WPS7564

Policy Research Working Paper 7564

Market Integration and Poverty

Evidence from South Sudan

Gonzalo Varela
Massimiliano Calì
Utz Pape
Esteban Rojas

World Bank Group
Trade and Competitiveness Global Practice Group
February 2016

Abstract

This paper examines the effects of market integration on household consumption using data on seven food and two energy markets across South Sudan. The analysis reveals that markets in South Sudan are highly segmented. Price differences for narrowly defined products, across cities exceed in some cases 100 percent. In addition, price volatility increased substantially following the imposition of the trade restrictions with Sudan. This increase tends to hurt disproportionately the poor, who cannot smooth purchasing decisions over time because of liquidity constraints. Transportation costs explain almost half of the variation in food prices across space, and improving the quality of roads has a large potential to reduce prices in the most expensive towns. On the basis of this price effect, the simulations suggest that bringing all road quality across states to that of primary roads can yield a reduction in poverty from the rate of 51.7 percent in 2009 to between 42.8 and 46.9 percent. These estimates have to be interpreted as conservative, as they do not take into account the second-order effects of road construction from increased trade that will result from better road connectivity.

This paper is a product of the Trade and Competitiveness Global Practice Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at gvarela@worldbank.org.

Market Integration and Poverty: Evidence from South Sudan

Gonzalo Varela, Massimiliano Calì, Utz Pape and Esteban Rojas

The World Bank

Keywords: market integration, prices, poverty, South Sudan, roads

JEL Classification:

Q11, Q17, O12

1. Introduction

Market integration matters for economic development. Non-integrated markets are somehow "blind". Producers cannot see what is appreciated in other markets and what is not, and therefore they cannot make the best possible production decisions, leading to inefficiencies. Through scale, market integration also allows for spreading fixed costs and productivity improvements through specialization. Better integrated markets help development through price stabilization, as local shocks are mitigated more rapidly through trade between surplus and deficit areas (Timmer, C.P. (1996), Donaldson (2014)). Finally, in food markets integration increases the power of price interventions as a public policy to reduce prices has larger impacts on poverty and shared prosperity.[1] The integration of markets is associated with large gains from increased trade. Donaldson (2014) estimates that increased connectivity across districts due to the railroad network raised real agricultural income by over 16 percent in British India. This gain is entirely explained by the increased trade between districts. That also confirms the theoretical results of Arkolakis et al. (2012).

Despite its importance, relatively little evidence exists on the effects of market integration on poverty. That is particularly the case for low income countries, which have poor data, but have the highest barriers to internal trade. This paper aims to help address this gap, focusing on the case of South Sudan. In order to do that, it first examines to what extent key commodity markets are spatially integrated across states. It then checks to what extent this domestic integration is affected by imports, by testing whether the border closure in 2011 with Sudan has affected this integration. It also tries to identify the drivers behind the (scant) markets' integration using price differentials between Juba and the other major towns as the inverse measure of integration. The paper then uses these estimates to compute the possible effects of changes in these drivers on poverty.

The question on the poverty impact of market integration is important in South Sudan, which has one of the highest incidences of poverty in the world. Years of wars and instability, which continues unabated to this day, have killed thousands and profoundly affected all economic activities. This instability is compounded by an unfavorable location without access to the sea, unstable neighbors, and weak political institutions. The outcome is a country where more than half of the population is poor (according to estimates from the 2009 household survey, which have likely worsened after the latest rounds of violence).[2]

Much of the population, including the poor, relies on markets for their basic consumption. Indeed South Sudan's economy has a very low domestic production capacity – excluding oil. Before the oil closure, the oil sector represented around 66 percent of GDP, 98 percent of government

[1] For example, governments or parastatal agencies could affect the price structure for a commodity produced and consumed within the country through arbitrage by operating on small amounts of easily controlled trade flows (Timmer, 1986).

[2] World Bank (2011), "A Poverty Profile for the Southern States of Sudan". Africa Region, World Bank, and World Bank (2014), "South Sudan Poverty Note: Impact of a Continued Internal Conflict on Food Security and Poverty", World Bank.

revenues, and almost 100 percent of exports.[3] In rural areas, subsistence agriculture constitutes the largest part of production. However, food production was insufficient even before the onset of the conflict. Only the Greenbelt area of Western Equatoria has excessive food production; while all other states are food deficient.[4] The patchy trade data and recent evidence in Calì and Varela (2013) suggest that the food deficit in most parts of the country is filled by imports (mainly from Uganda and Sudan) and to a limited extent by domestic trade.

However relying on markets for consumption is both costly and perilous in South Sudan. The very poor transport infrastructure in large parts of the country – especially in northern states – creates significant transportation costs leading to considerable price variations across the country. In addition the violence, within South Sudan and sporadically with Sudan, has greatly undermined the security of trade and thus increased price volatility.

We estimate the degree of integration in seven food markets, and two energy markets across eight state capitals.[5] The former group includes sorghum, maize, millet, wheat flour, sesame, broad beans and groundnuts; the latter group includes diesel and gasoline. The choice of products reflects the combination of its importance in the consumption basket of South Sudanese and of data availability. The period analyzed spans 2009-2013, with exceptions again due to data availability.[6] The analysis reveals four main messages.

First, markets in South Sudan are highly segmented. Price differences for narrowly defined products, across cities exceed in certain instances 100 percent. For sorghum, for example, a key staple in South Sudan, inter-city prices differences are on average, 43 percent. These differences within South Sudan exceed those reported in the literature for inter-countries price gaps in Central and Western Africa (Brenton et al., 2015).

Second, price volatility has increased substantially since the imposition of the trade restrictions with Sudan. Groundnuts and sorghum, for example, show the most geographically widespread increase in price volatility when comparing the pre- and the post-border closure periods. These increases in price volatility tend to hurt disproportionately the poor, who cannot smooth purchasing decisions over time due to liquidity constraints.

Third, trade restrictions associated with the Sudan border closure in mid-2011 have increased market segmentation, particularly for cities in northern states. The border closure increased price differences in northern states by about 6 percent, on average. And this segmentation does not include that induced by other restrictions to trade within the country, chiefly the formal and informal tolls charged in checkpoints throughout the country to users of the road network.

Fourth, transportation costs explain up to 33 percent of the variation of food price differences across South Sudan. In particular increasing the portion of primary roads by 10 percentage points

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[3] See World Bank (2014) "Trade, Poverty, and Economic Diversification in South Sudan", PREM Africa Region, World Bank, mimeo.

[4] The 'greenbelt' comprises the states of Western Equatoria, Central Equatoria and portions of Eastern Equatoria, and it is so named because of the usual rainfall, beginning in March and ending in October. The soils there are generally productive, ranging from coarse-textured sands to loamy clays. See World Bank (2012) "Agricultural Potential, Rural Roads and Farm Competitiveness in South Sudan, Report No. 68399-SS.

[5] The major towns with available data considered are Aweil, Bentiu, Bor, Kajok, Juba, Malakal, Rumbek, and Wau.

[6] For Sorghum, for example, data for Malakal and Wau are available since 2006 and 2007 respectively. For Sesame, most data are available since 2010. For diesel and gasoline, data are available only since 2012.

would reduce price differences by between 26 and 66 percent. And an increase in fuel prices of 1 percent above Juba prices lead to increases in food prices by up to 0.4 percent with respect to prices in Juba.

On the basis of these estimates of the determinants of price differences, we estimate large welfare gains from increased market integration via road construction. Upgrading road quality across states to that of primary roads would yield a first-order increase in total consumption by 28 percent for the average household. This increase would yield a reduction in poverty from the rate of 51.7 percent in 2009 (the latest year for which poverty data are available) to 46.9 percent. Taking the upper bound elasticity of price reduction with respect to road building, the poverty reduction would be even more substantial to 42.8 percent. These estimates have to be interpreted as conservative as they do not take into account the second-order effects of road construction, coming from the increased trade due to better road connectivity.

The remainder of the paper is structured as follows. Section 2 describes South Sudan's geography, trade and production structure. Section 3 presents the data on prices for the nine products considered across the country, examines the main patterns of these prices (levels, trends, volatility) and the cross-city differences of these prices It also discusses the extent to which each of these nine markets are spatially integrated and analyzes the drivers of market integration. Section 4 uses the previous estimates to compute the effects of road upgrading on poverty. Finally, Section 5 presents conclusions and policy implications of the analysis.

2. Geography, Trade, and Production Structure

Lack of adequate domestic transportation infrastructure inhibits both international and domestic trade. South Sudan has more than 7,000 km of primary roads, which makes for an extremely low road density of 15 km of road per 1,000 km^2 of arable land; compared to more than 45 km of road in other low-income countries (World Bank 2014a). Only 5 percent of the roads are in good condition and accessible in all seasons. Most roads in South Sudan cannot withstand the wet season rendering most parts of the country inaccessible by car or truck within the rainy season. In the dry season, accessibility is increased but costs for transportation remain high due to the poor state of most roads (World Bank, 2012b). For example, transport costs between two state capitals Juba and Yei are around 0.65 USD/ton-km. While this is relatively low compared to other areas in South Sudan, transportation costs in Kenya and Uganda are considerably lower at around 0.20 USD/ton-km. The high domestic transport costs limit market access and fragment markets at the local level with producers serving only local markets or at subsistence level without taking advantage of economies of scale.

Transport infrastructure connecting the capital city Juba with Nimule at the border with Uganda is in better condition. This connection is a 300 km stretch of tarmac road, which is currently the best access to the sea through Kampala and Nairobi.[7] Indeed most international goods arrive from Uganda through the Nimule – Juba corridor with significantly lower transport costs than elsewhere in South Sudan (at about 0.10 USD/ton-km). This cost advantage for imported goods contributes to the lack of competitiveness of domestic produce especially in large markets like Juba. Road

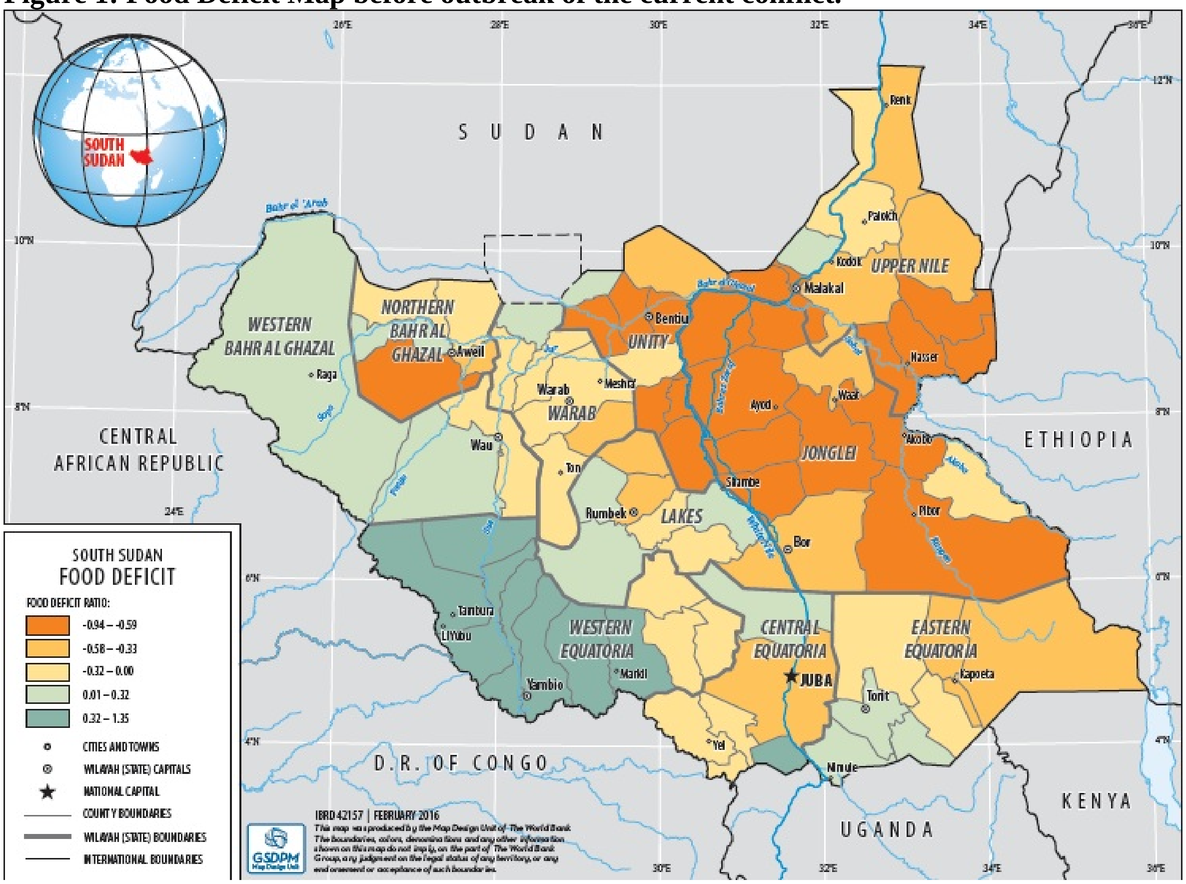
[7] A second tarmac road is currently planned to connect Juba directly with Kenya.

