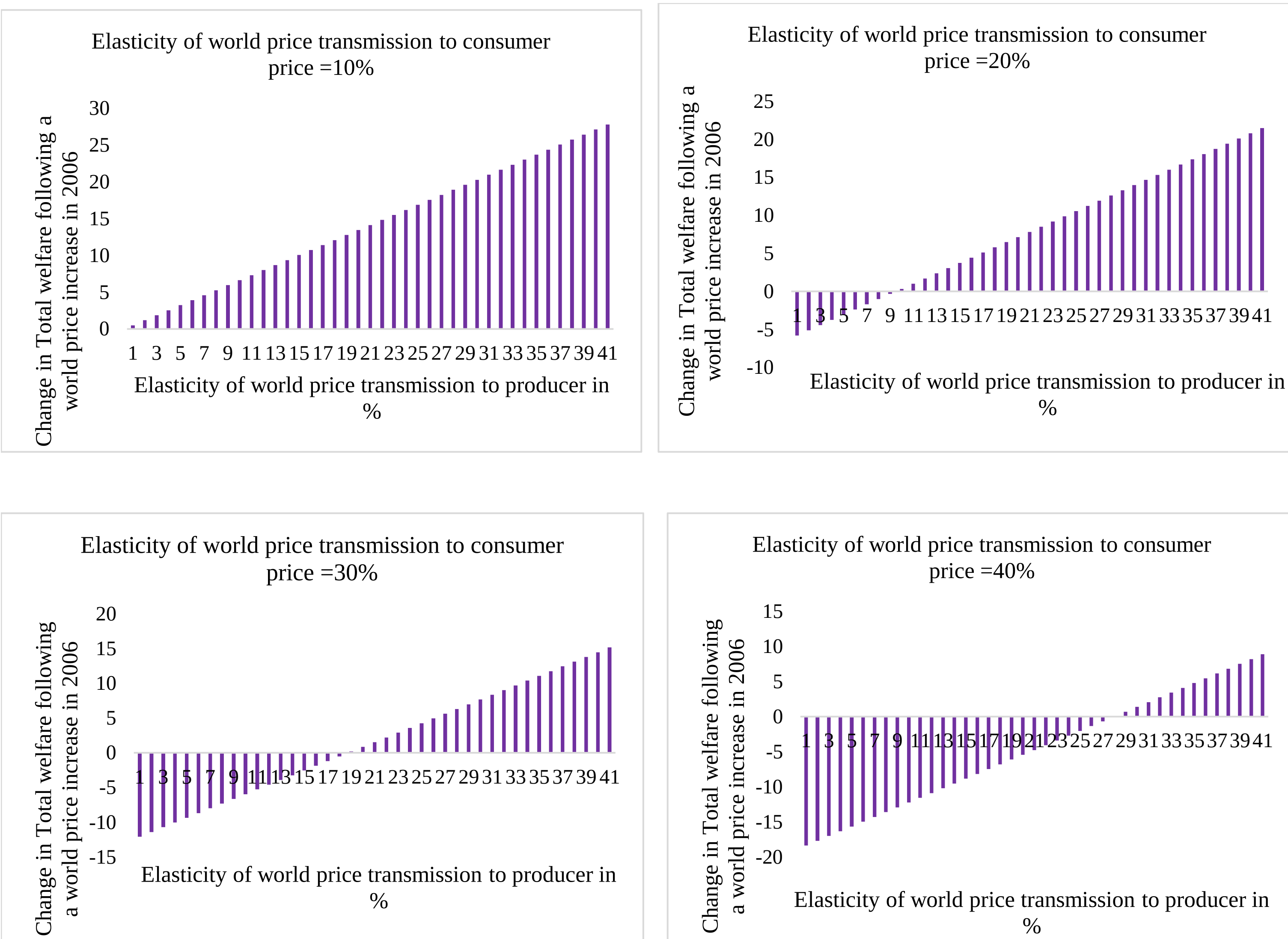



Figure 4a: Simulation of relative welfare change based on world price transmission elasticities variation for the year 2006

