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Price signals and supply responses for staple food crops in SSA countries

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Abstract

Several studies have focused on estimating the supply response of farmers in Sub Saharan Africa.This literature has used a variety of approaches and has generally concluded that price elasticities of supply were low or very low. However, only a few analyses have gone beyond estimating the aggregate supply response for the sector as whole or the specific case of cash crops. In most cases, data scarcity especially on producer prices has been the main limiting factor. In this paper, we revisit this question focusing on the supply response of main staple food crops in selected Sub Saharan African (SSA) countries. We use an innovative dataset recently developed by FAO's "Monitoring and Analysing Food and Agricultural Policies" (MAFAP) programme which provides prices at the producer, wholesale, and border levels for selected value chains. Using dynamic panel techniques, we are able to test how acreage, production and yields respond to price signals and other non-price factors over the recent food price crises (2005-2013).We observe that farmers producing staple food crops react to real price signals, even if with a limited intensity. Moreover, our results suggest that direct price incentives arising from border protection and government intervention in domestic markets and price shocks at the border are more important than macroeconomic policies in influencing farmers' decisions. We also show that omitting marketing costs from the supply response function leads to underestimation of the price elasticity. Conversely, using wholesale instead of farm gate prices as proxy for producer prices leads to overestimation of the price elasticity.

Keywords: supply responses; price incentives; agriculture commodities; dynamic panel data

JEL Classification: Q11, Q18, C33, O55

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1. **Introduction**

Despite the wave of agricultural policy reforms carried out in Sub-Saharan Africa (SSA) during the last decades, the lack of results in terms of productivity and growth has been attributed – among other factors – to a weak or absent supply response to market signals (Di Marcantonio et al, 2014). During the 1960s and 1970s, some authors argue that this is particularly true for staple food crops because the marketing systems are less developed and production is mainly devoted to on-farm consumption, making price incentives of limited relevance for farmers' decisions. Most governments in SSA used the argument that subsistence farmers do not respond to market signals and run a static business to justify an excessive taxation of the sector in favour of pro-urban and industry-oriented policies (Bates, 1983; World Bank, 2008). The rationale was that taxing agriculture would make additional resources available to be invested in other sectors without substantially slowing down overall growth (Helleiner, 1975; Askari and Cummings, 1977; Krueger, Schiff, and Valdes, 1991; Schiff and Montenegro, 1997; McKay et al., 1998; Anderson and Masters, 2009).

Since the 1980s and 1990s, governments eventually reduced the *anti-agricultural bias* (Anderson and Masters, 2009). Concomitantly, the assumption that farmers' supply response is generally absent or very low has been less widely accepted as the literature has showed repeatedly that farmers including smallholders do react to price signals. Yet the argument is still attracting some degree of controversy in the academia as well as in policymaking circles (Townsend, 1999; Haile et al. 2015).

The focus of research evolved over time and shifted towards understanding which internal and external factors limit the supply response to price incentives (Clover, 2003; Svendsen et al, 2007; Pratt and Yu, 2008). A consensus emerges around two points: i) the aggregate short-run supply response is quite inelastic, and ii) the supply response for individual crops is less inelastic than the aggregate because production factors can be easily moved across crops (Onal, 2012). In most cases, authors analyzed price elasticity with respect to either aggregate agricultural supply or individual cash crops, ignoring the specific case of staple food crops. These gaps in the literature can be explained by the lack of reliable and comparable cross-country data in SSA, especially for producer prices and marketing costs (Dawe et al., 2015).

Understanding if and how the food supply in SSA as a whole reacts to price signals constitutes a valuable piece of information for policymakers engaged in achieving food security in the region. In fact, even if subsistence agriculture might not be considered as a major driver of economic growth, it still has a crucial influence on the livelihoods to the most vulnerable sub-groups of the population (Poulton et al, 2006). Moreover, shedding more light on the relationship between price signals and food supply could help to enhance smallholder market participation in SSA and, hence, advance the development agenda on what has been a priority topic for several decades (Barrett, 2008). Lastly, reliable information at regional level beyond the usual country-crop specific cases is needed to support better regionally integrated food markets in SSA in order for Africa to meet its own raising demand for food (World Bank, 2012).

To help fill some of these gaps, we analyze the supply response for major staple food crops in several SSA. To do that, we use a recent dataset produced by the "Monitoring and Analyzing Food and Agricultural Policies" (MAFAP) programme of the Food and Agriculture

Organization (FAO) which provides detailed information on food crop prices, marketing costs and the effects of policy interventions for multiple value chains in ten SSA countries over the 2005-2013 period. In this study, we claim three contributions to the literature. First, to the best of our knowledge, this is the first attempt to perform a cross-country analysis of the price elasticity of supply in SSA focusing exclusively on staple food crops instead of cash crops or aggregate sector level production. Second, we exploit the richness of the MAFAP dataset to capture the different contribution of the direct incentives arising from i) domestic market intervention and border measures, ii) the monetary policies – especially those influencing the exchange rate - and iii) the border prices in the formulation of the farmers' price expectations and their relative impact on the supply response. Third, we demonstrate that estimates of the price elasticity of supply are biased when i) the wholesale price is used as proxy of the producer price; and ii) the marketing costs are omitted from the response function.

The results show that short-run price elasticity of supply is always positive and statistically significant, irrespective of the proxies used to measure the agricultural supply –acreage, production or yield – and the expected prices – farm-gate or wholesale - in the response function. This suggests that Sub-Saharan farmers are capable of interpreting market signals and responding positively to price increases for staple crops. In particular, we observe the highest response for production (0.59) while for yield and acreage the price elasticity is substantially lower (i.e. 0.30 and 0.22). We also find that the supply responses are significantly influenced by marketing costs paid by farmers to commercialize their product and – not surprisingly - by past and current weather shocks. In comparison, the prices of competing commodities and the cost of inputs have less important effects. By decomposing the expected price into three components – the nominal coefficient of protection, the real exchange rate and the border price – we find that farmers in SSA respond to price signals arising primarily from shocks in the international market and from direct incentives resulting from border measures and government interventions in domestic markets. On the contrary, they are less stimulated by macroeconomic policies affecting the exchange rate.

The reminder of the paper is organized as follows. Section two introduces the methodology. Section three describes the dataset while section four presents the empirical strategy. Section five reports the results of the econometric exercise. Finally, section six concludes.

2. Methodology

Since the pioneering work of Nerlove (1956), economists have put a lot of efforts into investigating farmers' response to price signals. The agricultural supply response in Sub-Saharan Africa has historically been subject to much debate (Schiff and Montenegro, 1997; Onal, 2012) and most authors have primarily focused on explaining why the supply response in this region was generally low. However, isolating the main factors constraining the supply response has proved to be a difficult task (Baffes and Gardner, 2003). There is a certain consensus on the role of structural and institutional constraints (Kherallah et al., 2002) such as lack of complementary inputs, rural infrastructure, difficult access to credit, insufficient provision of extension services and lack of reliable insurance mechanisms (Binswanger et al., 1987; Key et al., 2000). In addition, authors like Bloom and Sachs (1998) argue that natural conditions such as low soil fertility and irregular rainfall further contribute to lower price elasticity of supply, especially in case of severe drought. Other empirical results suggest that an unstable political environment adversely influences food supply via production inefficiencies and attenuates competitiveness (Knack and Keefer, 1995; Keefer and Knack, 1997; Hall and Jones, 1997 and 1999).

Haile et al. (2015) propose a thorough and useful review of the literature providing an extensive range of methodological approaches and empirical strategies in a variety of settings for measuring agricultural supply response. To decide on the best method to adopt for our analysis, a number of conditions have to be considered. Most of the literature focuses on the analysis of the supply response for specific country-crop case studies (e.g. Bond, 1983; McKay et al., 1998; Baffes, 2003; Thiele, 2003; Leaver, 2004; Muchapondwa, 2009; Vitale et al., 2009; Molua, 2010; Mkpado, 2012) either at macro level (e.g. Thiele, 2003; Barr et al, 2009; Imai et al., 2011; Onal, 2012; Haile et al, 2014 and 2015) or at micro-level, i.e. plot, farm, and household (e.g. Lansink, 1999; Vitale et al, 2009; and Yu et al, 2012). Only few authors provide cross-country estimates of the price elasticity of supply (e.g. Binswanger et al. 1987; Subervie 2008). For example, Onal's study (2012) proposes cross-country estimates of the price elasticity for SSA countries for export crops in Kenya, Mozambique, Tanzania, Uganda and Zambia. For our own study, we decide to perform a cross-country analysis of the supply response for staple food commodities which are fundamental in terms of food security in Sub-Saharan Africa, i.e. cereals, tuber and roots, and pulses.

To do that, we follow the standard model proposed by Nerlove (1956) based on the hypothesis that farmers partially adjust their output (Q) towards a desired level (Q^*) determined by an expected price (P^*)[1]. Unfortunately, neither Q^* nor P^* are observable. In the literature, the preferred proxy for the desired output level is the acreage allocation because it is fully under farmers' control and it is not affected by exogenous shocks that occur after planting (e.g. Askari and Cummings, 1977; Chavas et al., 1983; Rao, 1989; Coyle, 1993; Vitale et al., 2009; Haile et al.,2015). However, the resulting price elasticity of supply can be considered a lower bound of the farmers' response to price signals because it does not capture the choices made between planting and harvesting (Rao, 1989; Oyejide, 1990; Haile et al., 2015). In this respect, to estimate the supply responses part of this literature employs not only acreage as an output proxy but also production and yield as complementary dependent variables (Braulke, 1982; Coyle, 1999; Weersink et al., 2010; Onal, 2012; Yu et al., 2012; Haile et al., 2015). We prefer to follow the latter approach, using all three proxies in estimating the supply response for the following reasons. First of all, the price elasticity estimates highly depend on the choice of the proxy (Rao, 1989), therefore combining a broader set of output measures will provide more robust estimates. Second, the possibility for farmers to adjust planted acreage is likely to be limited due to rigid patterns of land use which, in the case of staple food crops in SSA countries, are determined by

[1] Another common approach is to estimate the supply function derived from a profit maximizing framework with the joint estimation of output supply and input demand functions. However, this approach requires detailed information on all the input quantities and prices.

subsistence needs and constraints on arable land availability (Askari and Cummings, 1977). Lastly, while the best estimator of farmers' production decisions is arguably planted acreage, we could only obtain data on harvested acreage which, if used alone, could reduce the accuracy of our results.