connections to Sudan exist but are in dilapidated state. A quality upgrade of the primary road network would lower costs for domestic production and increase domestic trade, conditional on an adequate supply response from producers. The only international airport (Juba) is primarily used as passenger airport, without warehouse capacity.[8]

Agricultural Production

Agricultural production is highly insufficient in large parts of the country to meet the population requirements. For cereal equivalents alone, it was estimated that production (including both traditional and mechanized) will fall short of national consumption needs by 408,000 tons during 2013/14 even before the conflict in December 2013 broke out. The northern states of South Sudan and especially Jonglei have highest production deficits (Figure 1). Generally, 57 percent of assessed households were expected to rely on markets as their main source of food in 2013. Foreign exchange from oil exports is used to finance imports satisfying the basic needs of the population.

Figure 1: Food Deficit Map before outbreak of the current conflict.

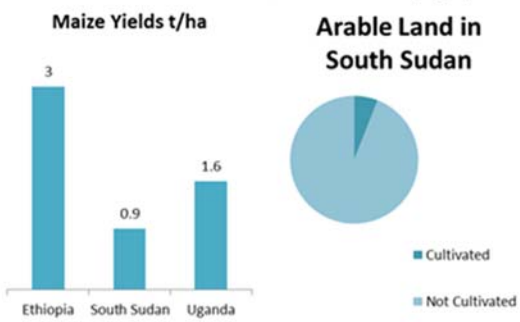


Note: Green areas indicate a surplus in staple grain production, red areas indicate a deficit. The numbers indicate the ratio of surplus or deficit. The Map does not reflect the World Bank or its partners' views of South Sudan's territorial claims.
Source: Authors' calculations based on WFP/FAO (2013, 2014).

[8] Major constructions to finish multiple modern terminal buildings were halted because of insufficient funds.

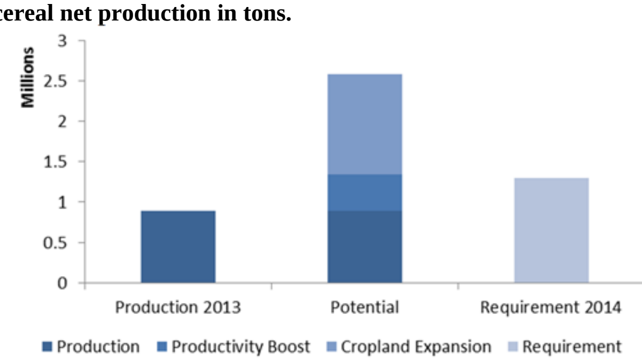
South Sudan has a huge but largely unrealized agricultural potential. South Sudan has 2.7 million ha of land under cultivation (Figure 2). Given the abundance of arable but not cultivated land (47 million ha.), a modest expansion to 6.3 million ha would increase the share of cultivated land from 4% to 10% of total land area. This would still leave 85% of arable land uncultivated. This modest cropland expansion would increase agricultural output to 240 percent. Yields in South Sudan of around 0.8 – 0.9 tons per ha are currently significantly below yields of neighboring countries (Uganda: 1.6 t per ha, Kenya: 2 t per ha, and Ethiopia: 3 t per ha). An increase of productivity by 50 percent paired with the cropland expansion would boost agricultural production by 360 percent (Figure 3).[9] Insufficient infrastructure, lack of access to credit, inadequate tenure land rights and low yields inhibit investment in agriculture and commercial farming (World Bank, 2012b; World Bank, 2014a; World Bank, 2014b; World Bank, 2014c).

Figure 2: Yields for Maize in t/ha (left) and fraction of cultivated arable land in South Sudan (right).



Source: Adapted from World Bank (2012b).

Figure 3: Estimated agricultural potential for South Sudan for cereal net production in tons.



Source: Authors' estimation based on World Bank (2012b).

Trade

Trade estimates ignore flows between Sudan and South Sudan. Lack of data for cross-border trade between Sudan and South Sudan under-estimates imports and exports. Before independence in 2011, intra-state trade between the northern and southern states of Sudan was not officially recorded. However, the southern states exported 10,000 heads of cattle to the northern states of Sudan as well as small volumes of fish, gum Arabic, honey and timber (USAID, 2011). Also, an estimated 80,000 Metric Tons (MT) of key staples like sorghum, wheat flour, millet, wheat grain and groundnuts were imported from Sudan in 2010 (USAID, 2011). In addition, an estimated 631,000 MT of fuel was imported from the North.

The reduction in trade between Sudan and South Sudan preceded the border closure in late 2011. In the first months of 2011, trade volumes were reduced by about 40 percent in the aftermath of the referendum for independence and increasing border insecurities. Afterwards, the border was often closed. Goods reach the South Sudanese markets at the border with Sudan either from Sudan or from the South (other states in South Sudan, Kenya, and Uganda). Transportation within South Sudan adds an expensive premium on prices of goods delivered from the South. Barriers for crossing the border between Sudan and South Sudan restrict the availability of goods. Prices of key staples close to the border with Sudan have fluctuated pronouncedly after the border closure

[9] World Bank (2012b).

emphasizing the importance of policies to support cross-border trade with Sudan (World Bank, 2014a). Since 2013, the border was re-opened leading to increased trade. However, absence of bilateral trade statistics with Sudan makes it impossible to estimate the volume.

Before 2012, exports exceeded imports considerably. Between 2008 and 2011, exports remained above 60 percent of GDP largely consisting of oil. Imports averaged 22 percent of GDP from 2008 to 2011. The oil shutdown in January 2012 led to a collapse of oil exports and, hence, a significant trade deficit. The import share of GDP increased from around 22 percent in 2011 to 39 percent in 2012 and the resulting trade deficit reached 36 percent of GDP. In absolute values, imports of goods remained stable in 2012 but GDP declined sharply (World Bank, 2014a).

South Sudan imports food and vegetables as well as transportation and machinery. In 2008, the main imports categories were food, with 26 percent of imports in the category for food stuff and 12 percent in the category for vegetables.

Nimule, on the border with Uganda, is the most important border crossing. In 2012, about 80 percent of customs revenue was collected at Nimule. Kaya, another customs station at the border with Uganda, and Juba airport each contributed a share of about 10 percent to customs revenue. Other border stations with respect to revenue generation are negligible.[10] The vast majority of these imports are headed to Juba, which effectively represents the only international trade node in South Sudan.

3. Price Differentials and Price Volatility

The integration of spatially separated markets implies interconnectedness among them through trade or through the possibility of trade. Thus, the forces of arbitrage make the long-run price differences that remain among them reflect trade costs only.[11] Assessing integration involves examining carefully the evolution of prices of specific products across different cities in South Sudan, and testing their short and long-run co-movement. When doing so, the drivers of different degrees of co-movement can also be explored, which allows us to understand how policy actions can help achieve greater market integration.

3.1. The Data

We use consumer price series for seven food products for the period 2009-13: broad beans, groundnuts, maize (white), millet, sesame, sorghum and wheat flour, and for two energy products: diesel and gasoline. Five food products were dropped due to absence of data. These are: cassava and cassava meal for which the data available only covered the capital city of Juba, and red beans, maize in grains, and cooking oil for which data available covered less than 12 observations per city. For the remaining products, the period of analysis is heterogeneous, but typically covering 2009-2013 (diesel and gasoline prices, for example, are only available for 2012-2013). Appendix

[10] This might change with the construction of the all year passable road to Kenya.
[11] Varela, G. et al (2012).

Table **7** reports the data coverage per product and per city.

3.2. Price Differences

As a first pass to understand how integrated markets are in South Sudan, we calculate the log price gap of each product in a given city relative to Juba. The log price gap is an approximation to the percentage difference in the price. A positive gap indicates that prices are higher in the city in question than in Juba, while the opposite is true when the gap is negative.

Three dimensions of the price differences are of interest: their size, their signs and their trends. Table 1 shows descriptive statistics for the price gaps, in absolute value, by product. **Error! Reference source not found.** to **Error! Reference source not found.** in the Appendix show the evolution of the price gaps against Juba for all products considered.

There is substantial heterogeneity in prices of food products and fuels. For example, people living in Malakal faced the lowest prices for wheat flour. For a kilogram of that product, they had to pay 10.25 SSP in April 2012. Instead, those living in Rumbek had to pay the highest price in the country: 15 SSP for the same quantity of the good. Almost a year later, wheat flour prices in Malakal had fallen to 9 SSP per kilogram, while those in Rumbek had increased to 20 SSP per kilogram. On average, the wheat flour price gap between any given city and Juba's price over the period considered was 50.5 percent, while the standard deviation is 33.5 percent. For other products, the average price differences across state capitals are relatively lower. In broad beans, the average price difference is 15.4 percent (although this average masks substantial variation across pairs of cities). More surprisingly is the case of standard products such as diesel and gasoline, which vary in price substantially across cities (on average, 79 and 95 percent differences, respectively). People in Juba face the highest prices for broad beans, groundnuts and millet. Rumbek's inhabitants pay the highest prices for sorghum and wheat flour, while in Malakal they pay the highest diesel and gasoline prices, as well as high prices for maize. These observed price differences *within* South Sudan are substantially higher than those reported between countries for 13 countries in Central and Eastern Africa, reported in Brenton et al (2013).

Table 1: Descriptive Statistics of Price Differences

Product	Average Price Difference (in absolute values)	Standard Deviation	CV	Min Price	Max Price
Broad Beans	15.4%	25.8%	167.9%	Rumbek	Juba
Groundnut (Shelled)	31.2%	30.4%	97.5%	Rumbek	Juba
Maize (White)	49.9%	36.9%	74.0%	Kajok	Malakal
Millet (White)	24.2%	29.6%	122.4%	Malakal	Juba
Sesame	22.2%	31.4%	141.3%	Bor	Kajok
Sorghum (White)	43.2%	31.8%	73.7%	Aweil	Rumbek
Wheat Flour	50.5%	33.5%	66.2%	Malakal	Rumbek
Diesel	79.1%	27.9%	35.3%	Juba	Malakal

Gasoline	95.3%	31.2%	32.7%	Juba	Malakal

Source: Authors' calculations based on WFP data.

