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Grain price seasonality in Kebbi state, Nigeria

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ABSTRACT

Recent studies on food prices in sub-Saharan Africa (SSA) found that food price seasonality in SSA remains an issue. In addition to it causing price risk, and, hence, limiting market participation among farmers and traders, the continued existence of substantial price seasonality implies that interventions that improve food market development are needed. Using a dataset that is unique for Nigeria, we contribute to this literature through measurement of the extent of seasonality in grain prices in a set of markets in Kebbi state. We believe that our focus on seasonality at the state, rather than country or continental, level can provide needed insights that are useful for identification of areas deserving stakeholder focus for rural development related initiatives. A main contribution is that we find that there are large enough differences in price behavior across the assessed markets to justify this more localized analysis.

Keywords: grain prices, seasonality, market structure, Kebbi state, Nigeria

1. INTRODUCTION

Through the publication of its "World Development Report 2008: Agriculture for Development", the World Bank both proposed that the agriculture sector can be a vehicle for rural development and poverty reduction in developing countries in the future and showed that the degree that this has been realized to date varies greatly across regions and countries (World Bank 2007). Notably, their data showed vast disparities regarding productivity and associated input usage between developing countries in sub-Saharan Africa (SSA) and others in the developing world (World Bank 2007). Since the publication of that report, the World Bank has also invested, in collaboration with national statistical agency partners, in nationally representative household surveys through its Living Standards Measurement Survey – Integrated Surveys on Agriculture (LSMS-ISA) program in eight SSA countries. These household surveys provide much needed data on the disparities in agricultural development at the household level within countries and across the surveyed countries. While these cross-regional, cross-country, and national level comparisons are useful for determination of broad levels of agricultural development, they do not provide clear direction for local agricultural policymakers, such as those who are agricultural ministers in state Ministries of Agriculture or related local government institutions, regarding how best to invest public finances to enhance rural development. Thus, more disaggregated analyses and data are needed.

However, the absence of more disaggregated data is a signal that implementation of household surveys that are representative at the state level is prohibitively costly for governments in SSA countries, including in Nigeria, the focus country for this paper. Therefore, it is worthwhile for stakeholders to try to identify other types of information that are available and that can be used to inform local policymaker decisions by providing insights into local rural development issues. One type of information with these characteristics is price data, which are commonly gathered by national statistical agencies for purposes such as the calculation of a national Consumer Price Index (CPI). The goals of this paper are to explain how and why prices are informative for broader issues of rural development and to determine whether there is sufficient variation in prices across markets at the local level – in our case Kebbi state, Nigeria – to justify price analyses at such a local scale.

This study builds on the recent contributions by Kaminski et al. (2016) and Gilbert et al. (2017) that analyzed the existence and extent of seasonality in food markets in Tanzania and SSA, respectively. They argued that the continued existence of substantially more pronounced seasonality in their analyzed markets than that observed on global markets is related to market development factors such as the existence of storage and the degree of trade. We, therefore, devote substantial attention to a review of the literature on SSA seasonality and how it relates to the literature on market participation, trade, and competitive storage.

Our empirical examination of grain prices in Kebbi state, Nigeria shows that prices behave in general in line with our expectations such that the markets that we anticipate would have similar market characteristics also have analogous price behavior. But, importantly, there appears to be substantial enough differences across markets within the state to rationalize state-focused price analyses. Specifically, we observed that price behavior is substantially different in Birnin Kebbi, the administrative and economic hub of the state, especially in terms of the intra-annual ranges and the number of price direction changes over the observation period, than in the other markets studies. We posit that this is related to generally better market development there in terms of storage availability and other amenities that help facilitate trade. We expect that this study can direct stakeholders' attention toward improving rural development and food market efficiency through targeted investments in market infrastructure.

2. REVIEW OF LITERATURE: FOOD PRICE SEASONALITY, TRADE, AND STORAGE

Contributions in the literature related to food price seasonality, trade, and storage provide conceptual guidance on: 1) why there are differences in price behavior among grain markets in Kebbi state, Nigeria; 2) why and how those difference relate to market characteristics; and, 3) how examination of the price data can help in formulating market-related interventions by the state and local governments and their donor partners to improve rural market development.

2.1 Food price seasonality in sub-Saharan Africa and in northern Nigeria

The recent studies by Kaminski et al. (2016) and Gilbert et al. (2017) have brought the previously well-researched issue of food price seasonality in SSA food markets back onto the research agenda. They found that, depending on the crop, the magnitude of seasonality in SSA food prices is between two and three times higher than that of the global market reference prices, such as those included in the World Bank Commodity Prices database. As such, food price seasonality continues to be worthy of researcher and policymaker attention (Kaminski et al. 2016; Gilbert et al. 2017).

Gilbert et al. (2017) define seasonality as the intra-annual variation in price observations that correspond with the annual crop planting and harvesting patterns. Seasonality is important for study and policymaker attention because it influences and reflects decisions made by market participants. It affects consumption decisions among net buyers due to substitution and income effects, which are important for household food security and nutrition[1], sales decisions, and associated income for net sellers, and planting decisions by farm households (Sahn and Delgado 1989; Heltberg and Tarp 2002; Kaminski et al. 2016; Gilbert et al. 2017).

These recent studies contribute to the rich literature on seasonality in developing countries that emerged a few decades ago. This literature includes the seminal book and encompassed chapters by Sahn (1989), and many preceding studies that were implemented in our focus country of Nigeria. The notable early studies on Nigerian food market price behavior, which found large divergences in food price patterns across Nigerian markets and crops, include those by Jones (1968) and Hays and McCoy (1977).

Another study that deserves a more detailed discussion is that by Delgado (1986), which focused on the intra-annual seasonal patterns of grain prices in northern Nigeria. Notably, Delgado found substantial differences between food price behavior in markets in the area near Gusau, Zamfara state and those near Funtua, Katsina state, which are about one-hundred kilometers apart, such that they could not justifiably be included within a pooled analysis. This implies that many of the factors that influenced price behavior in these markets were local ones and that they were isolated enough from each other and had enough differences in their characteristics to have substantially dissimilar price behavior. Additionally, Delgado found that within both the Gusau and Funtua areas price variability was substantially higher during the harvest period than during the post-harvest period, which is inconsistent with the perfect competition assumptions in the competitive storage theory literature, discussed in more detail below.

Sahn and Delgado (1989) provide a summary of the typical seasonal pattern of prices for a given crop within a typical food market in many developing countries. This provides the context needed for comparison to the observed reality. Under the assumptions of perfect competition, the price of a seasonally produced crop falls to an annual low after harvest and then steadily rises in the post-harvest period at a rate equal to the costs of storage. Under this framework, differences in inter-annual price variation are associated with the (assumed random) disturbances in production. Any seasonal divergences between supply and demand, which will be reflected in the prices, can be met either with trade or storage.

[1] Kaminski et al. (2016) estimated that seasonality in prices was associated with up to a 10-percent average difference in seasonal calorie intake among urban poor and net food seller households in Tanzania.