Choosing the proxy for the expected output price P* is another crucial methodological consideration, which entails two different problems: a) choosing the price series that is actually driving the farmer decision and b) adopting the appropriate farmers' expectation hypothesis to determine which variable needs to be inserted in the empirical model. As pointed out by Askari and Cummings (1977), the researcher must select the price series which could support the best answer to the question: why would farmers produce more? If farmers do not market the crop they produce, then the price variable does not interest them. Nonetheless, if farmers seek to produce more it is usually to increase their income and be able to buy a broader range of goods. Hence, they will adjust their production decision looking at the price of their crop relative to those of other goods. Of course, in the literature on developing countries, the implicit assumption is that farmers want to increase the possibility of diversifying their consumption and are expected to react to changes in relative prices. These changes are usually captured by the crop price deflated by the consumer price index.

The literature on SSA countries estimates price elasticities of supply using - if available - the farm-gate price. The underlying assumption is that this price drives farmers' decisions. However, many exceptions have been made because it is generally difficult to assemble reliable producer price series in SSA countries (Dawe et al., 2015). As a consequence, most of the cross-country studies investigating the effect of price movements on agricultural supply have used less desirable variables such as the wholesale and retail prices or even the international price deflated by domestic price indexes. These are sub-optimal choices because farm-gate price and other domestic prices such as wholesale and retail behave differently in most SSA countries(Dawe et al., 2015), mainly due to incomplete price transmission along the domestic value chain (Meyer and von Cramon Taubadel, 2004). In the following sections, we show how using wholesale prices as a proxy for farm-gate prices biases the resulting price elasticity estimates.

For modelling farmers' price expectation, there are three well-known and widely applied hypotheses: a) naïve expectations (Ezekiel, 1938); b) adaptive expectations (Nerlove, 1958); and c) rationale expectations. The first hypothesis assumes that prices do not change and the expected price is equal to the most recent observable one. The second hypothesis is also backward looking but assumes that farmers make adjustments in formulating price expectations in order to correct for past errors. Finally, the last hypothesis assumes that farmers efficiently use all the available information in predicting future prices. Following the Nerlove model, we assume adaptive expectations because they are more efficient than naïve expectations and more realistic than the rational expectations. For most farmers in SSA countries, accessing reliable, timely and up-to-date information on prices is problematic. Even if they have the opportunity to receive such market signals, they often lack the means to process them (Chavas, 2000 and Haile et al., 2015). The standard version of the Nerlovian partial adjustment model consists of the following functional forms:

$$Q_t^* = a_0 + a_1 P_t^* + a_2 X_t + \varepsilon_t \quad (1)$$

$$P_t^* = P_{t-1}^* + \eta(P_{t-1} - P_{t-1}^*) \quad (2)$$

$$Q_t = Q_{t-1} + \gamma(Q_t^* - Q_{t-1}) \quad (3)$$

where Q_t^* and Q_t denote desired and actual level of output (acreage, production or yield) at time t, P_t^* and P_t the expected and observed price, and X represents other exogenous factors affecting the supply at time *t*, such as price of competing crops, fixed and variable production costs, weather variables and technological changes. η and γ are the expectation and adjustment coefficients. The reduced form is obtained by solving the system (1)-(3) to eliminate the unobservable variables Q_t^* and P_t^*(Askary and Cummings, 1977):

$$Q_t = b_0 + b_1 Q_{t-1} + b_2 P_{t-1} + b_3 X_t + \mu_t \quad (4)$$

with b_2 measuring the short-run price elasticity of agricultural output. Equation (4) is the basic dynamic function considered in our analysis where Q_t, Q_{t-1}, P_{t-1} and the set of exogenous factors are selected according to the choices described above. More specifically, we assume that farmers' decisions on acreage are based on the price expectations available at planting-time regarding the output price at harvest-time, marketing costs, competing crop prices, input prices, and other exogenous factors such as previous weather shocks. We also assume that once acreage has been allocated, farmers adjust their production decisions by increasing or decreasing the intensity of their farming activities during the growing season according to other factors such as current weather conditions (Oyejide, 1990). Following the existing literature, when we use production or yields as dependent variable in equation (4), we augment the set of variables in X_t to include contemporary weather shocks, and drop competing crop prices and past weather shocks because they do not influence the farmers' choices between planting and harvesting (Haile et al., 2015).

For each output variable, we provide estimates of equation (4) alternating the farm-gate price and wholesale price for the same value chain as proxy for the past price, i.e. P_{t-1}. Following World Bank (1994), Mamingi (1996) and Thiele (2003), we decompose the price P_t into its different components to trace separately the impact of direct incentives arising from border protection and government intervention in domestic markets, macroeconomic policies such as the exchange rate policy and variations in border prices. To do that, we rewrite the real producer price P_t as:

$$P = \frac{P_N}{CPI} = \frac{P_N}{CPI} * \frac{P_N^B}{P_N^B} * \frac{e}{e} * \frac{WPI^{US}}{WPI^{US}} =$$

$$= \frac{P_N}{P^B * e} * \frac{WPI^{US} * e}{CPI} * \frac{P_N^B}{WPI^{US}} = NPC * RER * P^B \quad (5)$$

where P_N is the nominal price at farm gate, CPI is the consumer price index used to calculate the real producer price P, e is the nominal exchange rate (domestic units per US$), WPI^{US} is the US wholesale price index and P_N^* the nominal price of the commodity at the border, expressed in US$. As shown in the last term of Equation 5, the real producer price can be finally re-written as the product of three elements: i) the nominal protection coefficient (NPC); ii) the real exchange rate (RER); and iii) the border price expressed in real terms (P^B). To embed them into the Nerlove model, we follow Chavas et al. (1983) and Parrott and McIntosh (1996) assuming that the expected price is a weighted average of these three elements. Therefore, we substitute equation (5) in (4) and we obtain:

$$Q_t = b_0 + b_1 Q_{t-1} + b_2[a_1 NPC_{t-1} + a_2 RER_{t-1} + a_3 P_{t-1}^B] + b_3 X_t + \mu_t$$

$$= \beta_0 + \beta_1 Q_{t-1} + \beta_2 NPC_{t-1} + \beta_3 RER_{t-1} + \beta_4 P_{t-1}^B + \beta_5 X_t + \mu_t \qquad (6)$$

where $\beta_2 = b_2 a_1$, $\beta_3 = b_2 a_2$ and $\beta_4 = b_2 a_3$.

The NPC compares the farm-gate price with the maximum the farmers would get from selling their product on the world market. A ratio above (below) one indicates that producers of a specific commodity receive direct price incentives (disincentives) resulting from trade and domestic market policies and overall market performance. Clearly, we expect a positive supply responses to an increase in the NPC.

The RER measures the price ratio between tradeable and non-tradeable goods and it is influenced by macroeconomic policies, such as monetary and fiscal interventions (Mamingi, 1997). An increase in the RER – corresponding to a devaluation in real terms of the domestic currency – is expected to increase farmers' incentive to produce because it raises the price of tradeable relative to non-tradeable goods. Finally, the border price captures the impact of price changes on the international market and we expect it has a positive impact on the agricultural supply.

3. Data

For estimating equation (4) and (6), we require a rich dataset with information on outputs, prices at different points of the value chain, marketing costs, a measure of policy support and other exogenous factors that influence farmers' decisions on staple food crops. Most of this information is provided by the MAFAP dataset (MAFAP, 2015) which covers more than 70 agricultural value chains spread over ten different SSA countries from 2005 to 2013. These countries are Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Tanzania and Uganda. For each value chain, farm-gate, wholesale and border output prices are collected together with the respective marketing costs, which include transport costs, processing costs, handling costs, taxes, fees and commercial margins of different agents. The ultimate data sources in most cases are government institutions such as statistical offices and research centres[2].

[2]See table A1 in the Appendix for detailed information on specific data sources.

In our analytical framework, the farm gate price is defined as the amount received by the producer for selling a unit of a good (i.e. tonne) as output minus any value added tax (VAT), or similar deductible tax paid by the purchaser. Similarly, the wholesale price is defined as the price observed in the market where the domestically produced commodity competes with the internationally traded commodity. It represents a point in the value chain between the farm gate and the point of entry (exit) of imported (exported) commodities (MAFAP, 2015). Finally, the border price represents the FOB (CIF) price for exported (imported) goods, with the underlying assumption that international prices can be considered as a valid benchmark for prices undistorted by domestic policies and free of influence of domestic market failures[3].

Table 1. Dataset Coverage

Country	Crop	Period	Country	Crop	Period
Burkina Faso	Maize	2005-2013	Kenya	Potatoes	2005-2013
Burkina Faso	Sorghum	2005-2013	Malawi	Maize	2005-2013
Burkina Faso	Rice	2005-2013	Mali	Maize	2005-2012
Ethiopia	Maize	2005-2012	Mali	Sorghum	2005-2012
Ethiopia	Wheat	2005-2012	Mali	Rice	2005-2012
Ethiopia	Sorghum	2005-2012	Mali	Millet	2005-2012
Ethiopia	Barley	2005-2012	Mozambique	Maize	2005-2013
Ethiopia	Beans	2005-2012	Mozambique	Rice	2005-2013
Ghana	Maize	2005-2013	Mozambique	Cassava	2005-2013
Ghana	Rice	2005-2013	Nigeria	Sorghum	2005-2010
Ghana	Cassava	2005-2011	Nigeria	Rice	2007-2010
Ghana	Yam	2005-2012	Uganda	Maize	2005-2013
Kenya	Maize	2005-2013	Uganda	Wheat	2005-2013
Kenya	Wheat	2005-2013	Uganda	Rice	2005-2013
Kenya	Sorghum	2005-2013	Uganda	Cassava	2005-2013
Kenya	Rice	2005-2013	Tanzania	Maize	2005-2013
Kenya	Cassava	2005-2012	Tanzania	Rice	2005-2013
Kenya	Beans	2005-2012			