There have been changes in price patterns over time. For example, in the case of sorghum and wheat flour, the price gaps shifted from negative to positive. While initially prices for these two products tended to be higher in Juba than in the rest of the state capitals, as time passed, prices became relatively lower in Juba. This is likely related to a shift in production and trade structures for those products as a consequence of the imposition of trade restrictions with Sudan. Although trade data by product and origin is scarce and incomplete, evidence suggests that imports of both wheat flour and sorghum increased substantially in recent years, and the origins of these flows are Uganda (for wheat flour) and the USA (for sorghum). In both cases, these imported products enter the country through Juba, making it reasonable for their prices being lower in that point of entry. For example, the prices of sorghum in Malakal during 2009 and 2010 were lower than in Juba, but these prices increased rapidly and became volatile after the independence referendum (January 2011) remaining higher than in Juba for the following two years. The increases in prices are likely related to transportation costs, multiple check points, roadblocks and payments of several formal and informal taxes.[12]

How did the border closure of August 2011 affect spatial price differences across the country? Are there identifiable differences for states in the north? We look at the effect of the border closure on price differences and its differential impact on northern states by product. Results are presented in Table 2.[13] The absolute values of price differences of a given product in a given city with respect to Juba are greater after the border closure, suggesting that the trade restrictions increased segmentation. For the cases of groundnuts, maize, sorghum and wheat flour, these differences are statistically significant. In addition, price differences with Juba appear higher in northern states than in southern states (which is likely attributable to higher geographical distance). Only for sorghum, however, the effects of border closure on price differences are significantly different for cities in northern states (Wau, Aweil, Kajok, Bentiu and Malakal). Results suggest that in this case, price differences actually fell, in absolute value, with respect to Juba. This is likely related to a change in the direction of trade for this product, and it is consistent with the change in the sign of price changes for this product. While before the border closure Sorghum was typically more expensive in Juba, after the border closure, the disruption of trade with Sudan, increased the price of Sorghum – and in particular in northern regions (see Cali and Varela (2013)), bringing it closer to levels observed in Juba.

Table 2: Price Differences: Before and After the Border Closure, For Northern and Southern States

Price differences	Broad Beans	Groundnuts	Maize	Millet	Sesame	Sorghum	Wheat Flour
Border Closure	0.0292	0.108**	0.0989**	0.00443	0.0483	0.0973***	0.0995**
	(0.06)	(0.05)	(0.05)	(0.06)	(0.06)	(0.03)	(0.05)

[12] The analysis in WFP (2013) presents analogous results to ours.

[13] Methodologically, this analysis consists in a tabulation of price differences across two periods (pre and post border closure), and two regions (northern states, and the rest), through the inclusion of a border closure step dummy, a region dummy and its interaction.

Northern States	0.154***	0.218***	0.222***	0.364***	0.365***	0.157***	0.0202
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.03)	(0.04)
*Border Closure * Northern States*	0.0783	-0.122	-0.113	-0.0714	-0.0607	-0.169***	-0.103
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.04)	(0.06)
Constant	0.249***	0.278***	0.180***	0.0314	0.0606	0.167***	0.257***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)
Observations	250	371	273	166	237	503	304
R-squared	0.095	0.056	0.094	0.358	0.23	0.063	0.018

Standard errors in parentheses
Source: Authors' calculations

3.3. Price Volatility

High price volatility, and in particular that of food products, is costly for the poor. It makes it difficult to plan ahead and to adjust to fluctuating market signals. Episodes of extreme volatility, especially when these imply food prices spikes are an important threat to food security in a country like South Sudan, in which the average share of food in total expenditures is 80 percent. The negative impact is exacerbated by little access to savings or credit that would allow households to smooth consumption decisions over time (e.g.: by buying and storing food when prices are low to be consumed later when prices are high). As a consequence, in this context, food spikes result in hunger and malnutrition in the absence of other interventions, making it a crucial issue for policymakers. In addition to the spatial dimension of price differences discussed above, food and energy prices in South Sudan have fluctuated substantially within each state capital over time.

Has price volatility increased after the imposition of trade restrictions with Sudan? To answer this question, we first measure the volatility associated with the prices of each product in a given state capital by calculating the standard deviation of the monthly rates of change of prices for each product for the period pre-border closure, and post-border closure. Second, we test for a difference in the standard deviation of price changes before and after border closure.[14] Figure 28 to Figure 34 show the pre and post border closure price volatility for those food products for which there was available price data spanning both sub-periods. We report the state capitals in which the differences in prices volatility were statistically significant.[15]

Whenever there was a significant change in price volatility after the border closure, this change implied an increase in volatility. For the case of broad beans, for example price volatility more than tripled in Bor, it doubled in Juba, and increased by almost 10 percentage points in Malakal. Sorghum is the product for which the increases in price volatility were more widespread spatially (similarly for groundnuts). Volatility roughly doubled in Aweil, Bor and Rumbek; increased by 75 percent in Juba, and by 17.5 percent in Wau.

[14] Statistically, the test results from the comparison of the sample variance of price changes pre-closure with the sample variance of price changes post-closure. Both sample statistics are distributed Chi-Squared, and its ratio is distributed as an F.

[15] Given the short sample period, a cut off of 20 percent significance is considered. The full set of results for this volatility comparison as well as figures showing the evolution of the standard deviation of price changes for each state capital and product are presented in the Appendix.

How did the border closure affect price volatility across the country? Similarly to the analysis of the impact of the border closure on price differentials, we also examine the patterns of price volatility pre and post closure by geographic region. For this purpose, we construct a rolling measure of price volatility, that consists of the standard deviation of monthly price changes for a given commodity in a given city, over a window of five months (the graphs above, instead, show the standard deviation of monthly price changes for a given commodity in a given city over the whole pre-border closure period, and post-border closure period). Results from tabulating that measure of price volatility across the pre and post border closure periods and by region are presented in Table 3. They confirm that for sorghum, price volatility increased across the board after the border closure. In addition, they show that volatility was on average higher for northern states, although the post-border closure did not affect northern states any differently than it affected the rest of the country. For groundnuts and maize, for example, price volatility increased in northern states after the border closure, but it fell in the rest of the country.[16] For sesame, price volatility increased in northern states but remain unchanged in the rest of the country after the border closure, while for millet, volatility remained relatively stable in northern states and fell in the rest of the country after the border closure. For wheat flour, instead, volatility decreased in northern states, but remained stable in the rest of the country.

Table 3: Price Volatility: Before and After the Border Closure, For Northern and Southern States

Volatility	Broad Beans	Groundnuts	Maize	Millet	Sesame	Sorghum	Wheat Flour
Border Closure	0.0484***	-0.0624**	-0.0288	-0.084***	-0.0231	0.0605***	-0.00092
	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.01)	(0.02)
Northern States	0.0732***	-0.0163	-0.053**	-0.128***	-0.071***	0.0467***	0.0271
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
Border Closure X Northern States	-0.079***	0.199***	0.122***	0.0647*	0.0592**	0.00279	-0.083***
	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)
Constant	0.0719***	0.186***	0.173***	0.233***	0.167***	0.0736***	0.183***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
Observations	251	378	289	303	275	452	289
R-squared	0.073	0.128	0.045	0.121	0.05	0.157	0.067

Source: Authors' calculations

3.4. Market Integration

The presence of high price differences for a given product in two different cities does not necessarily reflect lack of integration between these two markets. In fact, the notion of market

[16] Formally, we test these statements by jointly testing the significance of the border closure effect and the interaction term of border closure and northern states. For groundnuts we reject the null of the sum of the border closure coefficient and the interaction being equal to zero at any conventional level of significance (the test statistic is distributed as F (1, 374), and it takes value 28.41, p-value=0.000). The same results are obtained for maize (F(1, 255)=11.99, p-value=0.0006)).

integration is compatible with significant price differences as long as these differences are relatively stable over time, or they reflect the evolution of logistic and overall trade costs. Thus, in addition to examining spatial price differences, we also test whether the different sub-markets across South Sudan, for each of the products being analyzed form one market in which demand and supply shocks are transmitted across the country, regardless where they are originated, and therefore its effect gets dissipated. As mentioned above, spatially separated markets of a homogeneous product are considered to be 'integrated' when they are connected by trade or its possibility in a way in which price differences for a given pair of regions reflect, in the long term, the costs of trading between them.[17]

Empirically, to assess the extent of spatial integration, either between domestic and world prices or between the prices in two given cities in South Sudan, we analyze how the price series under consideration co-move. We report correlation coefficients of the price levels and their changes, and then follow Engle and Granger (1987), and use a 2-step procedure. The first step consists of estimating a long-run static relation between every possible pair of price series p_{it} and p_{jt}, corresponding to regions i and j respectively, as in equation (1):

$$p_{it} = \beta_0 + \beta_1 p_{jt} + u_t \qquad (1)$$

A pair of regions *i* and *j* are *integrated* forming one market, if prices in region *i* and *j* are integrated of order 1 (I(1)) and share a stochastic trend, which implies that there exists a linear combination of p_i and p_j that renders *u* in equation (1) stationary.[18] Operationally, testing for spatial integration implies estimating equation (1) testing for a unit root in the estimated residuals, $\hat{u}$, and rejecting the null. In the second stage, we look at the dynamics, estimating the following relation:[19]

$$\Delta p_{i,t} = \alpha_0 + \sum_{n=1}^{12} \beta_n \Delta p_{i,t-n} + \sum_{n=1}^{12} \gamma_n \Delta p_{j,t-n} + \delta \hat{u}_{t-1} + \varepsilon_t \qquad (2)$$

The lag length is chosen using the Akaike information criterion, and the price series are purged from their seasonal components in the estimation. From equation (2) we obtain information on short and long run dynamics.

1. Short Run: short run responses of prices in region *i* to prices in region *j*.[20]

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[17] For a detailed description of the methodology to test for market integration see **Error! Reference source not found.**.

[18] We control for a deterministic trend in the long run relation.

[19] The unit root tests are augmented Dickey Fuller, with the choice of lags being determined by the Akaike Information Criterium. Because the test is performed on the residuals from equation (1) that are estimated with error, the critical values are non-standard. We used the critical values tabulated by Engle and Yoo (1987). For brevity sake, these results, as well as the estimates of β2, which represent the pass- through coefficient from region j to region i are only summarized here. The full set of results is available from the authors upon request.

[20] We could also obtain information on whether one regional price series Granger-causes another regional price series, by testing the joint significance of the twelve γ coefficients. If they are jointly significantly different from zero, that

2. Long Run: whether the regions are integrated (an additional test to that discussed above), and a measure of integration. If *i* and *j* are integrated, then prices share a long run stochastic trend. In the short run, misalignments from the equilibrium may exist, and they are captured in uˆ. If $\delta < 0$, these are corrected period after period. If no correction process exists (either because $\delta = 0$ or $\delta > 0$), then there is no long run relationship between the two price series. Therefore, the negative sign and the significance of this coefficient constitute another test of market integration. Its size is a measure of integration and indicates how much of the disequilibrium is corrected every period. The more efficiently markets work, the faster information flows, and therefore, the faster these short run disequilibria will be corrected.

We choose the Engle-Granger approach to more sophisticated techniques such as those of Johansen (1988) or Stock and Watson (1993). Our decision is based on three elements. First, the Engle-Granger approach is intuitively appealing and consists, essentially, of a careful examination of relative prices. Second, Johansen and Stock and Watson's techniques have proven to outperform Engle-Granger in large samples. These techniques rely on asymptotic properties (their estimators are obtained through maximum likelihood techniques), which fail to hold in small samples like the ones we are using in this study. Third, Johansen's techniques are superior to Engle-Granger when the cointegration analysis is multivariate. Our analysis is bivariate.