The speed at which gaps between supply and demand are met via trade depends on the extent of market participation and the market characteristics that influence participation in trade and marketing (Sahn and Delgado 1989).

2.2 Trade, marketing, and food price seasonality

Relying on the definition given by Newbery and Stiglitz (1982), markets serve two primary duties: to facilitate trade and to provide information. The stylized fact observed by Kaminski et al. (2016) and Gilbert et al. (2017) that SSA food markets have two to three times more seasonality than the global reference prices implies that SSA food markets are not facilitating similar degrees of participation or providing as much information to market participants as could be achieved. That these conditions remain an issue in SSA food markets is undesirable from the point of view of reducing poverty and malnutrition. Such conditions signal the existence of what Barrett (2008) defines as a “low level equilibria”, associated with “poverty traps”, due to low market participation and asset acquisition among market participants. The more auspicious “high level equilibrium” is one in which there is greater market participation, specialization, higher productivity, and greater wealth accumulation with its associated welfare benefits (Barrett 2008).

Some stylized facts observed by Jayne (1994) are helpful for understanding how and why the characteristics of SSA food markets can lead to “low level equilibria”. These include the existence of higher price differences between farmgate and market prices than in other developing countries, and the concentration of processing and storage in urban areas (Jayne 1994). In support of these observations, Delgado (1995) argued that transactions costs and marketing risk are substantially higher in SSA than anywhere else in the world. These large disparities between farmgate and retail prices, which broadly are the “transactions costs” of trade, are caused by inter-related factors such as high transportation costs, deficient market infrastructure, and policy-related institutions that are ineffective or absent (Jayne 1994). Heltberg and Tarp (2002) decompose transactions costs into variable and fixed components: variable transaction costs are those related to transportation and distance; fixed transactions costs are those related to market information.

The relevant implication of the observations in these studies is that SSA food markets remain relatively imperfect regarding the definition of Newbery and Stiglitz (1982). They are not facilitating trade or providing information to the degree observed elsewhere, even compared to developing countries in other regions.

2.3 Competitive storage theory and seasonality

We briefly depart from the stylized fact of market imperfections in SSA food markets to draw on the economic logic presented within the competitive storage literature, which assumes perfect competition and its underlying conventions. Wright and Williams (1982), two principal contributors to this line of research, assert that storage is a productive activity that allows for the carrying over of production from one period to the next. Therefore, intra-annual storage is essential for meeting inter-temporal demand for a crop with a single annual harvest, like many rainfed grains grown in SSA. Creation of a competitive storage system facilitates a mean-preserving reduction in the dispersion of consumption over time (Wright and Williams 1982), and, hence, is clearly related to efforts to reduce food insecurity.

Regarding seasonality, the establishment of a competitive storage system, along with its associated characteristics, such as well-developed capital markets, reduces the likelihood of precipitous falls in the price of the stored commodity, since traders and farmers increase demand for stocks when the price is falling (Wright 2011). However, if capital markets are not well-developed, and, hence, farmers face liquidity constraints and are selling rather than buying when the price is falling (as observed by Stephens and Barrett

2011), then storage does not lead to these price effects (Wright 2011). Analogously, storage can also reduce the likelihood of price spikes. Since traders and farmers sell when the price is rising, there is a lower likelihood of a steep rise in prices if there are stocks available to sell (Wright 2011).

If the conditions of perfect information and capital markets are met, then, in a given crop year, post-harvest prices rise over time to account for the physical costs of storage, reach a seasonal peak just prior to the next harvest, and fall right after that harvest to the minimum level for the subsequent crop year. If these conditions are not met, then there would be both lower intra-annual minimum and higher intra-annual maximum prices than if they are satisfied.[2] Thus, a competitive storage system is something that all well-functioning commodity markets possess and is desirable due to its consumption smoothing enabling qualities. However, the establishment of storage systems is costly.

In addition, some of the most costly and difficult elements to establish in such markets are those associated with the formation of well-developed capital markets and market information provision. Indeed, the World Bank (2013) identifies imperfections in financial markets, which broadly restrict saving and borrowing, as a key inhibitor of risk management in developing country economies. Hence, missing or imperfect financial markets can inhibit traders and farmers from buying and selling in a manner consistent with the competitive storage economic logic outlined above. Additionally, d'Hôtel and Le Cotty (2018) have found evidence that the assumption of homogeneous information – specifically, information related to market level grain stocks availability – among market participants does not hold for grain markets in Burkina Faso. They propose that differences in expectations among market participants (i.e., information heterogeneity) is such that larger farmers are better able to infer market stocks levels than are small farmers. They view this heterogeneity to be the cause of differences in price behavior across their studied markets (d'Hôtel and Le Cotty 2018). Thus, the absence of well-functioning capital markets and heterogeneous expectations can cause the storage market not to operate as expected, and hence, lead to greater seasonality in prices in food markets in developing countries.

2.4 Market infrastructural development to reduce seasonality

Establishment of well-functioning capital markets, while clearly needed, is plausibly a medium to long-term issue that is unlikely to be resolved without coordinated efforts across many public and private institutions. Since the goal of our paper is to provide recommendations to state Ministries of Agriculture and related local government agencies in Nigeria or their donor partners, we turn our attention more toward the issue of improving markets, especially in terms of physical infrastructure.

In their recommendations for policy initiatives to address the issue of price seasonality, Sahn and Delgado (1989) recommend indirect policy interventions such as mechanisms that can increase market competition and improve market infrastructure[3]. Notably, they argue that interventions should be location specific (Sahn and Delgado 1989). Similar recommendations to improve efficiency of rural markets are provided by Jayne (1994) and Heltberg and Tarp (2002). These efficiency gains are plausibly of interest to rural development stakeholders since they would reduce price risk, and, hence, increase market participation.

The point made by Barrett (2008) on the effects of investment in actual physical infrastructure within rural markets, including improving security, providing grades and standards, and supplying

[2] Figure 8 on p. 45 in Wright (2011) shows visually the difference in price paths with a competitive storage system and without, which is consistent with our description here.

[3] Sahn and Delgado (1989) also provide a richer discussion of the issues related to direct intervention in grain markets, which involves the public institution facilitated sale and purchase of grain either through trade or storage, and argue that indirect interventions are preferred from an economic theoretical point of view since they are more feasible and dramatically less costly than direct interventions. We do not address the issue of the relative benefits and costs between direct and indirect interventions, but rather direct the reader to Newbery and Stiglitz (1982) and the cited literature therein for a thorough discussion.

electricity, and how the infrastructural development itself can influence price risk is important to the objective of the analysis in this paper. Barrett argues that much of the literature on SSA food market participation has focused on the development of individual household assets to improve the ability of household members to participate in markets. However, Barrett suggests that the evidence that interventions at the household level are comparatively more effective in the development of well-functioning markets than infrastructural and institutional interventions is “suggestive at best” (Barrett 2008; p. 314). While it is beyond the scope of this paper to make clearer the linkages between market infrastructure, market participation, and prices, we move forward with our price analysis under the expectation that differences in market characteristics exist in Kebbi state, Nigeria, and that those differences are plausibly reflected in price behavior.