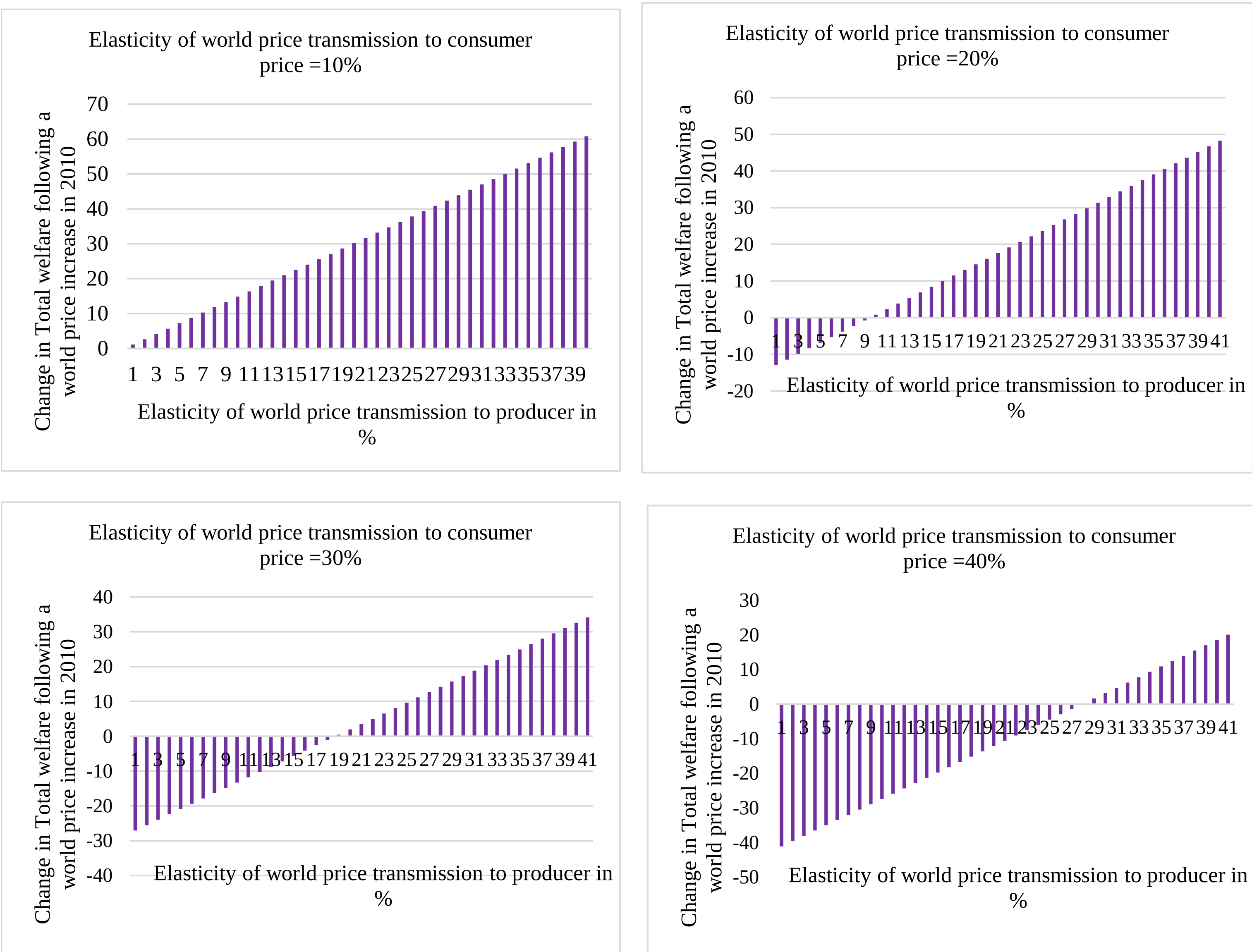



Figure 4b: Simulation of relative welfare change based on world price transmission elasticities variation for the year 2010

Finally, we conducted a sensitivity analysis to empirically assess the impact of variation in price transmission on rural welfare. For this, we performed a sensitivity analysis by setting consumer price elasticities to 10, 20, 30 and 40 percent. For each of these consumer elasticities, we allowed producer price transmission elasticities to vary in the range of 1 to 50 percent, with 1 percent increments. We observed that at a fixed level of purchase and sale, the welfare can be either positive or negative depending on elasticities values (Figure 4a and Figure 4b). Consistent with Equation 2, higher world price transmission to consumers' local price worsens farmers' welfare, while higher world price transmission to producers' local price was associated with welfare improvement.

Nevertheless, it is worth noting that the mechanism through which world price shock is transmitted to domestic market is mostly distorted by trade policies from both importing and exporting countries. Studies by Giordani et al. (2016); Gouel & Jean (2015); Minot (2011); Tovar (2009); WTO (2004); Zorya et al. (2012) argued that the restrictive policies imposed by exporters and tax reduction policies adopted by importers exacerbate the impact of world price spike on domestic prices. Most likely, the lack of appropriate domestic policies of food price monitoring and control leaves developing countries mostly with distortive trade policies (Giordani et al., 2016). Such mechanisms used in Burkina Faso can affect the magnitude of price transmission (Aker et al., 2010). The simulation of transmission elasticities conducted is partly mean to account for the effect of such distortions.