For each product considered and for which necessary data were available, we tested for market integration of each state capital with the market in Juba, and report the results in **Error! Reference source not found.** to **Error! Reference source not found.**. Market integration in fuels was not explored since prices in Juba showed no variability, neither for diesel, nor for gasoline, which, on one hand prevents an adequate fit of the model, while on the other hand, and given that fuel prices vary substantially in other cities, it suggests the lack of integration of fuel markets in the first place. In addition, the analysis was only performed when we had at least 15 periods of consecutive price records. For certain state capitals, the price series were too short, so they were excluded, since short series limit the degrees of freedom of the estimation and undermine the conclusions that can be drawn from the results.

From a product perspective, results indicate that markets are most integrated for wheat flour, sorghum and groundnuts. For those products, prices in at least four state capitals co-move with prices in Juba. In contrast, for sesame, millet and broad beans, and to a lower extent maize, markets appear more segmented.

From a geographical perspective, results indicate that Aweil and Wau tend to form a market with Juba (with different degrees of intensity) for all products considered. On the other hand, Bentiu and Malakal display more isolated markets (the former only displays weak integration with Juba's sorghum markets and no integration for all other products). Markets were considered to be integrated with Juba when two conditions held: (1) the cointegration test on the long run relationship was passed (the null of a unit root in the residual of the long run relationship was

implies that lagged prices in j are relevant to explain (and therefore predict) prices in i. That analysis is out of the scope of this paper.

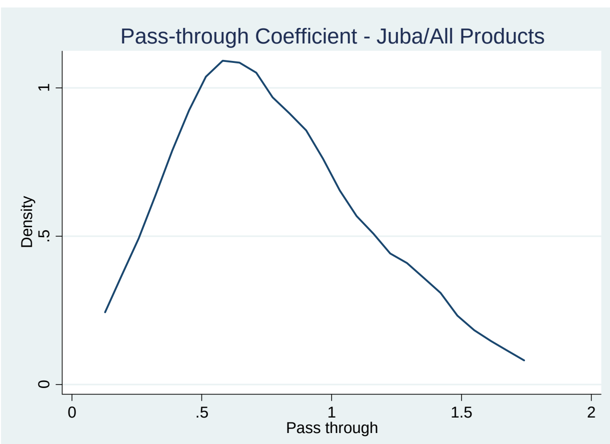
rejected at 20 percent significance), and (2) the speed of adjustment to shocks was statistically significant. Markets were considered to be *weakly* integrated with Juba if only (1) or (2) held.

For those markets that show some degree of integration, transmission of price shocks is incomplete and slow and highly heterogeneous by market and by product.

The pass-through coefficient, that shows the long run effect of a shock to prices in Juba, to prices in a given state capital, for a given product, varies substantially depending on the product and on the state capital. For example, a shock to groundnut prices in Juba, implying for example, a 1 percent increase, is associated with an increase in groundut prices in Rumbek of about one-third of a percentage point in the long run. However, if the same shock affects the prices of sorghum in Juba, transmission is almost complete: in the long run, sorghum prices in Rumbek will end up increasing by 0.84 percent. Figure 4 plots the distribution of the estimated pass-through coefficients across cities and products, reflecting heterogeneity in the extent of the transmission.

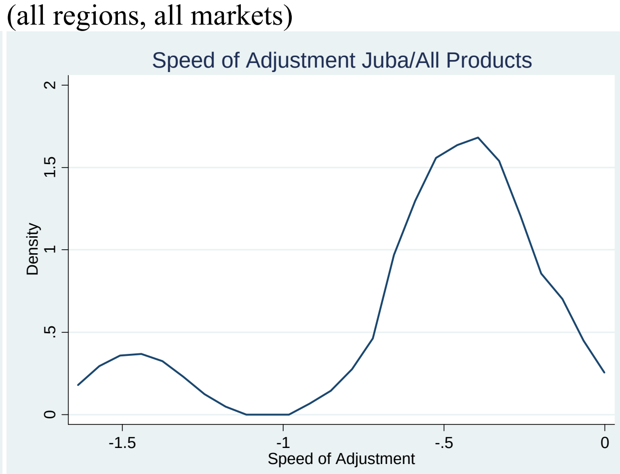
Similarly, the speed at which markets adjust prices after a shock in the capital city is heterogeneous, and often slow. Figure 5 plots the distribution of the estimated speed of adjustment to shocks that bring markets to temporary disequilibria, and also reveals substantial heterogeneity. For example, the aforementioned price adjustment in Rumbek after a 1 percent increase in sorghum prices in Juba will not be automatic. Our estimates of the speed of adjustment to equilibrium in that market for that product reveal that 45 percent of the adjustment will take place in the first month. However, the speed of adjustment to the same shock in Wau reveals that only 11 percent of the shock will be adjusted in the first period.

Figure 4: Distribution of estimated pass-through of shocks in Juba's prices (all regions, all markets)



Source: Authors' calculations based on WFP data.

Figure 5: Distribution of estimated speed of adjustment to equilibrium after a shock to prices (all regions, all markets)



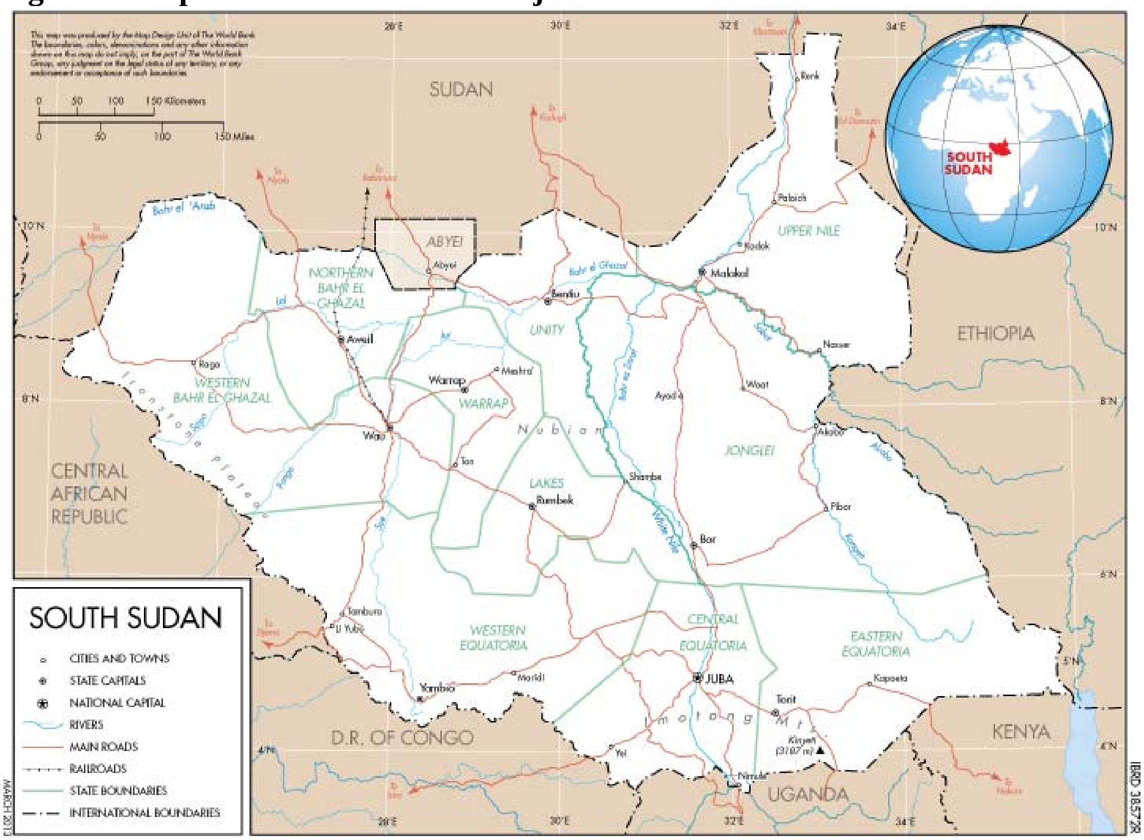
Source: Authors' calculations based on WFP data.

3.5. Determinants of Price Differences

As documented above, price differences for narrowly defined products are heterogeneous across the country, as well as the degree of integration of relevant regional markets. This stresses the importance of understanding the drivers of these differences. Understanding whether price differences, for example, are driven by distance, poor infrastructure, fuel costs, or other factors give essential information to the policy-maker about allocating scarce resources to increase the availability and accessibility of key staples to the poor.

Given the structure of the data, this section examines econometrically the determinants of price differences across different cities of South Sudan (Figure 6). It would have been interesting to examine determinants of market integration measures (pass through and speed of adjustment), however, the short time-period with available data prevents us from calculating time-varying pass-through and speed of adjustment coefficients, which eliminates the scope for an econometric analysis of their determinants. Instead, price differences exhibit three sources of variation to exploit: by commodity, by city and over time.

Figure 6: Map of South Sudan with major roads.



Source: World Bank.

Descriptive Statistics

Table 4 shows that Aweil is the most remote region from Juba, while Bor is the closest, being 794 and 199 kilometers away, respectively. Bor presents the largest network of roads in km followed by Malakal, whereas Bentiu has the smallest network. The road grade, measured as the fraction of primary roads of all roads, is higher in Bor than in the rest of the regions, while Aweil and Wau exhibit the lowest fraction. Road density per square km (or road area) is highest in Aweil and almost three times higher compared to Wau, which is the least dense region. Finally, the density of roads per capita is largest in Wau and then the rest of the regions present roughly the same numbers. There are other factors that play a role in how easy it is to travel from one city to Juba, such as the amount of formal and informal tolls needed to pay at checkpoints, as well as the number of checkpoints in given routes. Unfortunately, the systematic data required to add this element into the analysis are not available. However, an informative discussion is presented in Box .

Table 4: Transport-Related Conditions by State Capital

	State's Road Length	Road Grade	Road Area	Road Density	Distance to Juba
Aweil	1487	0.310	0.049	0.0021	794
Bentiu	1029	0.359	0.027	0.0018	736
Bor	3058	0.448	0.025	0.0023	199
Kajok	1527	0.319	0.034	0.0016	713
Malakal	2280	0.322	0.030	0.0024	588
Rumbek	1416	0.324	0.032	0.0020	418
Wau	1497	0.310	0.016	0.0045	643

Note: Road length indicates the total length of roads in kilometers within each state; road grade is the fraction of primary roads in all roads. Road area is the density of roads per square kilometer in the state; road density is the density of kilometers of roads per capita in the state. Available data are constant for the period 2008-2013. Distance is the road distance from the indicated state capital to Juba.
Source: Authors' calculations based on World Bank 2014a

Box 1: Checkpoints in South Sudanese Routes

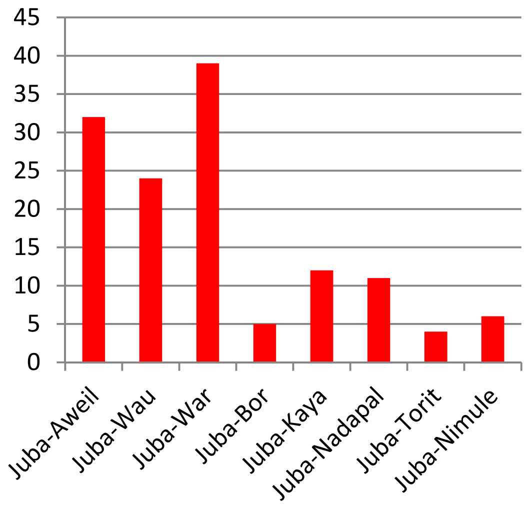
Price differences across food products across a country are not only driven by fuel prices, distances, quality of networks, and demand and supply conditions, but also by a variety of restrictions to trade and transit along routes, which are often difficult to quantify systematically.