3. STUDY AREA AND DATA

The area of focus for this study is Kebbi state in northwestern Nigeria. Kebbi state was chosen because of its location in northern Nigeria, which has a unimodal rainfall regime and is drier than the southern coastal regions. Most farmers in Kebbi specialize in the rain-fed production of any of a number of cereals that are harvested once a year. The primary planting season coincides with the onset of the rainy season in May or June, with harvest occurring three to six months later, depending on the crop[4]. Additionally, Kebbi state is one of the United States Agency for International Development (USAID) Feed the Future focus states[5], which implies there may be opportunities for initiation of donor supported development projects that relate to rural market infrastructure improvement based on outcomes of this and related studies.

Kebbi state shares international borders with Republics of Benin and Niger to the west and north, respectively (Figure 3.1). Additionally, domestically it borders Sokoto, Zamfara, and Niger states. The Niger and Sokoto rivers divide the state. Tributaries flow into these two main rivers from other parts of the state, providing opportunities for irrigated farming, especially for rice (FEWSNET 2014).

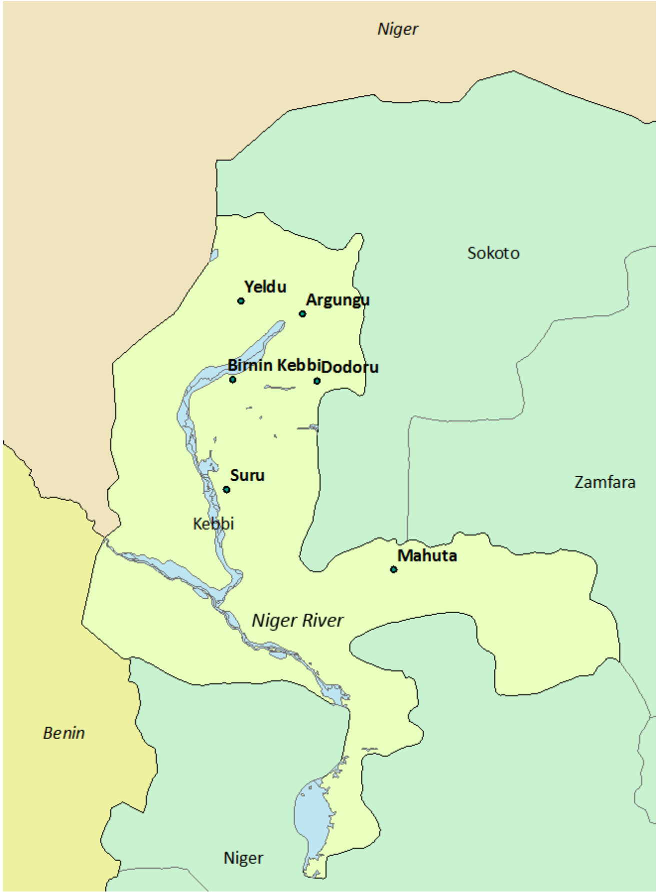
Figure 3.1 maps the locations of the six markets analyzed: Argungu, Birnin Kebbi, Dodoru, Mahuta, Suru, and Yeldu. The selection of these markets was based on the nature of the price data, which were obtained from the National Bureau of Statistics (NBS). These price series have a few unique and favorable characteristics relative to other price datasets available in Nigeria. First, these are non-aggregated, market-specific prices. The other price data provided by NBS are nearly exclusively statewide aggregates.[6] Secondly, they are complete series with monthly observations for the seventeen year period of January 2000 to December 2016. The other main sources for food price data are FEWSNET and the World Food Programme (WFP), which contribute data to the WFP administered Vulnerability Assessment and Mapping (VAM) Country Report Portal website, and the Global Information and Early Warning System (GIEWS) Food Price Monitoring and Analysis Tool administered by the Food and Agriculture Organization of the United Nations. While both are rich datasets, they cannot be used for state-based price analyses such as this. GIEWS only gathers prices in Nigeria for one market (Kano). While WFP VAM compiles prices for fourteen of the thirty-seven Nigerian states (but only up to three markets in any one state), most of the price series in that dataset begin in 2014. Lastly, both the WFP VAM and GIEWS datasets commonly have missing observations, while the NBS series are complete.

[4] See FEWSNET (2014) for a map of the geographical distribution of the agricultural livelihood zones in Nigeria, and FEWSNET (2013) and USDA FAS for graphical representations of the crop calendar for Nigeria based on region (e.g., north or south) and crops.

[5] The USAID-Nigeria Feed the Future focus states are: Benue, Cross River, Delta, Ebonyi, Kaduna, Kebbi, and Niger.

[6] NBS gathers price data each month to calculate the Consumer Price Index (CPI), and the data obtained from the field are aggregated at the zonal level prior to transmission to the NBS Headquarters in Abuja for calculation and dissemination of the CPI. It appears that there is much information lost in this aggregation process, since market level data gathered at the zonal level are typically not stored electronically due to lack of physical and human capacity for such data management.

Figure 3.1. Map of Kebbi state markets included in the analysis



Sources: DIVA-GIS and Google Maps.

While the NBS data we use have these positive attributes, there are a few issues with the data. First, the initially provided NBS dataset had prices for fifteen markets, but only six of them were included in the analysis after examination of data quality. Data from eight markets were excluded since there was virtually no variation in the price series. Some of this can be ascribed to the markets being relatively very close geographically to each other, and one would not expect much variation in such cases. But for other markets, this lack of price variability seemed to be due to error in data transcription and dissemination. Additionally, one market was excluded for the opposite reason – its values were nearly all outliers relative to the other series, which called into question the accuracy of the data.[7]

Although some of the price data were excluded, the six included markets have sufficient differences in terms of geographical separation and socioeconomic characteristics to expect dissimilar marketing patterns, and, hence, price behavior and dynamics. For instance, Birnin Kebbi is the administrative capital of the Kebbi state government, and has a more vibrant, diversified local economy than is found in other parts of the state. These characteristics provide marketers who operate in Birnin Kebbi access to associated infrastructural and business services (e.g., banking) – advantages that are either unavailable or available to a lesser degree in other markets, especially those in rural areas. Additionally, Argungu, and Dodoru markets are situated within well-developed road networks, being located in the transport corridor that connects Kebbi state to the northern Nigeria economic and cultural hub of Sokoto. This means that Birnin Kebbi, Argungu, and Dodoru markets likely are similar in many regards, although Birnin Kebbi will stand above the other pair, since it is the local administrative and economic hub. The

[7] There also are occasional outliers in the price series of the six analyzed markets (such as for imported rice at Yeldu, Figure 4.3), which is likely due to transcription errors.

markets outside of this corridor, Mahuta, Suru, and Yeldu, are more geographically isolated, and so their prices can be expected to behave differently than prices in the three markets in the northern marketing corridor.