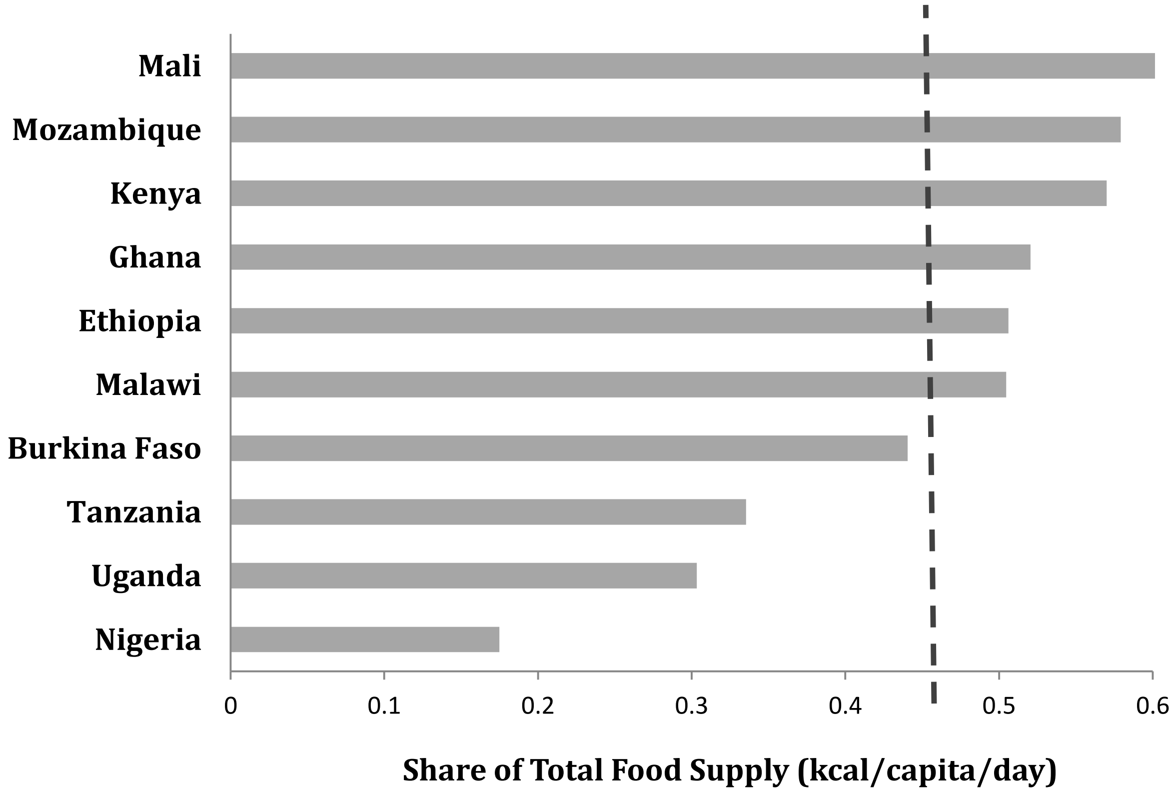
Source: FAO-MAFAP Database

In our analysis, we use a subset of the MAFAP database that only includes staple food crops. We consider ten commodities belonging to three main commodity groups considered essential for food security in SSA: cereals (maize, wheat, sorghum, rice, millet, barley); roots and tubers (cassava, yams, potatoes); and pulses (beans). Since not all the staple food crops are produced in the ten countries represented in our dataset, our panel data is unbalanced. Consequently, we decided to work with country-commodity pairs in the empirical analysis (see sections 4 and 5). Table 1 provides a full list of the 35 value chains used for our empirical exercise together with the period covered by the dataset. The most represented country is Kenya - with seven value

[3] For more information on the methodology, see (MAFAP, 2015) at www.fao.org/in-action/mafap.

chains - while Malawi has only one value chain. Maize is present in all countries except in Nigeria. Although in some countries the number of commodities may appear limited, Figure 1 shows that their relevance for food security is substantial. The commodities in our dataset cover over 45% of the total food supply (kcal/capita/day) in the 10 countries we consider, and over 50% in six of these countries.

Figure 1. Percentage Coverage of the Total Food Supply, by country (avg. 2005-2013)



Note: Authors' calculations from FAOSTAT (FAO, 2015).

We deflate farm-gate and wholesale prices and marketing costs using the consumer price index (CPI) provided by World Bank (WDI, 2015), assuming that farmers react to the relative prices of the produced crop with respect to the prices of the others goods in the market. Accounting for price of other good is coherent with our assumption that farmers want to improve their food security status buying other goods than those they produce. Additionally, it allows us to obtain price proxies expressed in real terms. Ideally, we would deflate prices using a CPI that excludes the commodity in question to obtain the true relative price of that commodity. However, such data are not available. Finally, we take from the World Bank (WDI, 2015) the US wholesale price index and the official nominal exchange rate necessary to calculate the nominal protection coefficient, the real exchange rate and the real border price.

Besides the data on prices, we also need data on agricultural output, competing output prices, input prices and weather conditions. For the dependent variables – commodity-specific acreage, production and yield for each country – we use data provided by FAOSTAT (FAO, 2015). Recall that FAO data on acreage refer to harvested area and not to the actual variable of interest, which is planted area. Using the harvested area could bias the results because it may differ from planted area as result of factors outside the farmers' control. In order to capture the effect of competing commodity prices on acreage decision, we use the producer price index of the respective food group, i.e. cereals, roots and tubers, and pulses provided by FAOSTAT (FAO, 2015). Ideally, we would use the price of the actual competing commodity, but the unbalanced nature of our panel prevents us from adopting this solution. As for the proxy of the relative cost of inputs, we use the ratio of the annual West Texas Intermediate (WTI) oil price index (Energy Information Agency of the United States, 2015) to the producer price index for the aggregate agricultural sector (FAO, 2015). This ratio can also be interpreted as a measure of profitability (Askari and Cummings, 1977).

Finally, to capture the influence of weather conditions on agricultural supply, we use different weather variable depending on the proxy selected to estimate supply in the response function. For planted acreage, farmers are likely to take into consideration what happened in the past to formulate their decision. Some studies employ past yield shocks (with respect to a long-run trend) as a proxy for weather and other natural shocks effects (e.g. Roberts and Schlenker, 2009; Roberts and Schlenker, 2013; Haile et al., 2015). The main limitation of this approach is that the deviations from the trend are completely attributed to weather-related events while there might be other exogenous factors influencing them (Roberts and Schlenker, 2009). Nevertheless, the same proxy cannot be used to explain production and yield responses because a) after planting, it cannot be argued that the past natural shocks influence the intensity of farming; b) using the yield shocks in the production or yield function raises endogeneity problems due to likely collinearity with other variables, especially the lagged dependent variable. Accordingly, some authors control for contemporaneous weather and other natural shocks to explain production and yield response by employing direct information on weather variables such as precipitation, moisture and temperature (Askari and Cummings, 1977). This is often hampered by the lack of primary data sources in developing countries – especially in Sub-Saharan Africa –due to the limited coverage of weather stations in agricultural areas (Rojas et al., 2011). We address this constraint using an FAO indicator based on remote sensing data, i.e. the Agricultural Stress Index (ASI). The ASI captures the anomalous vegetation growth and potential drought in arable land during the cropping season. Specifically, the ASI measures the temporal intensity and duration of dry periods and estimates the percentage of arable land affected by drought (FAO, 2015)[4]. The information collected using satellite technology to generate the ASI is synthesized at the country level and can therefore be employed in the supply function to estimate the effect of weather-related conditions occurred between planting and harvesting. Descriptive statistics of the variables used in the empirical analysis are given in Table A2 the Appendix.

4. The empirical model

[4] For more information on the ASI, refer to http://www.fao.org/climatechange/asis/en/

The supply response functions estimated in this study are based on equation (4) and (6) presented in section 2 and take the following forms:

$$Q_{i,t} = b_0 + b_1 Q_{i,t-1} + b_2 P_{i,t-1} + b_3 X_{i,t} + \rho t_i + \eta_i + \mu_{i,t} \quad (7)$$

$$Q_{i,t} = \beta_0 + \beta_1 Q_{t-1} + \beta_2 NCP_{i,t-1} + \beta_3 RER_{t-1} + \beta_4 P^B_{i,t-1} + \beta_5 X_{i,t} + \rho t_i + \eta_i + \mu_{i,t} \quad (8)$$

where $Q_{i,t}$ indicates the level of acreage, production or yield for the country-commodity pair *i* – for example maize in Kenya - at time t, $P_{i,t-1}$ the farm-gate or wholesale price of the same pair *i* at time t-1, $X_{i,t}$ the vector of control variables, while t_i and η_i are – respectively – a time trend capturing technological and structural changes and a country-commodity fixed effect to capture heterogeneity across different value chains. For equation (8), NCP, RER and P^B indicate, respectively, the nominal coefficient of protection, the real exchange rate and the border prices in real terms while $\mu_{i,t}$ is a normally distributed error term with mean zero and variance σ^2.

Since we only have a limited number of observations for each country-commodity pair, we pool the data and test for specific country/commodity-specific heterogeneity (see Table 1). This specification allows us to exploit all the panel dimensions of the dataset and obtain short-run cross-country price elasticities for staple food crops in SSA relying on robust inference (Onal, 2012). The vector of control variables, $X_{i,t}$, contains different elements depending on the supply proxy used for estimating equation (7) and (8), as discussed above. For acreage, we include marketing costs, the producer price index of the respective food group, the real oil price, yield shocks, a dummy for the food price crises, and a time trend. For production and yield, we drop the proxy for the competing price and the yield shocks and add the ASI. All the continuous variables used for estimating the model – except for the Producer Price Index and the ASI - are in logarithmic form so that coefficients can be interpreted in terms of percentage changes, which is particularly convenient for analyzing the short-run price elasticity.

There are a number of reasons why endogeneity might affect our estimates. Estimating equation (7) and (8) using Ordinary Least Squares (OLS) or Fixed Effects(FE) would yield biased estimates because of the correlation between the lagged dependent variable and the country fixed effect – the so-called dynamic panel bias (Nickell, 1981). As extensively discussed in the literature - even after the within-group transformation – the lagged dependent variable $Q_{i,t-1}$ would still be correlated with the error term, providing biased and inconsistent estimates for the fixed effect estimator. The problem becomes smaller as the length of the panel (T) grows (Nickell, 1981 and Roodman, 2009a). However, our data only include 9 years. The most common solution to the dynamic panel bias problem is the Generalized Method of Moments (GMM) estimator developed by Arellano and Bond (1991).One option is to use the difference-GMM estimator which consists of first differencing the data to eliminate the fixed-effect and, then, of instrumenting the first-differenced equation with the lagged level of the series. A more suitable alternative in our setting is to estimate the system-GMM as proposed by Blundell and Bond (1998). They refine the difference-GMM by transforming the instruments themselves in order to make them exogenous to the fixed effects (Roadman, 2009). In other words, they propose to estimate a system of equations in both differences and levels, where the instruments for the levels equation are the lagged first-differences of the series (Bond et al., 2001). Blundell and Bond (1998) show that when T is small there are significant gains in applying the system-GMM rather than the difference-GMM, provided that the initial conditions are not correlated with the fixed effect. Moreover, the difference-GMM performs quite poorly when series are persistent or close to being random walks, while the system-GMM estimator is consistent in the presence of unit roots (Bond, 2002; Binder et al., 2005).