A survey implemented in November-December 2010 and commissioned by the Ministry of Finance and Economic Planning of South Sudan quantified the time and monetary costs of authorized and unauthorized check-points along the major trade routes in South Sudan. To do this, authors made 147 journeys in commercial vehicles along major roads in South Sudan and collected detailed information on the number and location of check-points, payment and time waited, and officials present. A summary of the main results is presented here.

There are many check-points along major trade routes through South Sudan, both authorized and unauthorized. These check-points are justified on grounds of ensuring security of citizens, among other reasons. However, unauthorized payments and time consuming stops along trade routes can inflate prices for consumers. In addition time consuming processes at the road blocks adds to the delivery time of products and further raises the costs incurred by final consumers. The survey provides detailed information on the location of checkpoints along major routes, as well as time spent waiting at checkpoints and charges paid.

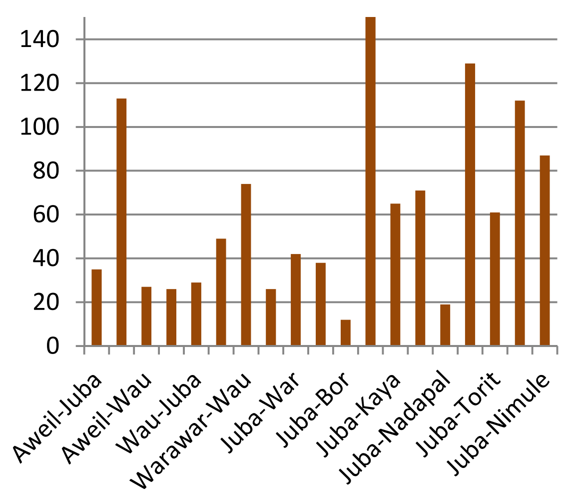
Over all routes surveyed, there was an average of more than two hours waiting per 100km and for most routes payment per 100km exceeded 200 SDG. Small check-points tend to affect low-value cargoes more, since payment does not vary significantly with the value of cargo. These checkpoints are detrimental to the development of industry and internal markets in South Sudan, and ultimately on consumers' welfare and poverty reduction possibilities.

Figure 7: Number of Check Points in Selected Routes



Source: NBS (2011)

Figure 8: Time Spent at Check Points as % of Total Travel Time



Source: NBS (2011)

Source: Authors' elaboration based on NBS (2011).

Market conditions typically matter for integration and price differences. Among all regions in South Sudan, Jonglei (containing Bor) is the largest region, while Northern Bahr el Ghazal (containing Aweil) is the smallest one (Table 5). In terms of cereal production, Kajok shows the highest, while Bentiu the lowest. When taking into account cereal requirements, the cereal deficit is larger in Bor than in the rest of the regions, whereas Wau, in the fertile Greenbelt, presents the smallest deficit. The Consumption and consumption per capita are highest in Wau and Malakal, respectively, and on the other side stand Wau and Aweil as the lowest regions for the mentioned indicators, respectively.

Table 5: Market Conditions By State Capital

Market	*Cereal Production*	*Cereal Surplus*	*Area*	*Consumption PC*	*Consumption*
Aweil	60,457	-36,780	30,543	60	48,600
Bentiu	19,210	-38,793	37,837	72	38,500
Bor	65,177	-74,615	122,581	98	118,000
Kajok	107,239	-8,976	45,567	67	80,500
Juba	100,103	-43,474	43,033	127	140,000
Malakal	41,044	-45,598	77,283	144	153,000
Rumbek	70,370	-13,382	43,595	110	75,000
Wau	42,666	-2,814	91,076	114	35,500

Note: All figures refer to the states where the towns are located. Cereal production in net, cereal deficit is the difference between production and consumption (and it is reported as the average over 2008-2013), area is expressed in squared kilometers, consumption expresses total consumption in thousands, as indicated in the Household survey for year 2012-2014, consumption per capita is the ratio of consumption and population.
Source: Authors' calculations based on FAO/WFP. 2012-2014

3.6. City Characteristics and Price Differentials

When markets are integrated and well-functioning, the price difference of a homogeneous product across regions converges to the cost of trading that product across the regions through the forces of arbitrage. The costs of trading include, for example, transportation and intermediation costs, and other costs related to, for example, overcoming regulatory obstacles that restrict trade. However, high transport costs, imperfect markets and barriers to trade may prevent arbitrage, resulting in market segmentation and high price differences between geographically separated locations, with associated welfare costs.

When markets are segmented, price dynamics in each region matter for price determination. In that case price differences may be associated with supply or demand conditions (differences in production costs, resource endowments, or with consumer preferences and market size).

To what extent do the heterogeneous characteristics of state capitals related to supply and demand conditions, and to trade costs can explain the observed patterns of price differences in South Sudan?

Methodologically, to identify the effects of state-capital characteristics on the price difference of a variety of products in each of these state-capitals relative to the price in Juba we estimate the following model:

$$p_{a,i,t} - p_{a,Juba,t} = a_{ai} + \beta_1 tc_{it} + \beta_2 d\,\&\,s_{it} + \beta_3 border_t * north_i + u_{a,i,t} \qquad (3)$$

were p is the price of product *a* in city *i* at time *t*, a is a commodity-city fixed effect, tc is a vector of transportation cost related variables, including: the price difference of diesel in city *i* relative to the price in Juba, the road distance from city *i* to Juba, the road length and the road quality of the mentioned route and the observed rainfall on those roads from *i* to Juba during time *t*. d&s include variables that affect demand and supply conditions in the market, given transportation costs, and include consumption per capita in city *i* at time *t*, and cereal production in the state corresponding to city *i* at time *t*. u is an error term. 'Border' is a step dummy that takes value one in periods after the border closure, and zero before, while 'north' is a dummy taking value one for cities in northern states that share border with Sudan, and are therefore likely to be more affected by border closure measures. Standard errors are clustered at the city level, to control for likely correlations of price-differentials within city, as suggested for these types of panel structures by Bertrand, Duflo, and Mullainathan (2004).

The inclusion of commodity-city fixed effects wipes out the role of any time-invariant city, commodity or city-commodity specific factor, such as distance between city *i* and Juba. For this reason, in some of the specifications, the commodity-city fixed effect is substituted for a commodity fixed effect and the role of distance (and other time-invariant factors) on price differences is estimated. Alternative specifications introduce commodity-year fixed effects, acknowledging the fact that specificities about commodities that vary over time may affect price differences.

Robustness checks & further hypotheses

Interactions between transport characteristics

The effects of diesel prices that vary substantially across cities, on food price differences, are likely dependent on the degree of remoteness (distance) of the city with respect to Juba. So, in addition to the level effects of distance and diesel prices, we include an interaction of fuel distance. Similarly, and given that rainfall affects the quality of roads, it is likely that the effect of distance on price differences is mediated by rainfall, and similarly, the effect of road quality on price differences. All of these interactions are explored.

Product Specific Models

The baseline specification of equation (3) is estimated separately for Sorghum and Millet. Given that these two products are key staples, it is likely that their prices are better tracked over time, with an impact on the quality of the data set.

North and South State- Specific Models

To understand whether the effects of transportation and market condition related variables affect price differences in a homogeneous way regardless of their location, we estimate equation (3) separately for northern and for southern states.

Results

Up to 33 percent of the variation of price differences across cities can be explained by variables that capture transportation costs, including fuel price differences, road distance and quality of roads (Table 6).

Efforts conducive to the reduction of fuel prices across the country will improve livelihoods not only through the direct effect of fuel prices on people's welfare, but also because it will substantially reduce food prices. Indeed, differences in fuel prices across cities have an important role in explaining the differences in food commodity prices. The estimated elasticity of price differences in food commodities with respect to price differences in fuel prices ranges between 0.12 and 0.146, implying that a 1 percent increase in fuel prices in a given city relative to fuel prices in Juba, leads to an increase in food prices of between 0.13 and 0.16 percent relative to prices in Juba, all other things being held equal.[21]

The role of road distance in explaining price differences is not as expected. Our results suggest that cities that are further away from Juba face lower price differences for the food products considered.

The quality of the road network also matters. Both the length of roads and the quality of roads (road grade) are relevant determinants of price differences, although their effects are not systematically significant across specifications. On average, increasing the portion of primary roads from the sample average of 0.34 to 0.44 (that is, an increase of 10 percentage points) would reduce price differences by between 26 and 66 percent. Increasing road length by 10 percent (i.e. increasing average road length from 1761 kilometers on average to 1937), price differences would drop by 2 percent.

Supply and demand conditions in the market also play a role in explaining price differences across cities. Richer cities tend to pay higher prices for the food products considered, given that consumption per capita (an indicator of income per capita) is positively and significantly associated with price differences. It is also likely that this variable captures the fact that in relatively richer cities, the quality of the traded product is likely better than in relatively poorer cities, and therefore its price is also higher. The cereal surplus effect suggests that cities with a greater cereal deficit tend to have greater price differences with respect to Juba (although statistically insignificant). The *a priori* expected sign for this effect is ambiguous. As cities' cereal deficits increase, they need to engage in inter-city trade, which should lead to a reduction in price differentials. On the other hand, greater cereal deficits would increase demand for the product domestically, increasing its price relative to other cities.

The border closure has led to an increase in price differences to northern states, of about 6 percent, on average. After taking into account the role of transportation costs and idiosyncratic demand and supply conditions, the closure of the border with Sudan does not seem to have a statistically significant effect on price differences for southern states, but significantly increased price differences for the northern states of Western and Northern Bahr el Ghazal, Warrap, Unity and Upper Nile.[22] The border closure, however, does not seem to have had product-heterogeneous effects on price differences.

[21] It is worth mentioning that these results could also be related to unobserved changes in demand conditions in the cities or to other city-specific shocks that affect both fuel and food prices.

[22] The effect is calculated as: exp(0.083-0.027)-1. To formally test this hypothesis, we look at the joint significance of the level effect of the border closure plus the effect of the interaction of border closure with the northern dummy is significantly different from zero. The null is rejected at 5 percent significance (the test statistic is distributed $F(1, 7)$, and it takes value 5.86).

3.7. Alternative Specifications

Interactions of Road Network Characteristics

We examined different ways in which road network characteristics could interact in their effect on price differences. Results are reported in **Error! Reference source not found.** in the Appendix. None of the interactions significantly affects the results reported above. In fact, in most cases they are not statistically significant.

North-South Specific Models

Distinct models were run for northern cities and for the rest, separately. Results are reported in **Error! Reference source not found.** in the appendix. The reduction in the sample size results in the loss of statistical significance for the model fitted on northern cities.

Sorghum and Millet Specific Models

Product–specific models were fitted for sorghum and millet. Both are key staples for South Sudanese, which is likely to be associated with better quality of the data. At the same time, by losing the cross-commodity variance, degrees of freedom are lost in the estimation. Results for these models are presented in **Error! Reference source not found.** in the appendix. In both cases, only transport cost related variables retain significance.