Apart from geographic and socioeconomic characteristics providing insights into how prices may vary in general across markets, the agroecological attributes of the state also mean that there are likely differences in marketing patterns across crops. The FEWSNET (2014) livelihood zone map shows that the primary agricultural production activity in the state is the growing of rice near the Niger River and its distributaries, and the more seasonal cultivation of sorghum and millet. Maize is not grown extensively in the state, except for in some of the irrigated areas in place of rice, and seasonally in some of the more southern regions near Niger state[8]. The implication of these stylized facts is that millet, rice, and sorghum are both produced and consumed locally, while maize is plausibly more consumed than produced locally, and some of that consumption is met through trade with other states in central Nigeria. In terms of seasonality, these patterns of production, trade, and consumption likely mean that there would be relatively more seasonality in millet, rice, and sorghum prices than for maize (and imported rice).

Based on this conceptual and situation analysis, we expect the following to emerge from a closer empirical analysis of the grain price series from these six markets:

1. Prices in Birnin Kebbi will have characteristics distinct from those in other markets due to its position as an administrative and business hub;
2. Prices in Mahuta will vary in behavior from those in the other five markets due to its relative isolation as a rural market that is relatively poorly developed in terms of infrastructure and low business investment; and
3. Less seasonality will be observed in maize and imported rice prices, which are consumed but not produced locally, than for millet, rice, and sorghum, which are both produced and consumed locally, and, hence, are subject to production-related price shocks.

4. PRICE SERIES CHARACTERISTICS

The goal for this price series assessment is to determine whether there are sufficient differences in the price series to justify a deeper investigation into the causal factors of those variances. To make our assessment, we looked at plots of the data to assess the evolution in the price series over the period of 2000 to 2016; calculated summary statistics to view differences in levels and variation across crops and markets; estimated seasonality regressions to estimate whether some markets and crops experienced relatively more seasonality than others; calculated annual price ranges, which are the differences between maximum and minimum prices in each year; and, evaluated the extent to which prices have experienced changes in direction, such that they were initially increasing but then started decreasing, or vice versa.

A common factor in the assessment of evolutions market and grain prices for the full period is the substantial adjustment in the Naira/US Dollar (USD) exchange rate in 2014, which coincided with a dramatic drop in the global oil price. The World Bank Commodity Markets database shows that the global oil price generally increased from 2010 to mid-2014, but then dropped from 108 to 30 USD/barrel between June 2014 and January 2016. It then stayed in the 40 to 50 USD/barrel range for the remainder of 2016. Exchange rate data from the International Monetary Fund International Financial Statistics database show that the Naira/USD exchange rate fluctuated between 150 to 160 Naira/USD from January 2010 to October

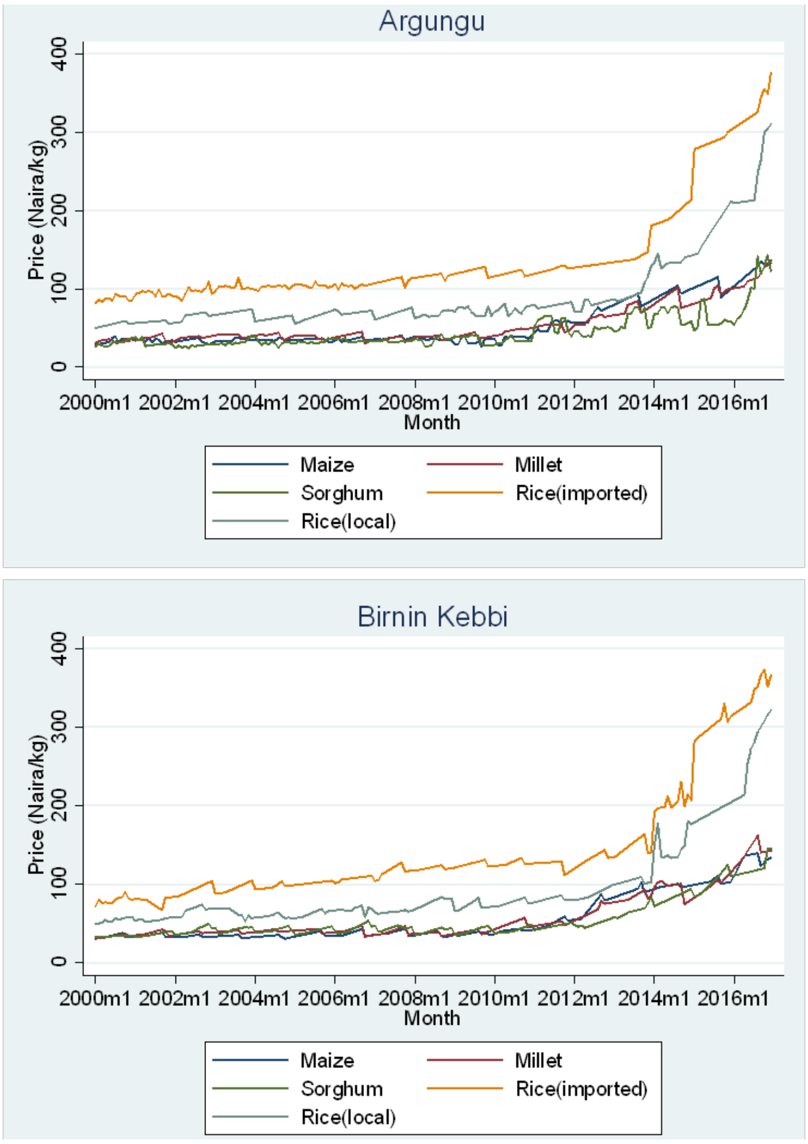
[8] Production data from CountrySTAT (2012), which are data from NBS and the Federal Ministry of Agriculture and Rural Development, confirm these general patterns of higher millet, rice, and sorghum than maize. However, Hatzenbuehler et al. (2017) provide an analysis of the issues of the representativeness of the surveys on which these production estimates were calculated, and how the estimates are plausibly not of much use beyond identifying general patterns as we use them for here.

2014. The exchange rate then jumped sequentially to 170 Naira/USD in November 2014, to 197 Naira/USD by March 2015, to 231 Naira/USD in June 2016, and finally stabilized at around 305 Naira/USD at the end of 2016. This near halving in the value of the Naira in USD terms greatly increased the relative price of imports to Nigeria, including that of imported rice which we assess here, and likely caused Nigerian consumers to substitute imported for domestically produced goods, with resultant price effects.

4.1 Data plots

The plots in Figure 4.1 show the price evolution for Argungu and Birnin Kebbi over the observation period. The just discussed exchange rate change effects on imported, and local, rice are immediately noticeable, although the price paths for imported rice are somewhat different after 2014, with slightly more frequent changes in Birnin Kebbi market than is observed in Argungu. Since both Argungu and Birnin Kebbi are within the same corridor that links Birnin Kebbi and Sokoto city to the north, it is not unexpected that the price series generally appear to have evolved in a comparable manner. It is also clear that before 2014, there was not really a trend in the price series in either market, except for a slight upward trend for imported rice. However, the Argungu price series displayed somewhat more intra-year variation for all crops except millet and maize relative to Birnin Kebbi prices.