## 6. Conclusion and Policy Implications

We analyzed the implications of a world cereal price shock on rural household welfare in Burkina Faso to contribute to the empirical discussion on impediments to poverty alleviation. The link was established using an agricultural household model with the world prices for cereals transmitting to local producer and consumer prices. Household net welfare, after a price shock, is derived as a function of its behavioral responses to local price change induced by the international price shock. We estimated the model using nationally representative data on rural Burkina Faso and time series of world cereal producers and consumers price indices.

The causal relationship between world and domestic cereal prices was established using an error correction framework which allowed us to measure and separate long- and short-run effects on domestic price from an exogenous change in world price. The estimation resulted in transmission coefficients in the range of previous studies found in low-income nations. Importantly, we found that the magnitude of world price transmitted to the producer price was higher than that transmitted to consumer price. This asymmetry was attributed partially to behavioral adjustment by farmers, marketing (middlemen), and policies interventions following a world price shock. We demonstrated that the status of net buyer or net seller is not a sufficient condition for a household to be a winner or loser from an international price shock. Furthermore, we studied household behavioral response in commodity supply and demand to the price changes identified using lagged yield and yield shocks. Significant household responses to price changes were found on both supply and demand sides.

The price elasticities, transmission coefficients, purchases and sales were combined to estimate household-level welfare changes induced by a global price shock. Overall, price increases, such as those experienced during the 2008 to 2009 period, were associated with an improvement in rural farmers' welfare because the producer effect outweighed the consumer effect. Increases in prices during the period from 2006 to 2014 was translated into welfare improvement. This improvement ranged from 0.02 percent in 2006 (lowest) to 0.06 percent in 2011 (highest) of the total purchase. This suggested that price increases may be associated with poverty reduction for rural households. Price shocks on the majority of crops generated positive welfare impact, except for sorghum and rice. In addition, we evaluated the robustness of the welfare impact generated by variation in price transmission elasticities by conducting a sensitivity analysis. We observed, by holding purchases and sales constant, that the welfare effect can be either positive or negative, depending on values taken by transmission elasticities.

Cereal producers will benefit from increases in world prices and suffer from world price declines. However, stronger integration into world markets, reduced trade barriers, and transaction costs will benefit a country by allowing it and its producers to capture the gains from trade based on comparative advantage as well as the reduced cost of doing business. Public policies and investments that strengthen market incentives and activity, such as improving physical infrastructure, can thereby pay dividends. Although greater integration into world markets will make consumers more vulnerable to fluctuations in world prices, targeted compensation is a preferred policy response, rather than market-distorting policy intervention.

Our analysis and results apply to crop-producing rural households, and as such have some important limitations. First, we excluded from our analysis the negative welfare effects on urban cereal consumers from increases in world prices. Consequently, our estimated national welfare effects from such price growth were upwardly biased. Second, we also excluded livestock and other food products for which cereal-producing households may be net consumers. Nevertheless, our findings provide insight into the role played by global price transmission to welfare analysis. Future research could focus on linking international price volatility to rural household welfare.

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Table 5: Estimated total value of crops purchased and sold by rural households in millions of USD.

| | 2008 Purchase | Sale | 2010 Purchase | Sale | 2011 Purchase | Sale | Average Purchase | Sale |
|---|---|---|---|---|---|---|---|---|
| Millet | 94.9 | 152.7 | 81.4 | 100.8 | 35.2 | 55.5 | 70.5 | 103.0 |
| Maize | 92.5 | 147.6 | 76.7 | 152.8 | 32.8 | 49.8 | 67.3 | 116.7 |
| Rice | 108.5 | 85.1 | 103.2 | 119.9 | 61.2 | 40.1 | 91.0 | 81.7 |
| Sorghum | 279.1 | 265.7 | 294.8 | 258.4 | 121.6 | 164.5 | 231.8 | 229.5 |
| Peanuts | 29.3 | 402 | 13.9 | 379.6 | 8.8 | 162.3 | 17.3 | 314.6 |
| Cowpea | 15.7 | 352.8 | 14.6 | 183.3 | 6.4 | 117.8 | 12.2 | 218.0 |
| Total | 620 | 1406 | 584.5 | 1194.9 | 266.1 | 590 | 490.2 | 1063.6 |

Source: Authors' calculations