In order to validate the system-GMM estimates, sensitivity analyses and robustness checks on the instrument choice and serial correlation are required. To avoid the instrument proliferation problem, we follow Roodman (2009b) by "collapsing" the instrument matrix and checking if we can exclude longer lags instead of using all the available information. Since the GMM estimator can be influenced by this choice, we test its stability by showing how the coefficients vary with the number of chosen lags[5]. Once the number of instruments has been fixed, we test both the validity of the full set of instruments using the Hansen test and the validity of a subset of instruments – precisely those for the levels equation based on lagged differences of the dependent variable– calculating the difference-in-Hansen statistics. The latter test is necessary because the original Hansen test may be weakened in case of instrument proliferation. Moreover, it allows us to confirm the Blundell and Bond (1998) assumption on the initial conditions (Roodman, 2009b). The other statistic reported is the Arellano-Bond test for autocorrelation which looks at the second-order correlation in difference to test for the first order serial correlation in levels of the error term. As additional robustness check, we compare the system-GMM estimates with estimates obtained with OLS, FE and difference-GMM. The main purpose is to verify that the coefficient of the lagged dependent variable lies in the credible range defined by Roodman (2009a), which is between the FE coefficient (lower bound) and the OLS coefficient (upper bound). Finally, we use the Windmeijer (2005) correction to obtain robust standard errors since two-step GMM estimates are biased downward in finite samples.

5. Results

Before estimating the supply function, we control for the stationarity of the variables in our dataset. We use two panel unit root tests suitable for unbalanced panel dataset, the Im-Pesaran-Shin test and the Fisher-type test. In both cases, the null hypothesis is that all the panels contain a unit root. Table A3 in the Appendix shows that only acreage, production, producer price index and real oil price are not stationary in levels while all of them are stationary once differenced. As far as the first-difference variables are stationary, the presence of some non-stationary variables in levels is not an issue considering that it will be addressed by the GMM during the differencing process, giving consistency to the estimates (Yu et al., 2012).

Table 2, 3 and 4 show the results of the empirical estimation of equation 7 and 8 using acreage, production and yield as dependent variables, respectively. For each table, column (1)

[5] While Hendricks (2012) highlighted this problem, the literature does not provide more robust guidance on how one should choose the optimal number of lags in a dynamic panel data setting.

and (2) report the supply response using – respectively - the lagged farm-gate and the wholesale price to proxy the expected price. We note that the short-run price elasticity of supply is always positive and statistically significant, no matter which dependent variable or price we use in the response function. More specifically, if the own-price of any given staple food crops at farm-gate level increases by 10%, acreage rises by 2.2%, production by 6% and yield by 3.1%. At the same time, if we consider the wholesale price as proxy of the farmers' expected price, the results show that a 10% rise in price will cause an increase of 3.9% in acreage, 6.2% in production and 4.3% in yield. Looking at this initial set of results, we can make several observations. First of all, farmers in SSA are able to interpret the market signals and respond positively to an increase of the real price of staple food crops, as suggested by economic theory. Furthermore, the results show that farmers use price information not only to decide how much acreage to plant, but also to modify their farming intensity during the cropping season.

Table 2. Empirical estimates of the annual acreage response

	(1)	(2)	(3)
Area (t-1)	0.976***	0.970***	0.989***
	[0.051]	[0.060]	[0.074]
FG Price (t-1)	0.216***		
	[0.066]		
WS Price (t-1)		0.394***	
		[0.103]	
Nominal Coefficient of Protection (t-1)			0.312**
			[0.156]
Real Exchange Rate (t-1)			0.020
			[0.220]
Border Price (t-1)			0.289**
			[0.147]
Marketing Cost (t-1)	-0.167**	-0.352***	-0.119
	[0.065]	[0.096]	[0.161]
Producer Price Index (t-1)	-0.032	-0.049	-0.185*
	[0.081]	[0.079]	[0.106]
Yield Shock (t-1)	0.021***	0.022***	0.033***
	[0.008]	[0.008]	[0.011]
Real Oil Price (t-1)	-0.143	-0.184	-0.189
	[0.144]	[0.173]	[0.178]
Food Crises	0.095***	0.097***	0.062
	[0.027]	[0.035]	[0.042]
Time Trend	-0.012	-0.015	0.013
	[0.016]	[0.017]	[0.020]
Observations	273	273	273

Number of Instruments	22	22	24
F-Test for Joint Significance	0.000	0.000	0.000
Hansen Test (p-value)	0.621	0.409	0.376
Diff-in-Hansen Test (p-value)	0.443	0.408	0.298
AR (1) Test	0.000	0.000	0.000
AR (2) Test	0.153	0.134	0.143

Note: coefficients are two-step system-GMM estimates with the lagged dependent variable and the price variable treated as predetermined. In parentheses, robust standard errors with the Windmeijer (2005) correction finite sample are reported. All the instrument matrices are "collapsed". The Diff-in-Hansen test reports the p-values for the validity of the additional moment restriction necessary for system GMM. The AR(1) and AR(2) report the p-values for first and second order autocorrelation of the first-differenced residuals. Stars *, **, and *** represent the 10%, 5%, and 1% levels of significance, respectively.

Table 3: Empirical estimates of the annual production response

	(1)	(2)	(3)
Production (t-1)	0.851***	0.865***	0.857***
	[0.122]	[0.106]	[0.072]
FG Price (t-1)	0.596***		
	[0.136]		
WS Price (t-1)		0.621***	
		[0.166]	
Nominal Coefficient of Protection (t-1)			0.559**
			[0.258]
Real Exchange Rate (t-1)			0.399**
			[0.156]
Border Price (t-1)			0.688***
			[0.151]
Marketing Costs (t-1)	-0.351**	-0.429*	-0.315**
	[0.154]	[0.219]	[0.156]
Agricultural Stress Index	-0.565*	-0.481	-0.527**
	[0.320]	[0.414]	[0.245]
Real Oil Price (t-1)	-0.501*	-0.334	-0.369
	[0.285]	[0.308]	[0.307]
Food Crises	0.036	0.042	0.075*
	[0.036]	[0.038]	[0.045]
Time Trend	-0.040***	-0.035**	-0.045***
	[0.015]	[0.015]	[0.011]
Observations	273	273	273
Number of Instruments	19	19	22
F-Test for Joint Significance	0.000	0.000	0.000
Hansen Test (p-value)	0.487	0.297	0.927

Diff-in-Hansen Test (p-value)	0.937	0.451	0.577
AR (1) Test	0.000	0.000	0.000
AR (2) Test	0.139	0.331	0.156

Note: coefficients are two-step system-GMM estimates with the lagged dependent variable and the price variable treated as predetermined. In parentheses, robust standard errors with the Windmeijer (2005) correction finite sample are reported. All the instrument matrices are "collapsed". The Diff-in-Hansen test reports the p-values for the validity of the additional moment restriction necessary for system GMM. The AR(1) and AR(2) report the p-values for first and second order autocorrelation of the first-differenced residuals. Stars $*$, $**$, and $***$ represent the 10%, 5%, and 1% levels of significance, respectively.

Table 4: Empirical estimates of the annual yield response

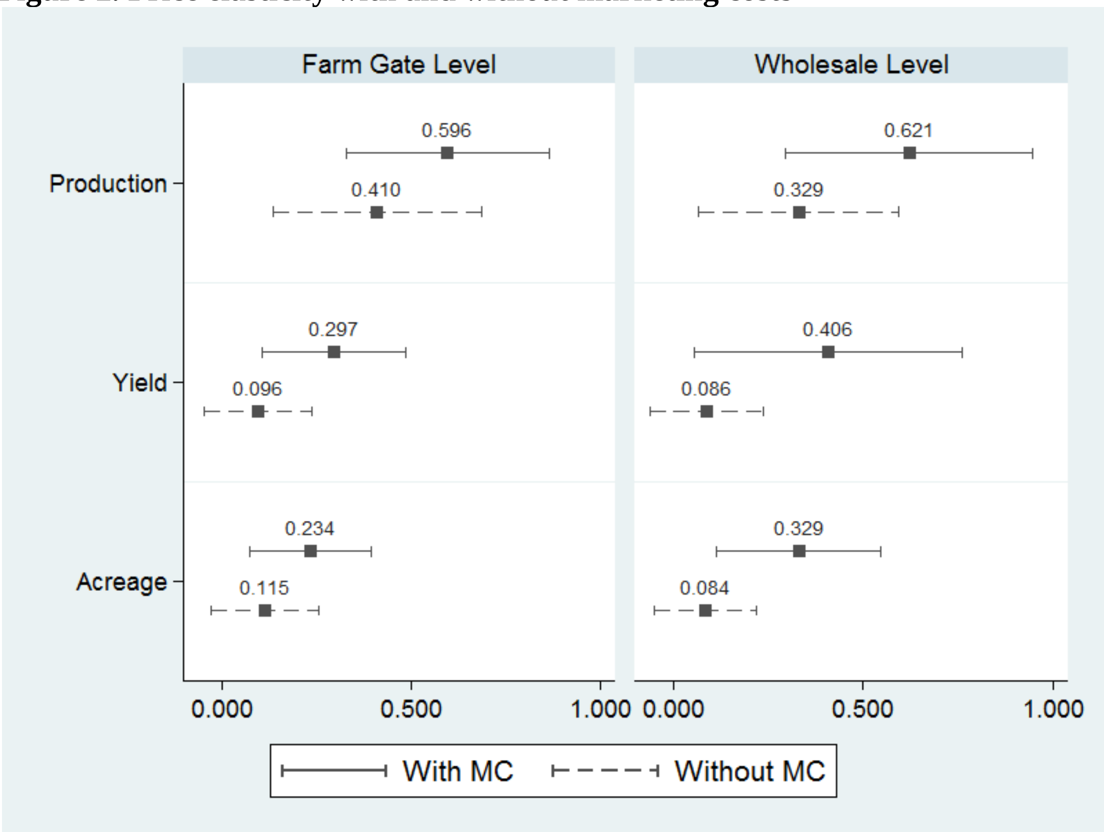
	(1)	(2)	(3)
Yield (t-1)	0.998***	0.961***	0.970***
	[0.063]	[0.062]	[0.065]
FG Price (t-1)	0.297***		
	[0.097]		
WS Price (t-1)		0.406**	
		[0.180]	
Nominal Coefficient of Protection (t-1)			0.212*
			[0.122]
Real Exchange Rate (t-1)			0.231
			[0.199]
Border Price (t-1)			0.384***
			[0.123]
Marketing Costs (t-1)	-0.273***	-0.367*	-0.264
	[0.094]	[0.187]	[0.187]
Agricultural Stress Index	-0.446**	-0.427*	-0.401*
	[0.203]	[0.230]	[0.230]
Real Oil Price (t-1)	-0.207	-0.149	-0.211
	[0.271]	[0.258]	[0.297]
Food Crises	-0.072*	-0.040	-0.038
	[0.038]	[0.040]	[0.038]
Time Trend	-0.027**	-0.020*	-0.030***
	[0.011]	[0.012]	[0.011]
Observations	273	273	273
Number of Instruments	19	19	22
F-Test for Joint Significance	0.000	0.000	0.000
Hansen Test (p-value)	0.584	0.333	0.891
Diff-in-Hansen Test (p-value)	0.436	0.648	0.704
AR (1) Test	0.000	0.000	0.000
AR (2) Test	0.357	0.435	0.608