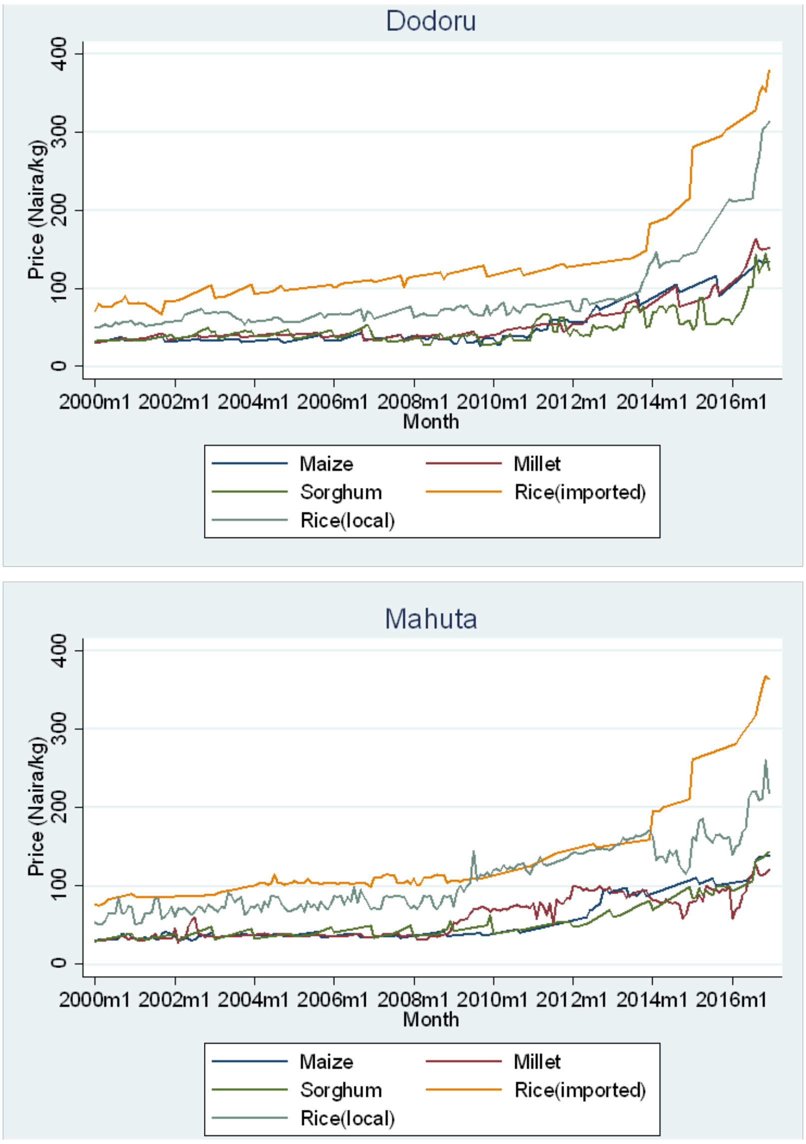
Figure 4.1. Grain price series plots for Argungu and Birnin Kebbi markets, 2000 to 2016



Source: NBS

Figure 4.2 shows the price evolutions for Dodoru and Mahuta markets. Recall that Mahuta is a relatively isolated, rural market, and so our expectation was that price behavior in Mahuta would vary from those in other markets. Dodoru market is within the more developed transportation corridor between Birnin Kebbi and Sokoto, so it is unsurprising that the Dodoru price series are rather like the Birnin Kebbi and Argungu price series. In comparison, the Mahuta prices vary, especially for local rice and millet. Local rice prices in Mahuta were occasionally higher than imported rice prices, and displayed much more intra-year variation than the Dodoru prices. This greater variation also applied for millet.

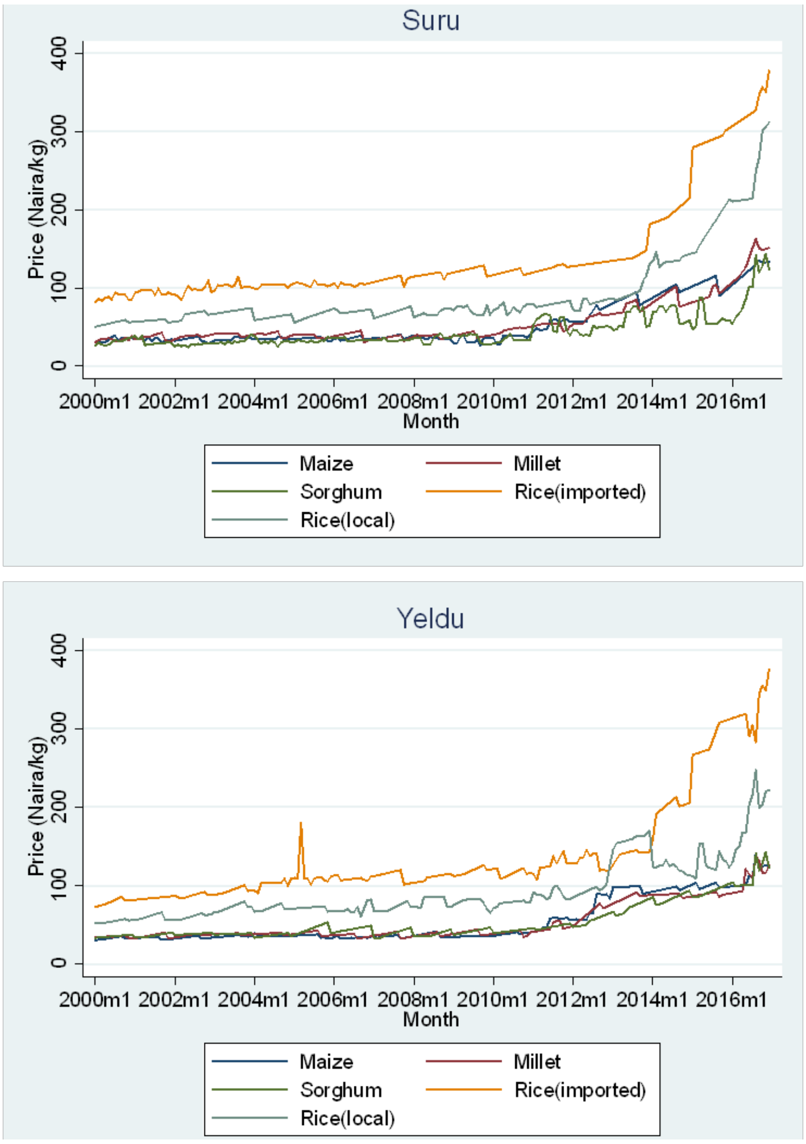
Figure 4.2. Grain price series plots for Dodoru and Mahuta markets, 2000 to 2016



Source: NBS

Plots for the final set of markets, Suru and Yeldu, are presented in Figure 4.3. Suru, although further to south than the other markets, is located at the southern end of the transportation corridor between Kebbi and Sokoto states. Thus, that its price series appear to have broadly evolved in a manner similar to those in Argungu, Birnin Kebbi, and Dodoru is not surprising. While Yeldu is about 50 kilometers from Argungu, it is off the main road linking Kebbi and Sokoto states. This appears to be enough of a factor to impact its prices such that they differ from those in Suru and the other markets examined. The prices for both imported and local rice particularly show a pattern different from those observed in the other markets. Notably, local rice prices temporarily exceeded imported rice prices around 2013, an occurrence which was only observed elsewhere in the Mahuta market. The Suru sorghum prices exhibited substantially more seasonal variation than those in Yeldu.