Table 6: Determinants of Price Differences in Food Markets in South Sudan

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Price Differential of Diesel	0.145	0.144*	0.146*	0.112*	0.118*	-0.37	-0.47	-0.18	0.54				
	(0.07)	(0.07)	(0.07)	(0.05)	(0.05)	(0.36)	(0.34)	(0.43)	(0.36)				
*Distance to Juba*Price Differential of Diesel*						0.00	0.00	0.00	0.00				
						(0.00)	(0.00)	(0.00)	(0.00)				
Distance to Juba						0.00	-1e-3**	-1e-3***	-1e-3***	-9e-4**	-9e-4**	0.00	0.00
						(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Road Grade (to Juba)							-3.22	-2.6*	-6.61***	-3.83**	-3.82**	-3.87*	-4.11**
							(1.77)	(1.09)	(1.29)	(1.42)	(1.4)	(1.64)	(1.43)
Road Length								0.00	-2e-4**	0.00	0.00	0.00	0.00
								(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Differential of Consumption Per Capita									0.00	0.00	0.00	0.00	0.00
									(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cereal Surplus			0.00	0.00					-4e-6**	0.00	0.00	0.00	0.00
			(0.00)	(0.00)					(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Average Rainfall on the road (to Juba)		0.00	0.00										
		(0.00)	(0.00)										
Northern State Dummy												-0.03	-0.04
												(0.15)	(017)
Border Closure Northern State Dummy*												0.04	0.07
												(0.04)	(0.03)
Border Closure										-0.04	-0.05	-0.07	0.00
										(0.04)	(0.05)	(0.06)	(0.05)
*Border Closure*Beans*											0.08		
											(0.05)		
*Border Closure*Groundnuts*											-0.02		
											(0.07)		
*Border Closure*Maize*											0.01		
											(0.08)		
*Border Closure*Millet*											-0.1		
											(0.1)		
*Border Closure*Sesame*											-0.05		
											(0.05)		

*Border Closure*Wheat*											0.05		
											(0.05)		
Constant	0.30***	0.31***	0.31***	0.31***	0.36***	0.72*	2.18**	2.28**	3.5***	2.38**	2.28**	2.29**	2.36**
	(0.03)	(0.04)	(0.08)	(0.06)	(0.04)	(0.32)	(0.79)	(0.567)	(0.34)	(0.61)	(0.64)	(0.84)	(0.73)
Month Fixed Effects	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Commodity Fixed Effects	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No
Commodity-City Fixed Effects	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Commodity-Year Fixed Effects	No	No	No	No	No	No	No	No	No	No	No	No	Yes
Clustered Standard Errors	City Level	City Level	City Level	City Level	City Level	City Level	City Level	City Level	City Level	City Level	City Level	City Level	City Level
Observations	557	557	557	557	557	557	557	557	557	1613	1613	1613	1613
R-squared	0.02	0.02	0.02	0.07	0.07	0.12	0.22	0.25	0.33	0.17	0.34	0.17	0.23
Number of commmkt1	52	45	45	52	52								

Clustered standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Source: Authors' calculations .

4. Implications for Poverty

What would be the welfare implications of modifying the relevant factors determining the price differentials in South Sudan? To address this question, we match the expected price effect arising from changing a specific determinant with the only household survey data available, i.e. the 2009 National Baseline Household Survey (NBHS). These need to be interpreted as partial equilibrium effects (i.e. everything else equal). Among the possible factors, we consider road quality and diesel price as those are amenable to policy interventions and are significant determinants of price differentials in **Error! Reference source not found.**. .

Due to data limitations the estimation relies only on the welfare effects via consumption but not via production.[23] The basic principle consists of applying the changes in prices faced by the household from modifying a specific factor to the overall household's tradable expenditures.

We start from the consideration that households minimize a household expenditure function C(u,p), which finds the minimum cost to attain utility level u given prices p (Deaton and Muellbauer, 1980; Friedman and Levinsohn, 2002). Any changes in the vector of prices that the household is exposed to would have a direct impact on its consumption, which can be measured as $\Delta C \approx q \times \Delta p$ where q is a vector of quantities consumed and Δp is a vector of price changes. This expression approximates the compensating variation, i.e. the change in income required to restore the household to the pre-price change utility level. The expression can be re-formulated in terms of initial expenditures of household j introducing the distinction between goods produced and consumed:

$$cv^j \approx \sum_{i=1}^{N} \frac{(P_i^j - S_i^j)}{Exp^j} \times dlnp_i \qquad (3)$$

Where P is the purchase of household j of good i, S is the sale and Exp is the total initial expenditure of household j. Expression (3) defines the effects of price changes on the basis of whether the household is a net seller or buyer of good i. In the former case the compensating variation for the price change of i will be negative (i.e. a positive effect of price increase). The variable dlnp is the change of the natural logarithm of price for good i.

This is an approximation of the compensating variation as there are two missing elements. First, changes in prices may also be associated with changes in wage income for the household members' working in the production of good i. Second, households could respond to the change in relative prices by changing the allocation of expenditures across consumption items. In particular they would tend to shift towards the consumption of relatively cheaper items to stay on the highest possible indifference curve. Due to data limitations, we do not take into account either of these two elements, which is likely to bias our estimates of the impact of changes in prices on welfare upwards (in absolute terms). However, the size of this bias should be moderate for two reasons: first wages take time before adjusting to price changes; second, South Sudan produces only half of what it consumes, so other goods which the households may try to switch to in response to price changes may also be imported and thus be subject to similar price changes. In case they are

[23] See Calì and Varela (2013) for a detailed discussion on these limitations.

produced locally, and the supply response is not elastic, their prices would also increase. Thus the extent of substitution following price changes may effectively be moderate.

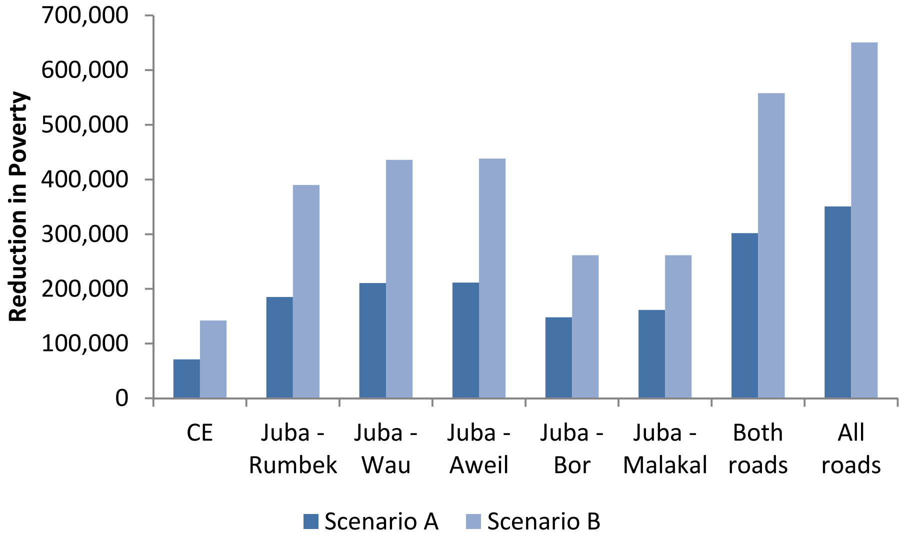
A more important limitation of our estimates is the absence of data to compute S (sale) in equation (3), which will induce a potentially relevant upward bias in the estimate of cv. The size of the bias will depend on the amount that households could sell on the market for the various goods we consider. We shall keep that in mind when interpreting the results of the estimation.

This approach relies on three further assumptions. First, we assume that all of the tradable goods' prices change by the same proportion following the shock. That is as reasonable an assumption as we can make in the absence of more disaggregated information. That is also reinforced by the fact that the coefficients in the above analysis are not statistically different across commodities. Second, due to data limitations we have also to assume no substitution between tradable and non-tradable products and no effect on the prices of non-tradables from the tradables price changes. The second and third assumptions generate biases that under-estimate the poverty reducing effect of the induced price changes. In this sense we consider our estimation to represent a lower bound of the effects of the deepening of the market integration.

We first simulate the impact of upgrading all the state-level roads to the quality of primary roads. Taking the lower bound coefficient of -3.22 from column (7) in **Error! Reference source not found.**, a 10 percentage point higher fraction of primary roads in a state would reduce the price differential between the state capital and Juba by 32 percent (). With an average of around 30 percent of primary roads per state, a complete upgrade implies an increase of primary roads by about 70 percentage points. This translates into a price reduction of about 39 percent for tradable goods as the average prices in the states are 48 percent higher than in Juba. Applying this reduction in price to equation (3), we estimate that the average consumption of tradable goods increases by 63 percent on average. With about 45 percent of tradable consumption for the average household, this road improvement increases total consumption on average by 28 percent. The computations with the upper bound coefficient -6.61 (derived from column 9 in **Error! Reference source not found.**) yields an average increase in consumption of 57 percent. Hence, the first-order impact of upgrading the quality of all roads to that of primary roads increases total consumption by between 28 percent and 57 percent for the average household.

A simulation confirms the results of the back-of-the-envelope calculation. Based on the NBHS 2009 data for South Sudan, the impact of the price reduction due to road improvement can be simulated. As Juba in Central Equatoria is the reference for the price differential, the impact of road improvement in Central Equatoria is simply estimated as the average price consumption effects per tradable item over the remaining states. We use the lower (-3.22) and the upper bound (-6.61) for the elasticity of reduction of the price differential with respect to road improvement . The simulation considers upgrading major roads connecting the state capitals assuming that the upgraded roads would yield a road quality of 100 percent for the corresponding states.

Figure 9: Reduction in poverty from first-order effects of road improvement.



Note: Scenarios A uses a lower bound estimate for the elasticity of reduction in the price gap relative to road improvement (-3.22) while scenario B uses the upper bound (-6.61).

As visualized in Figure 9, upgrading the roads only in Central Equatoria would reduce poverty by 71,000 to 142,000 people, depending on the scenario. Adding Rumbek, Wau and Aweil to the upgraded road network could reduce the number of poor people by up to 438,000. A second road from Juba to Malakal could reduce poverty by up to 262,000 people. Both roads together have the potential to lift 558,000 people out of poverty. Finally, upgrading roads in all states would remove another 93,000 people from poverty. Reducing poverty by a 651,000 people translates into a reduction of the poverty rate by 8.9 percentage points, from 51.7 to 42.8 percent using the 2009 poverty estimate.

Second-order effects are likely to be even more substantial, although we are unable to estimate them with the data at hand. Several second-order effects would further contribute to an improvement of consumption for households. The reduction in prices would also increase trade volumes exacerbating price reductions and increasing consumption and production. This type of extensive margin of the gains from connecting markets is likely to be of a larger order of magnitude than the static effects we are capturing (Donaldson, 2014). Lower input costs would also reduce production costs. Hence, the overall impact of road improvement on poverty is likely to be considerably higher than that estimated by the first-order effects only.

5. Conclusions

This paper has examined the possible welfare implications of increased market integration using the case of South Sudan. Market integration of spatially separated regions implies linkages among them through trade or through the possibility of trade, so that the forces of arbitrage make the long-run price differences that remain among them equal to the costs of trading. To tackle this issue, we examined the evolution of prices of specific food products across different cities in South Sudan, and tested their short and long-run co-movement. We also explored patterns in price volatility in each of these markets, as well as the drivers of market segmentation and price differentials. Understanding the patterns of market integration is important from a policy perspective. Segmented markets are "blind", since producers cannot see what is highly valued and what is not, which prevents them from making optimal decisions.

We considered various food markets, namely, sorghum, maize, millet, wheat flour, sesame broad beans and groundnuts. In addition we also have examined price patterns of diesel and gasoline. The choice of products reflects the combination of their importance in the consumption basket of South Sudanese, and on data availability. The period analyzed spanned 2009 to 2013, with exceptions, again, due to data availability, while the cities considered were Aweil, Bentiu, Bor, Kajok, Juba, Malakal, Rumbek, and Wau.

The market integration analysis revealed four main results. First, markets in South Sudan are highly segmented. This is observed both when performing market integration tests – pass through coefficients are highly heterogeneous in size, and often not statistically significant, and similarly, the estimates of the speed of adjustment of price changes to shocks that bring markets away from long run equilibrium conditions. In addition, price differences across cities, for all considered products, are high, in some cases exceeding 100 percent. For key staples like sorghum, prices differ, from city to city, on average, by 43 percent over the period considered. These within-country price gaps are larger than those reported in the literature for food products between countries. The degree of segmentation, as measured by price differences across cities has not been constant over time. In fact for Sorghum and wheat flour, for example, it has increased after the imposition of trade restrictions with Sudan. This is likely related to the fact that the trade route of sorghum and wheat flour changed as a consequence of the border closure (in the recent years sorghum has been imported from Uganda and even from the USA).