Note: coefficients are two-step system-GMM estimates with the lagged dependent variable and the price variable treated as predetermined. In parentheses, robust standard errors with the Windmeijer (2005) correction finite sample are reported. All the instrument matrices are "collapsed". The Diff-in-Hansen test reports the p-values for the validity of the additional moment restriction necessary for system GMM. The AR(1) and AR(2) report the p-values for first and second order autocorrelation of the first-differenced residuals. Stars *, **, and *** represent the 10%, 5%, and 1% levels of significance, respectively.

Nevertheless - although the estimated price elasticities are positive and statistically significant in all the cases - they are quite small and range from 0.216 to 0.621. Production and yield responses are higher than those for acreage, confirming that acreage should be considered as a lower bound for the total price elasticity of supply (Rao, 1989).

From tables 2, 3 and 4 we also see that the elasticity of supply with respect to the wholesale price (reported in column 2) is always higher than the elasticity with respect to the farm-gate price (reported in column 1). On average, this upward bias seems to be around 0.1, with a range that goes from 0.03 for production to 0.18 for acreage. The result can be explained referring to the work of Gardner (1975) on vertical price transmission. He shows that the elasticity of price transmission of the retail price with respect to the producer price is less than unity while other authors apply the same logic to the price spread between wholesale and farm gate price (e.g. Brummer et al., 2009). If this relationship is true, the price elasticity with respect to the farm gate price (b_2^{fg}) is equal to the price elasticity with respect to the wholesale price (b_2^{ws}) multiplied by the elasticity of price transmission between farm gate and wholesale prices (e_{fg}^{ws}), i.e. $b_2^{fg} = b_2^{ws} * e_{fg}^{ws}$. As consequence, b_2^{fg} will be always lower than b_2^{ws} as reported in tables 2, 3 and 4. Therefore, using wholesale prices to analyze supply responses instead of farm-gate prices might overestimate the supply response because it implies assuming perfect price transmission between different segments of the value chain. However, the literature extensively showed that this is often not the case in developing countries, mainly because of market failures – imperfect competition, high transaction costs, information asymmetries – and policy interventions (Key et al., 2000; Rapsomanikis et al., 2006; Short et al., 2014; and Balié and Morales Opazo, 2015).

Figure 2. Price elasticity with and without marketing costs



Note: price elasticity (FG & WS Price) represented in the figure are obtained using the two-step system-GMM estimates described in table 2, 3 and 4. Solid line reports the coefficient including the Marketing Cost in the regression (With MC) while dotted line reports the same regression excluding the marketing cost as covariate from the model (Without MC). The amplitude of the lines indicates the 90% confidence interval of the coefficient.

Besides the output price of the crop they produce, farmers also react to other factors such as the marketing costs (transport, processing, handling, taxes, fees and margins) paid to other agents along the value chain. As already mentioned, thanks to the flexibility and richness of the MAFAP dataset, we are able to control for specific country/crop marketing costs in our regression and the results we obtain are quite clear. As shown in Table 2, 3 and 4, the higher the marketing costs the lower the supply response, confirming that excessive marketing costs might prevent farmers to fully exploit market signals. The reported coefficients for the marketing costs are so close to those reported for the price elasticities that positive price shock, even substantial, might be easily offset by a similar increase in, for example, transport costs or local transit taxes. To further clarify the importance of introducing marketing costs in the supply response function, figure 2 reports how the price elasticity of supply would change estimating equation 5 with or without them. As expected, not considering the marketing costs would bring the price elasticity estimates downward. This is explained mainly by the positive correlation between marketing costs and the farm-gate and wholesale prices. The bias can turn out to be quite substantial and more than 0.3. In this respect, our exercise suggests that the observed low elasticities obtained by previous empirical estimates may not be entirely due to the lack of response from farmers but also to the difficulty to control for such marketing costs. In other words, previous studies may not have fully captured that - beyond the price signals - market imperfections are of critical importance in driving the supply response. This appears to be a useful finding for policy makers as it stresses the importance of addressing market functioning notably through targeted public investments to, for instance, lower transport costs or improve governance to eliminate illicit taxes along the value chain.

In table 2, the PPI of the food group containing the competing crops turns out to be negative – as expected - but not statistically significant. The non-significance of the coefficient can have one economic and one methodological explanation. Economically, it might indicate that once we control for more important factors such as the own-price and the marketing costs, the price of the competing crops is not a crucial factor in determining the farmers' decision on acreage. Indeed, the lack of significance of this factor has already been observed by other empirical works (Onal, 2012 and Haile et al., 2015). From a methodological standpoint, we cannot control for specific competing crops because our panel is unbalanced and prices are not available. As a consequence, the PPI of the competing group (e.g. cereals for maize or roots and tubers for cassava) may not fully capture those cross-price effects (e.g. wheat or rice price on maize). The real oil price in our results displays the expected negative sign but it is never statistically significant, except in column (1) of table 3. This negative sign confirms that the higher the cost of inputs, the lower the level of agricultural output. The lack of statistical significance can be explained by the fact that the input usage in SSA is quite limited, especially for the case of the staple food crops analyzed in this paper. Moreover, the oil price might be only weakly correlated with the price of the relevant basket of inputs, which also varies from country to country and crop to crop.

The weather proxies - yield shocks for acreage in table 2 and the Agricultural Stress Index for production and yield in table 3 and 4 – always show the expected sign[6]. In our experiment, the yield shocks turn out to be positive and statistically significant indicating that past positive deviations from the long-term trend are an incentive to expand the planted acreage. At the same time, the ASI is always negative, confirming that long and intense dry periods during the growing season reduce production and – consequently – yields. Lastly, we augment our supply functions introducing a dummy controlling for the recent food price crises (2008 and 2011) and a time trend to capture any other shocks due to institutional or unobservable factors. Interestingly, during the price crises, acreage has been – on average – 10% higher than the usual level while production increased but only by 3-4% resulting in a reduction in yields.

Finally, in column 3 of table 2, 3 and 4, we replace the observed price with the nominal protection coefficient, the real exchange rate and the border price expressed in real terms. As explained above, the purpose is to disentangle the effect of the observed price into three components: the direct incentives arising from border measures and interventions in domestic markets, the macroeconomic policy and the price variations in the international market. Results show that the three variables have a positive impact on the supply response, respecting the expected sign. Direct incentives and changes in the border price significantly stimulate the farmers' response in all cases while the real exchange rate is statistically significant only in table 3. It means that macroeconomic decisions, especially on the exchange rate influence production decisions while they are not affecting acreage allocation and, consequently, yields.

Sensitivity analysis and robustness checks

In order to validate the results obtained with the system-GMM estimator, we report some sensitivity analyses and robustness checks. The first test regards the sensitivity of our estimates to alternative number of lags used as instrumental variables. Figures A1, A2 and A3 in the Appendix show how the coefficient of the lagged dependent variable and the price elasticity for – respectively – acreage, production and yield change according to the maximum lag selection. As expected, a limited number of instruments return less efficient point estimates with higher confidence intervals (Roodman, 2009b). Considering the importance of the point estimates for the present work, especially for price elasticity, we prefer to use all the available lags (i.e. eight) as instruments to ensure higher stability to our coefficients. The downside of this choice is that we risk overfitting the lagged dependent variable, pushing its coefficient towards the one obtained with OLS. Nevertheless, the reported figures show that reducing the number of lags changes neither the autoregressive coefficient nor the price elasticity substantially.

The Hansen J-statistics for over-identifying restrictions reported in table 2, 3 and 4 also confirm the goodness of the instrument set. In all cases, the *p*-value is higher than 10%, indicating that the null hypothesis of joint validity cannot be rejected. Following Roodman (2009b), we also use the difference-in-Hansen test to check if the lagged differences of the

[6] Yield shocks are calculated as the jack-knifed residuals obtained from separate regressions of yield on time trend for each country-crop pair. We do not employ OLS residuals because they would give biased estimates of the errors (Roberts and Schlenker, 2009).

dependent variable are good instruments for the levels equation in order to verify the Blundell-Bond hypothesis on the system-GMM initial conditions. The exogeneity of this subset of instruments is confirmed in all cases, with *p*-values at least greater than 15%. The AR(1) and AR(2) tests in Table 2, 3 and 4 report the Arellano-Bond test for first and second-order autocorrelation of the differenced residuals. In all cases, the test for AR(1) rejects the null hypothesis of no serial correlation while the test for AR(2) fails to reject it, showing no evidence of autocorrelation at conventional levels of significance in our estimates.

Lastly, we check the robustness of our results by verifying that the estimated coefficients of the lagged dependent variable range between the fixed-effects estimate – which should be biased downward - and the OLS estimate – which should represent an upper bound (Roodman, 2009a). Figure A4, A5 and A6 in the Appendix compare the autoregressive coefficient and the price elasticity for – respectively – acreage, production and yield obtained using OLS, Fixed Effects, difference-GMM and system-GMM. In all the cases, the system-GMM coefficient on the lagged dependent variable lies between the FE and OLS estimates. As already noted by Haile et al. (2015), the autoregressive coefficient for the difference GMM behaves quite differently from the system-GMM, with an estimate closer to the FE and – in some cases – even below the credible bound. This and the fact that the system-GMM better handles the high persistence of the output supply both support our choice of the system-GMM estimator. Finally, figures A4, A5 and A6 show that the model selection substantially influences the estimates and it suggests that both OLS and FE results are always close to zero while GMM results give higher elasticities. Earlier estimates where are largely based on OLS and FE might therefore have contributed to the consensus that farmers in SSA do not react to price incentives.