Figure 4.3. Grain price series plots for Suru and Yeldu markets, 2000 to 2016



Source: NBS

4.2 Summary statistics

Examination of the summary statistics listed in Table 4.1 provide insights into the general differences in price levels and variation across crops and markets for the full observation period. The observation of higher price levels for imported rice and local rice that were seen in the data plots remains clear. The main differences in terms of price levels across markets were found for local rice and sorghum. That is, the mean price for local rice in the Mahuta market was noticeably higher over the observation period than for the other markets. Additionally, the mean sorghum prices in Argungu and Suru, and to some extent in Dodoru, were lower than those in other markets. Imported rice and sorghum generally had lower variation compared to the other crops, as measured by the coefficient of variation. For imported rice, this is likely because it is a purely traded good and so is not subject to the direct effects of local production on prices like the other crops, except maize. For sorghum, this is likely the case because the means were generally stable over the observation period, although some spikes were observed in some markets in 2016.

Table 4.1. Summary statistics for Kebbi state grain prices (Naira/kg), 2000 to 2016

	Argungu	Birnin Kebbi	Dodoru	Mahuta	Suru	Yeldu
Maize						
Mean	53.44	54.89	53.74	55.03	53.71	53.80
Std. Dev.	29.19	30.54	29.52	29.21	29.34	28.72
CV	0.55	0.56	0.55	0.53	0.55	0.53
Millet						
Mean	53.27	56.74	54.98	57.90	54.81	52.79
Std. Dev.	23.91	29.71	27.81	26.07	27.75	24.64
CV	0.45	0.52	0.51	0.45	0.51	0.47
Rice (imported)						
Mean	139.30	140.70	137.80	137.48	140.02	137.37
Std. Dev.	67.27	72.93	69.69	65.18	67.61	68.10
CV	0.48	0.52	0.51	0.47	0.48	0.50
Rice (local)						
Mean	90.18	93.85	89.76	107.31	90.64	91.28
Std. Dev.	49.94	56.73	50.98	41.64	50.20	37.85
CV	0.55	0.60	0.57	0.39	0.55	0.41
Sorghum						
Mean	43.78	53.63	47.57	53.08	44.00	52.88
Std. Dev.	20.96	24.88	19.50	23.89	21.07	23.35
CV	0.48	0.46	0.41	0.45	0.48	0.44

Note: CV is the coefficient of variation, which is the standard deviation divided by the mean.

4.3 Seasonal regressions

To understand the extent of seasonality in the price series, we estimated a set of seasonal regressions. In implementation, we defined three seasonal dummy variables that are associated with the FEWSNET (2013) crop calendar for northern Nigeria. Specifically, we defined the variable, H_t, which is associated with the "harvest period" months (*t*) in all years in the observation period, as taking the value 1 for November and December, and is 0 for all other months. Next, the variable PP_t was created, which is associated with the "pre-planting" months of January to March, and for all years takes the value 1 for those months and 0 for all others. Lastly, the variable PS_t represents the "planting season" months of April to June, and, thus, has a value of 1 for those months in all observation period years, and a 0 for all other months. Thus, the "lean season", which is the period just preceding the harvest (July to October), is the reference period.

These seasonal variables were included in a seasonal regression with the form:

$$p_t = \alpha_{LS} + \alpha_H H_t + \alpha_{PP} PP_t + \alpha_{PS} PS_t + \varepsilon_t, \qquad (1)$$

where, p_t is the price for a given market in each month (*t*); α_{LS} is the average price in the lean season reference period; α_H, α_{PP}, and α_{PS}, are seasonal parameters; and, ε_t is a random error. Regarding interpretation, the estimates for α_H, α_{PP}, and α_{PS} are the differences between the average lean season price and the average price during the harvest, pre-planting, or planting season, respectively. For example, the estimated value of the harvest season parameter, represented by $\widehat{\alpha_H}$ is equal to $\overline{p_H} - \overline{p_{LS}}$, where $\overline{p_H}$ is the mean price in all harvest months and $\overline{p_{LS}}$ is the mean price in all lean season months. The estimates for the other seasons are the same difference in their own seasonal mean values relative to the lean season mean.

The data plots in Figures 4.1, 4.2, and 4.3 showed that the sorghum price series were those that displayed the greatest amount of intra-year variation. Thus, it is not surprising that the greatest amount of statistical significance was found for the sorghum prices, and no other crops exhibited substantial seasonality. Given these results, only those for sorghum are presented in Table 4.2. The results show that Birnin Kebbi, Mahuta, and Yeldu observed the highest average prices during the lean season at around 55 Naira/kg, while those for Argungu and Suru were about 10 Naira/kg lower on average. The coefficient for the pre-planting period price was statistically significantly different from zero for the Mahuta and Dodoru series, and nearly so for the Birnin Kebbi and Yeldu series. This implies that for these markets, the pre-planting season price was on average about 7 Naira/kg (or about 13-percent) lower than during the lean season. The observation that the estimated harvest period parameter did not always have a negative sign, while those associated with the pre-planting and planting season period parameters did, suggests that the post-harvest decline in prices commonly occurs in the new calendar year (the pre-planting period), and then stays low for some months leading up to the lean season.

Table 4.2. Results for seasonality regressions for sorghum prices in Kebbi state, 2000 to 2016

	Argungu	Birnin Kebbi	Dodoru	Mahuta	Suru	Yeldu
$\widehat{\alpha_{LS}}$	45.55*** (17.84)	56.04*** (18.70)	50.43*** (21.38)	55.76*** (19.50)	45.78*** (17.84)	55.32*** (19.63)
$\widehat{\alpha_{H}}$	-0.97 (-0.22)	4.26 (0.82)	-1.49 (-0.37)	5.14 (1.04)	-0.97 (-0.22)	3.01 (0.62)
$\widehat{\alpha_{PP}}$	-4.27 (-1.10)	-7.53 (-1.65)	-6.97* (-1.94)	-8.56* (-1.96)	-4.29 (-1.10)	-6.90 (-1.60)
$\widehat{\alpha_{PS}}$	-2.16 (-0.55)	-4.95 (-1.08)	-3.48 (-0.97)	-5.57 (-1.28)	-2.17 (-0.55)	-4.85 (-1.13)

Note: Estimated parameter t-statistics are in parentheses below the parameter estimates. ***, **, and * denote parameters are statistically significantly different than zero at the 1%, 5%, and 10% significance levels, respectively.