Second, price volatility increased after the imposition of the trade restrictions with Sudan. These increases tend to hurt disproportionately the poor, who, due to liquidity constraints, cannot smooth purchasing decisions over time. Whenever there has been a change in price volatility over the period considered, it implied an increase rather than a decrease. For groundnuts and sorghum, for example, these increases have been geographically widespread when comparing the pre-border closure period with the post border-closure, affecting most of South Sudan's cities considered.

Third, transportation costs explain up to 33 percent of the variation of price differences in South Sudan, for the food products considered. Although some of these transport costs are geographical barriers difficult to alter, the most important factor affecting price differentials is related to the large gaps in fuel prices from city to city, that exceed 100 percent in some cases. Our estimates reveal that an increase in fuel prices of 1 percent above Juba prices lead to increases in food prices by up to 0.4 percent with respect to prices in Juba. The quality of the road network also play a significant role on price differences across the country. Improvements in the quality of the road network will help bring the markets closer to each other, reducing price differences, and increasing people's welfare, particularly for the poor.

Fourth, trade restrictions associated with the Sudan border closure in mid-2011 have increased market segmentation, particularly for cities in northern states. In fact, the border closure is estimated to have increased price differences in northern states by about 6 percent, on average. Although not quantified here, other restrictions to trade within the country in the form of formal and informal tolls that are charged in check-points throughout the country to users of the road network are also likely to increase segmentation.

The welfare gains from increased market integration via road construction are large. Upgrading all roads across states to primary roads would yield a first-order increase in total consumption by 28 to 57 percent for the average household. This increase would yield a reduction in poverty from the rate of 51.7 percent in 2009 to between 46.9 and 42.8 percent. These estimates have to be interpreted as conservative as they do not take into account the second-order effects of road construction, coming from the increased trade following due to the better road connectivity.

Our analysis has also provided a welfare-based comparison of the improvement of various roads, which can be helpful in guiding road infrastructure investments. The available data constrains our ability to make accurate estimations, but we believe this type of analysis could be replicated elsewhere to help prioritize investments on the basis of poverty reduction objectives. The findings also confirm the importance of connecting markets in order to reduce the exposure to shocks in other markets and thus the potential price volatility.

Road infrastructure is not the only policy to improve market integration. Our results also show that price differentials in the price of diesel also play an important role in maintaining high price gaps between towns. In addition, while the paper has not analyzed the issue, market intermediaries can be important drivers of price gaps and can appropriate welfare gains from lower prices (Atkin and Donaldson, 2014).

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Appendix

Table 7: Data Availability

Commodity	Aweil	Bentiu	Bor	Kajok	Juba	Malakal	Rumbek	Wau
Broad Beans	2010m2-2013m12	2010m7-2012m11	2009m5-2012m12	2011m5-2012m12	2009m5-2012m12	2009m3-2012m12	2009m10-2012m12	2009m5-2012m12
Red Beans	2013m1-2013m12	2013m1-2013m12	2013m1-2013m12	2013m1-2013m12	2013m1-2013m12	2013m1-2013m12	2013m1-2013m12	2013m1-2013m12
Cassava	N/A	N/A	N/A	N/A	2009m5-2012m12	N/A	N/A	2009m5-2012m12
Cassava Meal	N/A	N/A	N/A	N/A	2013m4-2013m12	N/A	N/A	2013m4-2013m12
Diesel	2012m1-2013m12	2012m1-2013m12	2012m1-2013m12	2012m1-2013m7	2012m1-2013m12	2012m1-2013m12	2012m1-2013m12	2012m1-2013m12
Gasoline	2012m1-2013m12	2012m1-2013m12	2012m1-2013m12	2012m1-2013m7	2012m1-2013m12	2012m1-2013m12	2012m1-2013m12	2012m1-2013m12
Groundnuts	2009m5-2013m12	2010m7-20123m12	2008m5-2013m12	2011m5-2013m12	2007m8-2013m12	2007m7-2013m12	2009m10-2013m12	2009m5-2013m12
Maize (White)	2007m9-2010m7 / 2012m3-2013m3	2012m4-2013m3	2008m5-2013m3	2012m4-2013m3	2007m8-2013m3	20010m9-2011m4 / 2013m1-2013m12	2009m10-2013m3	2009m4-2013m3
Maize (Grains)	2013m4-2013m12	2013m4-2013m12	2013m4-2013m12	2013m6-2013m12	2013m4-2013m12	2013m4-2013m12	2013m4-2013m12	2013m4-2013m12
Millet (White)	2007m9-2013m12	2010m9-2011m5 / 2013m4-2013m12	N/A	N/A	2008m8-2013m12	2006m1-2012m12	2013m4-2013m12	2006m12-2013m12
Oil (Cooking)	2013m4-2013m12	2013m4-2013m12	2013m4-2013m12	2013m6-2013m12	2013m4-2013m12	2013m4-2013m12	2013m4-2013m12	2013m4-2013m12
Sesame	2010m2-2013m12	2010m7-2013m12	N/A	2011m5-2013m12	2007m8-2013m12	2007m6-2011m4	N/A	2007m1-2013m12
Sorghum (White)	2007m9-2013m12	2010m7-2013m12	2008m5-2013m12	2011m5-2013m12	2006m1-2013m12	2006m1-2013m12	2009m10-2013m12	2006m12-2013m12
Wheat Flour	2009m5-2013m3	2010m7-2013m3	2009m5-2013m3	2011m5-2013m3	2009m5-2013m3	2009m1-2013m3	2009m10-2013m3	2009m5-2013m3

Note: Most series contain gaps, which are interpolated.

Table 8: Price Volatility Before and After Border Closure and Statistical Significance

Beans (Broad)	*Price Volatility Before*	*Price Volatility After*	*P-Value of Difference*
Aweil	14.3%	12.7%	67%
Bentiu	58.7%	16.1%	97%
Bor	11.0%	38.3%	0%
Juba	15.1%	26.8%	1%
Malakal	17.1%	24.3%	7%
Rumbek	8.2%	4.4%	93%
Wau	23.7%	19.4%	78%
Groundnut (Shelled)			
Aweil	24.4%	39.4%	2%
Bentiu	10.1%	16.4%	12%
Bor	26.5%	7.6%	100%
Kajok	74.0%	16.0%	100%
Juba	23.0%	23.4%	45%
Malakal	29.3%	72.6%	0%
Rumbek	25.0%	22.7%	64%
Wau	34.9%	58.9%	1%
Maize (White)			
Aweil	13.6%	81.4%	0%
Bor	23.3%	14.7%	97%
Juba	21.9%	13.3%	99%
Malakal	12.1%	10.2%	45%
Rumbek	29.7%	25.3%	71%
Wau	17.2%	18.9%	34%
Millet (White)			
Aweil	31.4%	5.3%	100%
Bentiu	9.9%	10.7%	43%
Juba	34.9%	26.3%	82%
Malakal	11.9%	22.9%	0%
Wau	17.8%	30.8%	0%
Sesame			
Aweil	14.7%	22.2%	6%
Bentiu	4.7%	22.8%	0%
Kajok	59.1%	25.3%	96%
Juba	27.4%	23.4%	77%
Rumbek			
Wau	21.7%	21.8%	48%
Sorghum (White)			
Aweil	14.8%	30.3%	0%
Bentiu	19.0%	21.1%	39%
Bor	8.5%	15.9%	0%
Kajok	15.8%	24.3%	47%
Juba	6.7%	11.7%	0%
Malakal	17.5%	19.7%	24%
Rumbek	13.5%	25.8%	1%
Wau	18.1%	21.2%	17%
Wheat Flour			
Aweil	20.6%	19.6%	58%
Bentiu	34.8%	14.4%	100%

Bor	19.9%	35.7%	0%
Kajok	10.9%	27.1%	31%
Juba	26.9%	24.2%	67%
Malakal	30.5%	11.5%	100%
Rumbek	25.7%	19.3%	85%
Wau	31.5%	9.8%	100%

Source: Authors' calculations based on data from WFP data.

Figure 10: Log Price Differences in Broad Beans

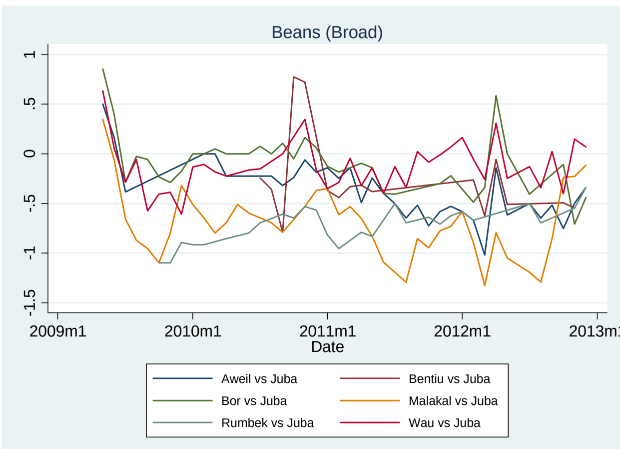


Figure 11: Log Price Differences in Groundnuts (shelled)

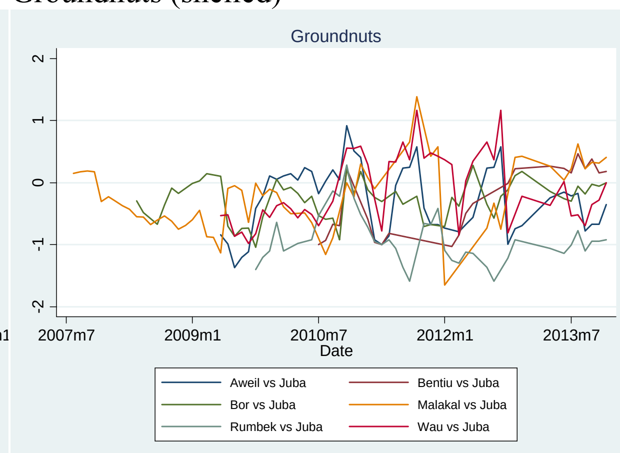


Figure 12: Log Price Differences in Millet (White)

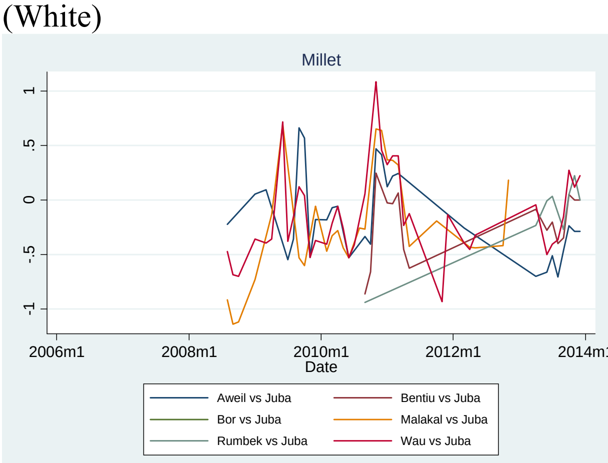
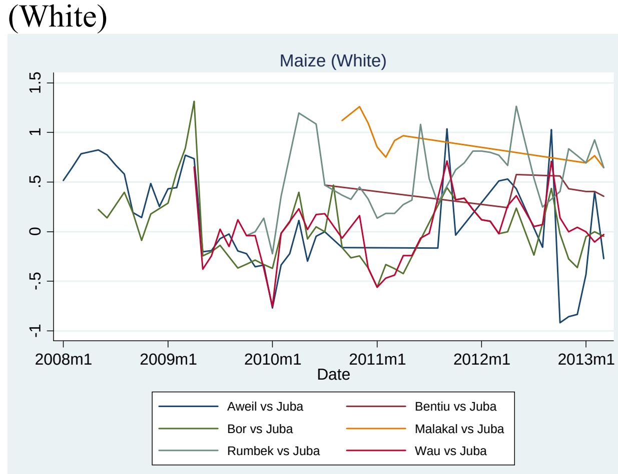


Figure 13: Log Price Differences in Maize (White)

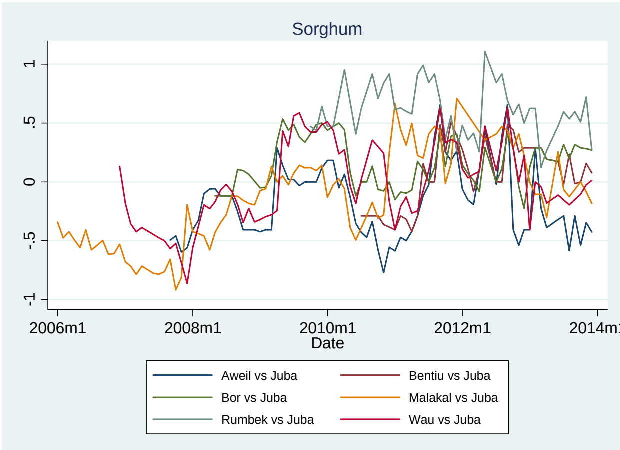


Source: Authors' calculations based on WFP data.