6. Conclusion

Better understanding if and how farmers react to price signals is one of the key priorities for policymakers interested in designing effective strategy to reduce or eliminate food insecurity in Sub-Saharan Africa. We shed more light on this topic by providing a cross-country analysis of the supply response for the major staple food crops in ten SSA countries over the period 2005-2013. To do that, we rely on a recent dataset produced by the Food and Agriculture Organization (FAO) in the framework of its “Monitoring and Analyzing Food and Agricultural Policies” (MAFAP) programme.

The results of this empirical exercise show that farmers in SSA are actually capable of interpreting market signals and responding to changes in staple crop prices However, the magnitude of the response is small and, often, partially or totally muted by other factors. We also find that the supply responses are significantly influenced by transaction costs paid by farmers to market their product. In this respect, we also suggest that results of the previous empirical works observing lower or even absent supply response to price shocks were not driven only by the impact of price signals but also by the impossibility to control for offsetting elements such as high marketing costs. Not surprisingly, we also find that past and current weather shocks play an important role in explaining the farmers’ decisions and supply performances while the cross-prices of the competing commodities and the cost of inputs seem to be less important. By decomposing the expected price into three components – the nominal coefficient of protection, the real exchange rate and the border price – we find that farmers in SSA respond to price signals arising primarily from direct incentives generated by border measures and government interventions in domestic markets and shocks in the international market. On the contrary, they are less stimulated by macroeconomic policies affecting the exchange rate.

We consider the findings of this cross-country analysis useful for policy makers seeking evidence to support and improve food security in the SSA region through a better management of their own agricultural resources. Producers of staple food crops can exploit market opportunities but their response to price signals is still too low. Governments should move public resources away from current discretionary interventions and redirect them towards more effective investments such as transport and other physical infrastructures, market information systems, research and technology, extension services but also transparent market regulations. An increase in the the provision of these public goods is likely to support a more effective price transmission along the value chains and stimulate a more active smallholder market participation capable of properly reacting to price signals.

Moreover, while national-level efforts are necessary, they are not sufficient to guarantee food availability and access in the region. Although it is well known that Sub-Saharan Africa has the potential to massively increase its agricultural production and drastically reduce food insecurity, farmers have not exploited much of the growth opportunities of the last decade such as the recent high prices for staple food crops (Saghir, 2014). As indicated by the World Bank (2012), this failure can be partially explained by the lack of coordination between governments to remove the unnecessary barriers to the creation of a fully integrated African market to boost regional staple food trade and most likely help increase the currently low supply response for staple food crops to price signals. Should the governments decide to tackle these major policy failures, they would not only make faster progress to reduce food insecurity but also create the condition for those regional complementarities to materialize and boost overall growth.

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APPENDIX

Table A1: Data Sources for producer, wholesale, border prices and marketing costs

Country	Institution	Link
Burkina Faso	Ministère de l'Agriculture de l'Hydraulique et des Recherches Halieutiques	http://www.agriculture.gov.bf/
Ethiopia	Ethiopian Development Research Institute	http://www.edri.org.et/
Ghana	Ministry of Food and Agriculture	http://www.mofa.gov.gh/
Kenya	Kenya Agicultural and Livestock Research Organization	not available
Malawi	Ministry of Agriculture and Food Security	http://www.malawi.gov.mw/
Mali	Institut d'Economie Rurale	http://www.ier.gouv.ml/
Mozambique	Ministro da Agricultura e Segurança Alimentar	http://www.masa.gov.mz/
Nigeria	Federal Ministry of Agriculture/National Bureau of Statistics	http://www.fmard.gov.ng
Uganda	Ministry of Agriculture, Animal Industry and Fisheries	http://www.agriculture.go.ug/
Tanzania	Ministry of Agriculture Food Security and Cooperatives	http://www.agriculture.go.tz/

Table A2. Descriptive statistics of selected variables, by country (2005-2013)

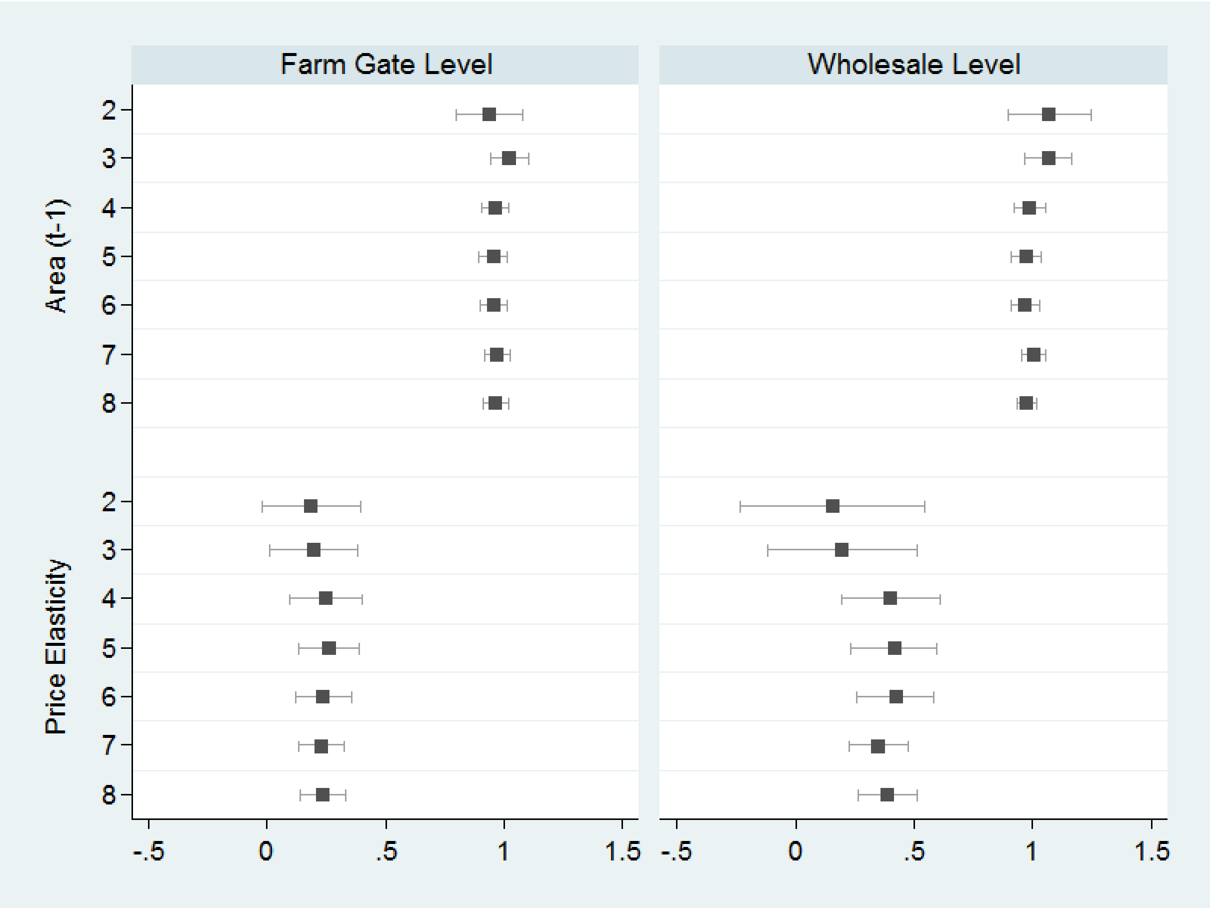
		Burkina Faso	Ethiopia	Ghana	Kenya	Malawi	Mali	Mozambique	Nigeria	Uganda	Tanzania
Area	Mean	13.01	13.84	13.00	12.10	14.28	13.61	13.41	15.26	11.89	14.30
	SD	1.31	0.76	0.76	1.45	0.11	0.57	1.06	0.58	1.69	0.74
Production	Mean	13.42	14.34	14.57	13.08	14.89	14.00	13.99	15.61	12.99	14.76
	SD	1.04	1.01	1.34	1.38	0.35	0.35	1.62	0.44	2.21	0.54
Yield	Mean	9.62	9.71	10.78	10.19	9.82	9.60	9.79	9.55	10.32	9.67
	SD	0.34	0.30	1.00	1.25	0.35	0.58	1.00	0.20	0.86	0.26
FG Price	Mean	11.72	8.23	5.87	10.03	9.87	11.83	8.69	10.26	13.24	13.12
	SD	0.20	0.29	0.75	0.44	0.38	0.44	0.43	0.15	0.47	0.63
WS Price	Mean	11.99	8.39	6.21	10.34	10.62	12.05	9.08	11.26	13.53	13.37
	SD	0.13	0.25	0.81	0.45	0.32	0.40	0.49	0.47	0.59	0.57
NCP	Mean	0.83	0.70	0.71	1.22	0.57	0.77	0.60	0.45	0.84	1.07
	SD	0.28	0.30	0.48	0.62	0.08	0.35	0.30	0.13	0.29	0.43
RER	Mean	497.40	13.78	1.47	86.75	172.46	501.51	30.01	163.65	2138.26	1425.36
	SD	31.66	2.05	0.08	16.27	28.19	34.34	2.69	14.03	159.19	127.38
BP	Mean	5.74	6.06	6.12	5.50	5.30	5.99	5.97	6.01	5.79	5.87
	SD	0.27	0.26	0.38	0.69	0.25	0.40	0.37	0.37	0.29	0.44
Market Cost	Mean	11.61	7.69	6.10	9.37	9.85	11.38	8.80	10.66	12.81	12.14
	SD	0.37	0.32	0.68	0.54	0.00	0.26	0.55	0.53	0.53	0.39
PPI	Mean	1.31	2.26	1.70	1.40	1.73	1.32	2.18	1.42	2.12	1.50
	SD	0.21	0.93	0.53	0.38	0.60	0.35	0.92	0.41	0.73	0.47
Y. Shock	Mean	0.08	-0.05	-0.30	-0.06	-0.03	0.17	-0.62	0.20	0.00	-0.04
	SD	1.12	0.91	1.36	1.32	1.22	1.35	3.06	1.63	1.20	0.92
ASI	Mean	0.05	0.12	0.02	0.14	0.02	0.03	0.04	0.03	0.10	0.11
	SD	0.08	0.06	0.02	0.14	0.03	0.04	0.04	0.04	0.10	0.16
Oil Price	Mean	0.61	0.42	0.49	0.60	0.50	0.63	0.49	0.58	0.41	0.62
	SD	0.09	0.15	0.14	0.11	0.10	0.13	0.13	0.14	0.12	0.11

Note: Area, Production, Yield, FG Price, WS Price, Border Price, Marketing Costs and Real Oil Price are expressed in logarithmic form.