4.4 Annual ranges of prices

We next analyzed the general patterns of intra-annual adjustments in prices by calculating the annual ranges of prices for all crops and markets. The annual price range, p_r, was defined as the difference between the maximum price observed in that year, p_{max}, and the minimum observed price, p_{min}. Thus, to calculate the range in prices for a given year, we first identified the maximum and minimum prices in that year, and then calculated their difference, such that $p_r = p_{max} - p_{min}$.

The values reported in Table 4.3 are the averages of the individual annual ranges calculated for each year for the full period of 2000 to 2016. Appendix Table 1 reports the individual annual ranges for every year in the observation period. In those comprehensive results, it was observed that intra-year ranges that exceeded 10 Naira/kg were considerably more common since 2010. Regarding the average results in Table 4.3, and focusing on the differences across crops first, it is observed that the intra-annual ranges were lowest for maize and millet, highest for imported and local rice, while sorghum was an intermediate case. The sorghum average intra-annual range of above 17 Naira/kg is substantial, however, considering it had the lowest mean value of all crops over the observation period – this average range is about 35-percent of the mean sorghum price. There was not a substantial amount of difference across markets, although Birnin Kebbi had the lowest average ranges of all markets. These observations are plausibly related to the status of Birnin Kebbi as a commercial and administrative hub, such that sudden shifts in local demand or supply are less likely to result in price spikes or drops there.

Table 4.3. Average difference between annual maximum and minimum Kebbi state grain prices, Naira/kg, 2000 to 2016

	Argungu	Birnin Kebbi	Dodoru	Mahuta	Suru	Yeldu	Grand mean
Maize	12.09	10.69	11.97	11.18	12.15	9.81	11.32
Millet	12.59	13.76	13.20	15.77	13.85	10.81	13.33
Rice (imported)	18.83	21.09	19.54	14.86	18.92	27.84	20.18
Rice (local)	22.13	20.77	19.91	31.29	22.25	23.22	23.81
Sorghum	19.64	14.82	19.91	16.35	19.74	12.38	17.14
Grand mean	17.06	16.23	17.57	17.89	17.38	16.81	…

Note: The "grand mean" is the average of the reported mean values for each crop for a given market.

4.5 Frequency of directional changes in price series

While the size of the intra-annual differences in prices allows us to infer which markets and crops have on average experienced the largest price spikes and dips over time, we next turn our focus toward determination of whether prices tend to adjust direction commonly or rather experience larger, less frequent adjustments. Thus, we calculated the number of directional changes, i.e., shifting from moving upward to moving downward, or vice versa, that occur over time for all crops and markets. The motivation for doing so is that the number of observed price changes may shed light on differences in information or general market behavior among participants across markets. In one sense, a change in the price direction due to the receipt of trusted, updated information would reflect a better operating market. However, if those price direction changes are too frequent or are unaligned with the timing of a reliable information broadcast[9], then frequent directional changes may reflect a generally poor market information system or behavior such as buying or selling due to liquidity constraints or other market imperfections. While obtaining fully developed inferences from the calculation of the number of directional changes in the price series is complex for any market and crop pair, our examination of the general picture across crops and markets provides some useful information regarding general differences in price behavior across markets and crops.

A change in direction for the price series were found by first calculating the price difference for each price series, which is $\Delta p_t = p_t - p_{t-1}$. A change in direction in any month, Δd_t, is then defined by the following conditional statement:

$$\Delta d_t = \Delta p_t \ if (\Delta p_t > 0 \ \& \ \Delta p_{t-1} < 0) \ or (\Delta p_t < 0 \ \& \ \Delta p_{t-1} > 0); \ otherwise, \Delta d_t \ is \ null.$$

The results from the identification of the number of directional changes in the price series over the observation period are shown below in Table 4.4. The highest number of directional changes were observed for sorghum and the lowest were found for millet. Some individual markets observed a relatively high number of directional changes for select crops, such as sorghum in Argungu and Suru and local rice in Mahuta. While there were more price direction changes for imported rice than millet, there were no markets for which there were more than 70 directional changes observed in the associated imported rice price series, while all the other crops had at least one market with that number of directional changes. This observation is consistent with imported rice being a purely traded good that is only indirectly affected by changes in local production. The differences in the number of directional changes observed across markets is clear. Birnin Kebbi had a substantially lower number of total price changes than all other markets. This

[9] For illustration, the USDA WASDE reports released in May each year are the first projections for maize and soybean production estimates for the upcoming crop year (for maize and soybeans in the US this lasts from September 1 through the following August). The release of these estimates is shown by Adjemian (2012) to commonly cause substantial market reactions and associated price direction changes. Examination of price data from the U.S. show that these changes may be anticipated to some degree by the market (i.e., see a reaction in April) and take a few months to stabilize such that directional changes are commonly observed in the months of April, May, and June. Directional changes in these months are more common than in other months.

suggests that the status of Birnin Kebbi as an administrative and commercial hub provides its markets with certain characteristics that make its prices have more predictable price paths and fewer sudden price jumps than in the other markets. Presumably this observation is related to the existence of better organized storage markets and other attributes that help facilitate trade in Birnin Kebbi.

Table 4.4. Number of directional changes in Kebbi state grain price series, 2000 to 2016

	Argungu	Birnin Kebbi	Dodoru	Mahuta	Suru	Yeldu	Total
Maize	74	38	60	42	74	70	358
Millet	48	36	38	81	50	39	292
Rice (imported)	62	46	32	51	62	61	314
Rice (local)	42	47	56	112	42	61	360
Sorghum	116	44	76	46	116	37	435
Total	342	211	262	332	344	268	…

Note: The "total" value is the sum of directional changes for all crops in each market (sum across rows) and markets for each crop (sum across columns).

5. CONCLUDING REMARKS

The primary goal of our analyses of these price series was to determine if price behavior, which reflects information such as the extent of storage infrastructure and trade, for markets within a state in Nigeria vary to a large enough degree across markets to justify in-depth analysis of food market development at the state or local level. This is an important exercise because such an analysis can help identify the markets that are most in need of rural development related policy interventions, and such projects are likely to be more efficient if they are implemented at the state or local government level.

The results from our analysis showed that, although there are some common factors that appear to have affected all markets, such as the substantial exchange rate adjustment in 2014 and its resultant price effects on imported rice and indirect effects on other crops, the extent and timing of those effects varied across markets. Additionally, even when the price paths in different markets followed similar trends, there were commonly deviations in the price paths that were unique to each market. The crop that was observed to experience the most seasonal variation was sorghum, a crop that is commonly both produced and consumed in the state, and, hence, its markets are subject to production-related price shocks.

A key result was that prices for Birnin Kebbi, the administrative and commercial center for the state, generally behaved differently than those in other markets. This was especially the case for the average annual price ranges and the total number of price directional changes over the observation period; both of which were lower for Birnin Kebbi than in all other markets. The implication is that markets in Birnin Kebbi experience smaller intra-annual fluctuations between maximum and minimum prices, and that prices do not as commonly change direction as in other markets. We conjecture that these differences are related to the characteristics of the Birnin Kebbi market relative to the other markets, especially regarding physical infrastructure (including storage) and information transmission.