Table A3.Unit Root Tests for Panel Data

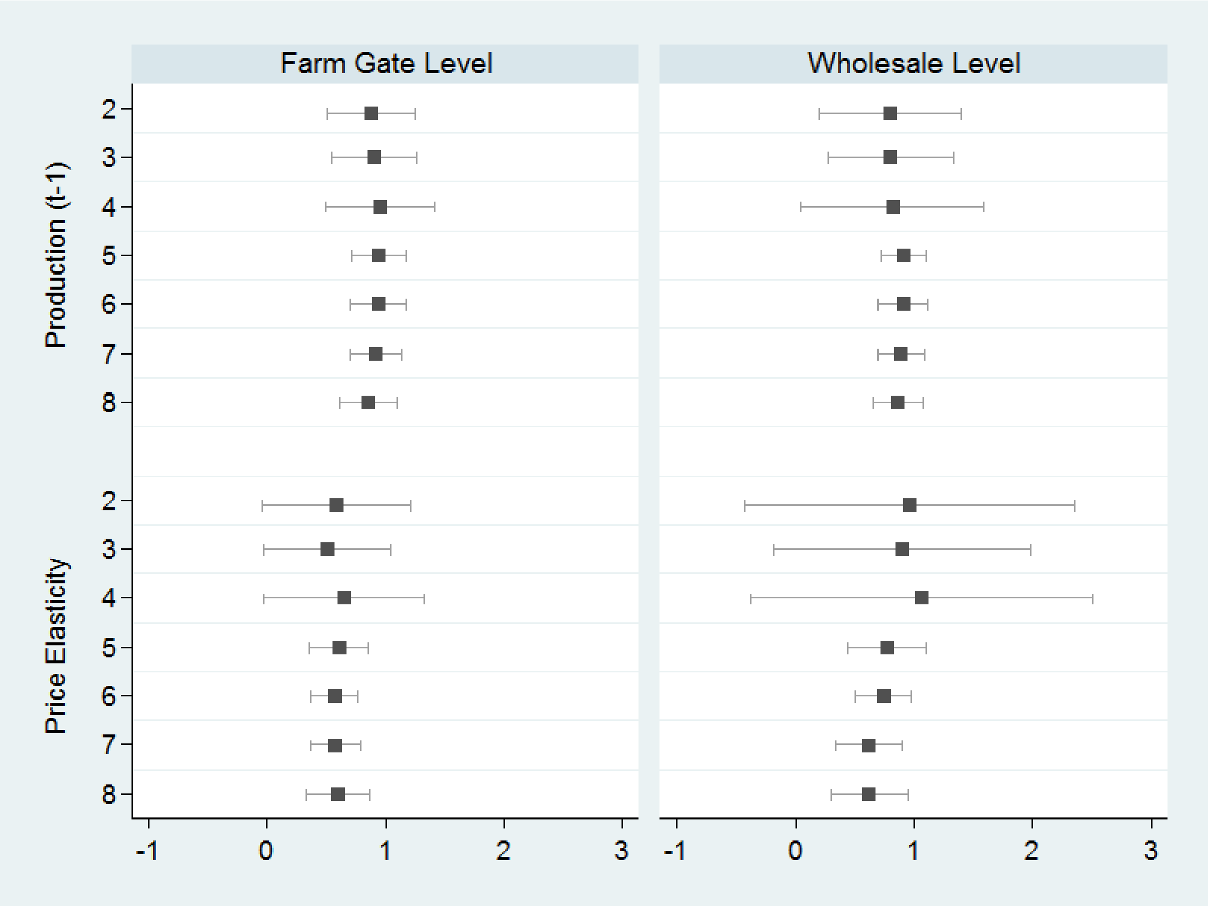
	Im-Pesaran-Shin		Fisher (ADF) - Inverse Chi Square	
	H0: Non-stationarity		H0: Non-stationarity	
	Level	Difference	Level	Difference
Production	0.182	0.000	0.967	0.000
Area	0.097	0.000	0.995	0.000
Yield	0.000	0.000	0.000	0.000
FG Price	0.000	0.000	0.000	0.000
WS Price	0.001	0.000	0.000	0.000
NCP	0.000	0.000	0.000	0.000
Real Exchange Rate	0.013	0.000	0.007	0.000
Border Price	0.000	0.000	0.000	0.000
Marketing Cost	0.000	0.000	0.000	0.000
Producer Price Index	1.000	0.000	1.000	0.000
Agricultural Stress Index	0.000	0.000	0.000	0.000
Real Oil Price	0.397	0.000	0.951	0.010
Yield Shock	0.000	0.000	0.000	0.000

Figure A1: Point Estimates with Alternative Maximum Lag Lengths for Instruments



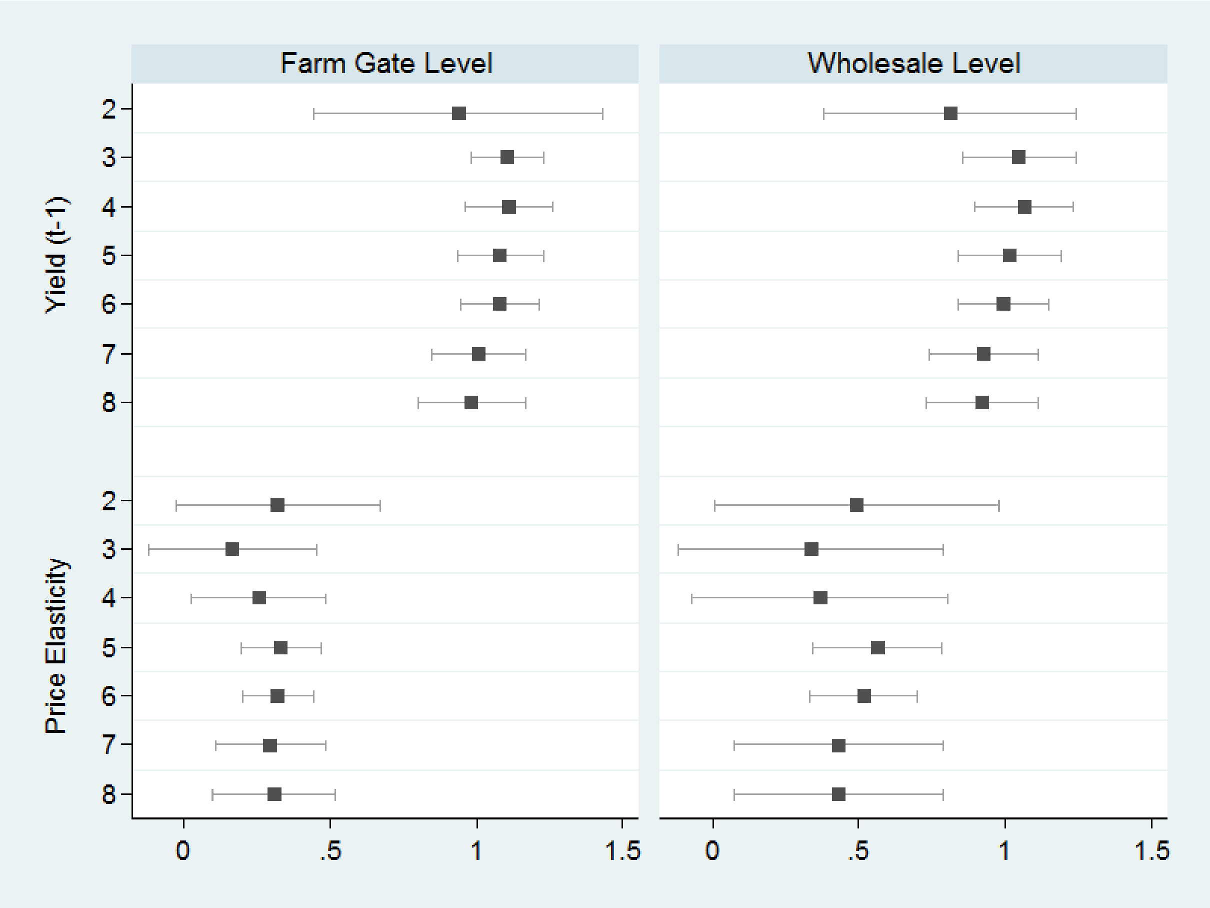
Note: Figure reports the lagged area and price elasticity coefficient estimates using alternative maximum number of lags to be used as instruments. The point estimates and the 90% confidence interval are obtained using the two-step system-GMM estimates described in table 2.

Figure A2: Point Estimates with Alternative Maximum Lag Lengths for Instruments



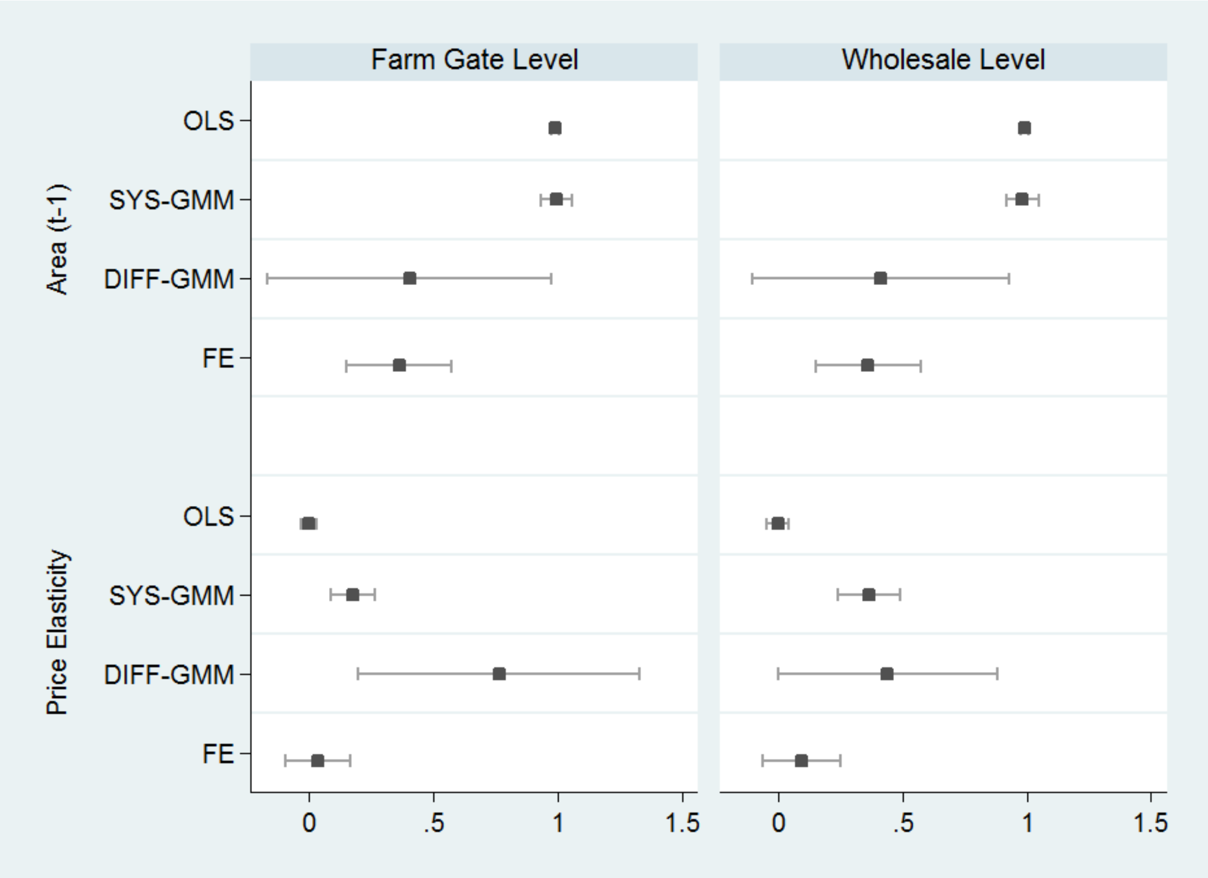
Note: Figure reports the lagged production and price elasticity coefficient estimates using alternative maximum number of lags to be used as instruments. The point estimates and the 90% confidence interval are obtained using the two-step system-GMM estimates described in table 3.

Figure A3: Point Estimates with Alternative Maximum Lag Lengths for Instruments



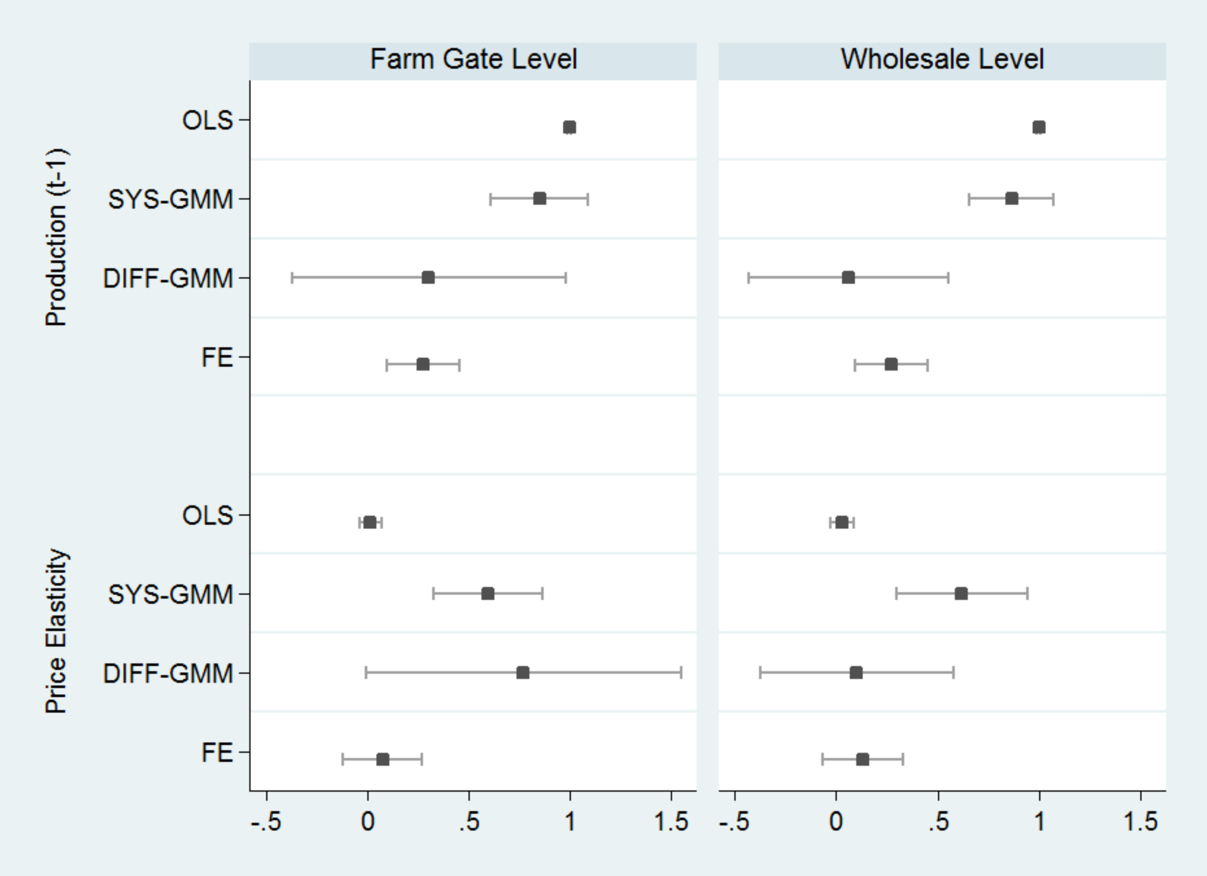
Note: Figure reports the lagged yield and price elasticity coefficient estimates using alternative maximum number of lags to be used as instruments. The point estimates and the 90% confidence interval are obtained using the two-step system-GMM estimates described in table 4.

Figure A4: Point Estimates using Alternative Econometric Models



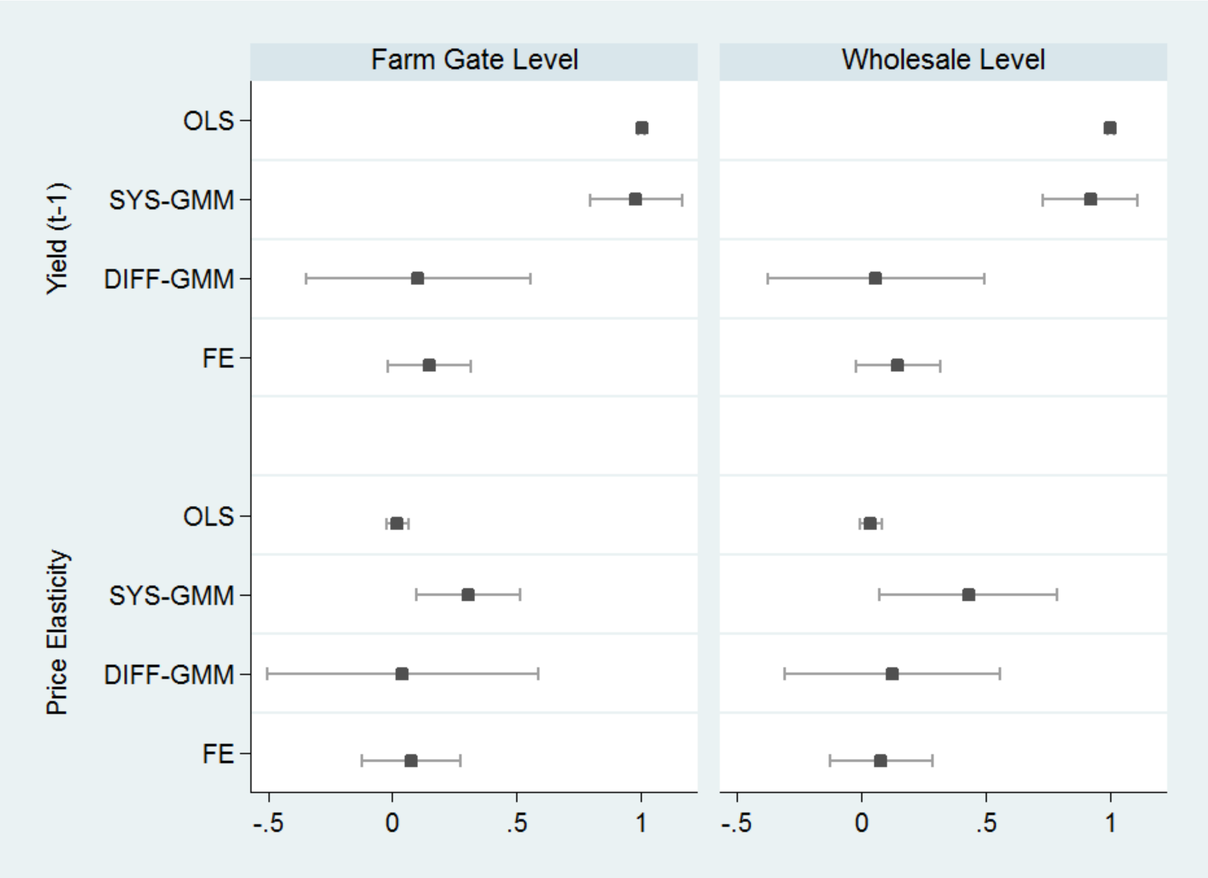
Notes: Ordinary Least Square (OLS) and Fixed Effect (FE) regressions are calculated using robust standard errors clustered by country-commodity. Two-step system-GMM (SYS-GMM) and difference-GMM (DIFF-GMM) regressions use robust standard errors with Windmeijer (2005) finite sample correction and treat the lagged dependent variable and the price elasticity as predetermined. The instrument matrices in the GMM models are collapsed.

Figure A5: Point Estimates using Alternative Econometric Models



Notes: Ordinary Least Square (OLS) and Fixed Effect (FE) regressions are calculated using robust standard errors clustered by country-commodity. Two-step system-GMM (SYS-GMM) and difference-GMM (DIFF-GMM) regressions use robust standard errors with Windmeijer (2005) finite sample correction and treat the lagged dependent variable and the price elasticity as predetermined. The instrument matrices in the GMM models are collapsed.

Figure A6: Point Estimates using Alternative Econometric Models



Notes: Ordinary Least Square (OLS) and Fixed Effect (FE) regressions are calculated using robust standard errors clustered by country-commodity. Two-step system-GMM (SYS-GMM) and difference-GMM (DIFF-GMM) regressions use robust standard errors with Windmeijer (2005) finite sample correction and treat the lagged dependent variable and the price elasticity as predetermined. The instrument matrices in the GMM models are collapsed.

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1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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