We also made one important administrative observation over the course of this study. The price data used were provided by the Price Department of the National Bureau of Statistics at its headquarters in Abuja. Upon receipt of the data, the pathway in data transmission was described, and it proceeds as follows. The prices are gathered weekly or bi-weekly at the market level, e.g., in up to 15 markets in Kebbi state, and these are transmitted (presumably electronically) to zonal offices, of which there are six in Nigeria. These data are then aggregated into statewide averages, and sent to NBS headquarters in Abuja (again, presumably electronically), primarily for calculation of the CPI. We were then told that these transmitted data from both state to zonal office and from zonal office to national headquarters are not saved in a database at any point along the data transmission line. All that is saved is the final national average that is included in the CPI calculation.

While it is understandable that the NBS maintains its chief focus on achieving its mandate to calculate the CPI, there is large amount of information that is “lost” along this pathway that is, thus, unavailable for use in analyses such as this. Our dataset was not without flaws – much of the data obtained was discarded based on a quality assessment. Moreover, it appears that the compilation of these price series stretched the capacity of staff in the NBS Price Department, who lack resources to gather and disseminate such data. An important opportunity to store and make available data that are already being gathered could be seized through investment in physical infrastructure and staff capacity throughout the NBS system.

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APPENDIX

Appendix Table 1. Differences between annual maximum and minimum grain prices for Argungu, Birnin Kebbi, Doduru, Mahuta, Suru, and Yeldu markets, 2000 to 2016, Naira/kg

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Argungu																	
Maize	9.2	6.3	8.9	4.3	4.2	4.8	6.4	5.7	5.0	12.5	12.0	15.1	21.5	16.4	16.7	25.5	31.0
Millet	7.0	10.5	5.9	4.7	9.0	5.4	14.8	7.5	6.6	8.1	9.9	9.9	13.2	17.7	25.9	22.8	35.0
Rice (imported)	12.0	8.6	24.8	17.2	6.6	8.6	7.3	14.0	9.4	14.1	8.5	10.6	6.4	46.3	31.0	24.7	70.0
Rice (local)	8.9	4.1	13.4	7.3	7.7	16.7	6.2	15.3	10.6	12.5	16.0	8.0	15.7	45.9	19.1	68.2	100.8
Sorghum	10.5	11.9	5.6	12.0	13.7	7.1	4.9	3.6	14.8	14.0	12.2	27.0	12.8	30.2	24.2	40.4	89.0
Birnin Kebbi																	
Maize	7.0	5.8	3.0	4.0	4.9	7.1	9.1	8.8	7.7	5.0	5.4	16.2	32.2	19.3	6.7	11.7	28.1
Millet	5.9	8.5	4.8	3.9	3.2	5.6	14.2	11.1	5.4	6.7	14.7	5.9	24.8	15.6	29.2	32.6	42.0
Rice (imported)	18.6	16.7	20.0	16.6	10.1	5.5	9.8	23.6	7.2	10.0	9.9	17.2	23.3	29.5	37.5	46.6	56.4
Rice (local)	8.6	5.7	16.0	16.6	6.8	11.6	14.9	4.8	15.8	17.7	11.3	8.8	18.2	9.5	46.4	25.7	114.8
Sorghum	2.2	7.2	14.0	9.5	8.3	10.3	16.7	7.8	9.8	11.4	11.3	9.2	12.2	26.5	21.4	39.9	34.3
Doduru																	
Maize	7.0	5.8	3.0	4.0	4.9	7.1	9.1	5.8	5.0	12.6	12.1	15.2	21.7	16.5	16.9	25.7	31.3
Millet	5.9	8.5	4.8	3.9	3.2	5.6	14.2	7.5	6.7	8.2	10.0	10.0	13.3	17.9	26.1	23.0	55.7
Rice (imported)	18.6	16.7	20.0	16.6	10.1	5.5	7.8	14.1	9.5	14.3	8.5	10.7	6.4	46.7	31.2	24.9	70.5
Rice (local)	8.6	5.7	16.0	16.6	6.8	11.6	14.9	15.4	10.7	12.6	16.1	8.1	15.8	46.3	19.3	68.8	101.6
Sorghum	2.2	7.2	14.0	9.5	8.3	10.3	16.7	3.6	14.9	14.1	12.3	27.2	12.9	30.4	24.3	40.7	89.7
Mahuta																	
Maize	8.9	10.7	10.7	4.3	2.9	7.5	4.2	3.1	6.1	3.4	5.6	10.8	40.0	11.3	16.7	9.5	34.7
Millet	6.7	9.1	32.0	2.3	4.0	1.8	3.4	4.1	11.9	21.0	7.7	34.1	6.4	9.1	25.3	20.3	68.9
Rice (imported)	14.4	1.7	1.7	11.5	13.6	6.9	5.8	12.1	13.9	7.0	11.8	18.8	6.4	6.7	15.6	16.8	87.8
Rice (local)	34.5	33.7	15.7	27.8	20.0	13.3	27.4	16.3	17.4	71.2	13.8	13.1	6.5	22.5	47.5	30.3	121.0
Sorghum	9.7	6.5	15.8	13.6	6.3	12.0	8.7	15.6	19.2	19.6	7.5	6.6	21.6	20.3	29.2	16.4	49.6
Suru																	
Maize	9.2	6.4	8.9	4.4	4.2	4.8	6.5	5.8	5.0	12.6	12.1	15.1	21.6	16.5	16.8	25.6	31.2
Millet	7.0	10.6	6.0	4.7	9.0	5.4	14.9	7.5	6.7	8.2	10.0	10.0	13.3	17.8	26.0	22.9	55.5
Rice (imported)	12.1	8.7	24.9	17.3	6.7	8.6	7.4	14.1	9.5	14.2	8.5	10.7	6.4	46.6	31.1	24.8	70.3
Rice (local)	9.0	4.2	13.5	7.3	7.7	16.8	6.2	15.4	10.6	12.5	16.1	8.0	15.7	46.1	19.2	68.6	101.3
Sorghum	10.5	12.0	5.7	12.1	13.8	7.2	5.0	3.6	14.8	14.1	12.3	27.2	12.9	30.4	24.3	40.6	89.5
Yeldu																	
Maize	5.1	4.0	3.9	2.9	4.3	5.5	3.5	4.9	7.5	1.4	4.7	18.4	32.6	10.0	7.6	8.7	42.1
Millet	5.0	7.5	5.2	2.4	3.6	7.2	6.0	8.9	5.4	7.4	8.5	13.9	28.4	14.1	5.5	6.5	48.3
Rice (imported)	13.2	4.5	7.9	11.8	19.1	79.1	7.2	18.8	11.5	14.0	13.0	37.1	26.3	18.8	53.0	45.4	92.5
Rice (local)	5.7	9.6	7.9	13.4	10.7	6.9	21.4	12.9	14.8	17.3	9.7	17.7	40.6	23.7	19.6	45.1	117.7
Sorghum	4.2	6.2	2.9	1.9	6.2	16.1	8.6	12.8	9.0	9.6	5.8	8.3	17.6	22.1	18.4	17.4	43.5

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