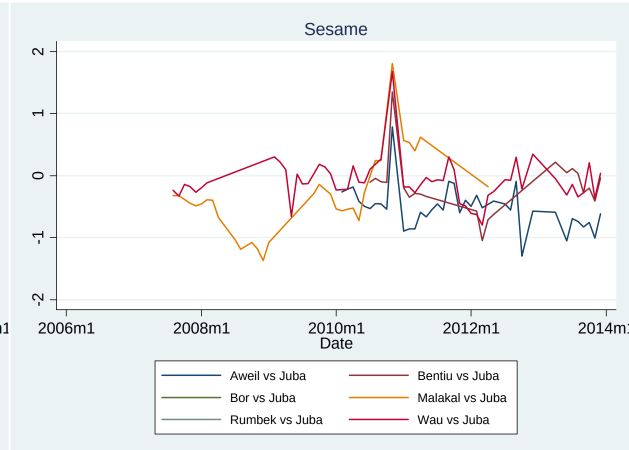
Source: Authors' calculations based on WFP data.

Figure 14: Log Price Differences in Sorghum

Figure 15: Log Price Differences in Sesame

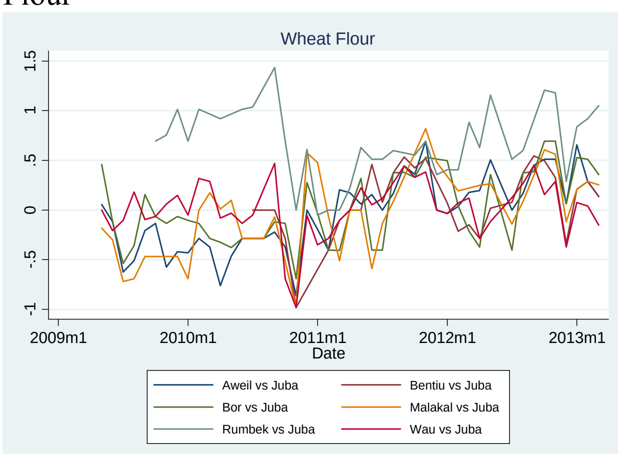


Source: Authors' calculations based on WFP data.



Source: Authors' calculations based on WFP data.

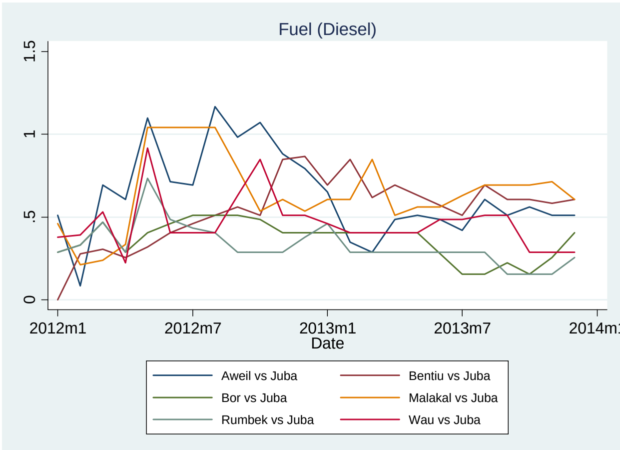
Figure 16: Log Price Differences in Wheat Flour



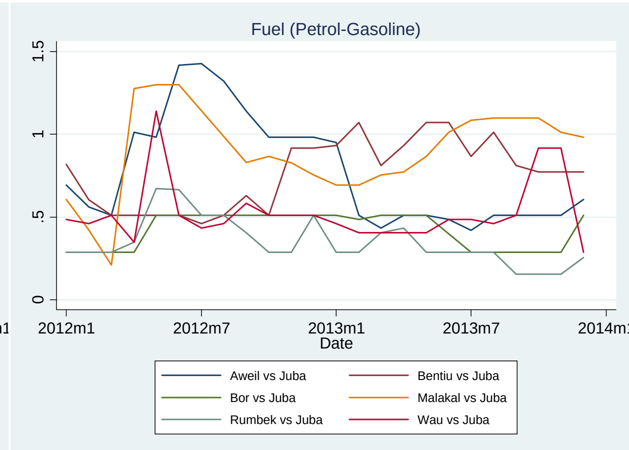
Source: Authors' calculations based on WFP data.

Figure 17: Log Price Differences in Diesel Fuels

Figure 18: Log Price Differences in Gasoline

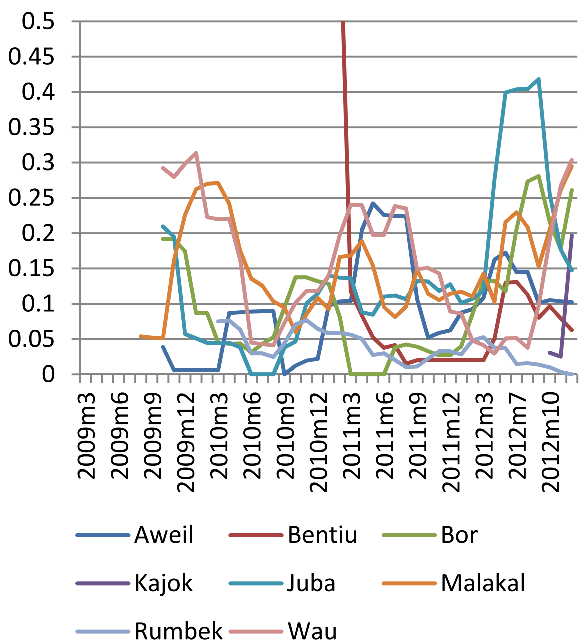


Source: Authors' calculations based on WFP data



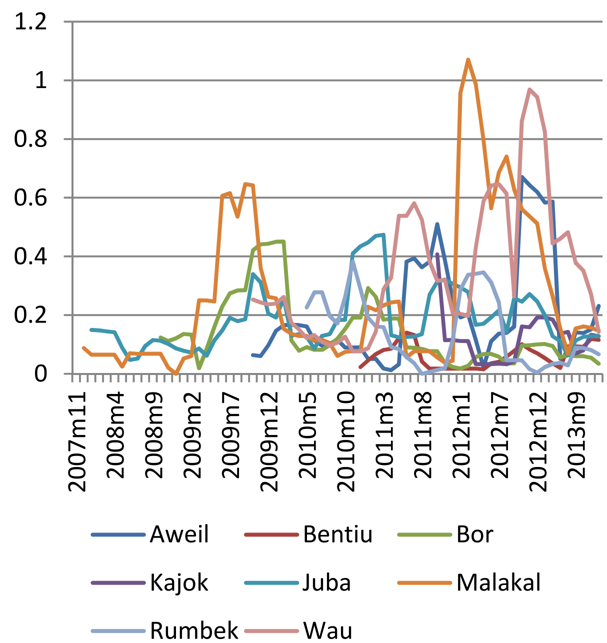
Source: Authors' calculations based on WFP data.

Figure 19: Rolling Standard Deviation of Rates of Change of Broad Bean Prices (2009m8-2012m12)



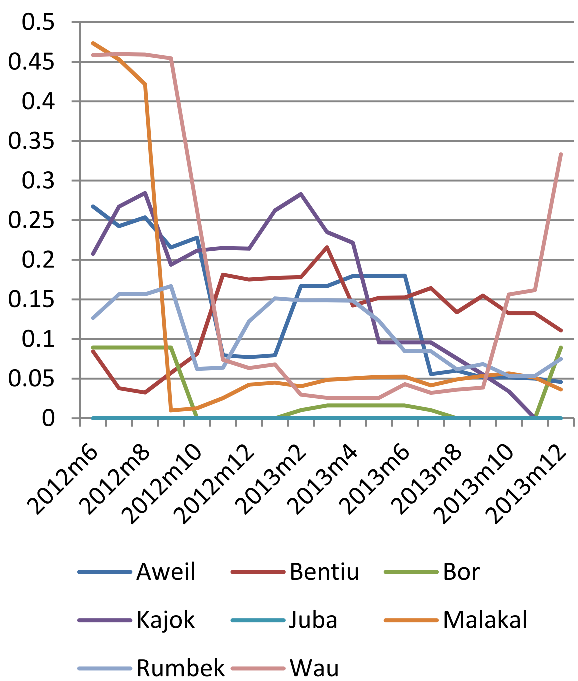
Source: Authors' calculations based on WFP data.

Figure 20: Rolling Standard Deviation of Rates of Change of Groundnut Prices (2007m12-2013m12)



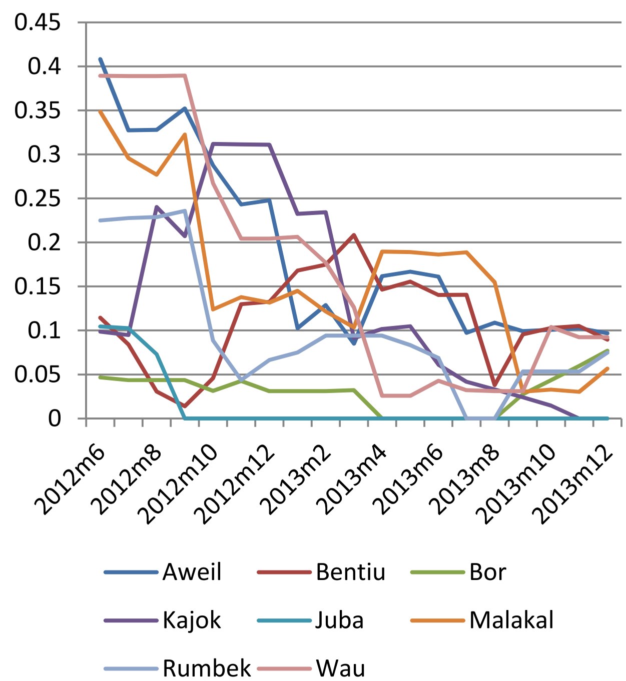
Source: Authors' calculations based on WFP data.

Figure 21: Rolling Standard Deviation of Rates of Change of Fuel (Petrol-Gasoline)
(2012m6-2013m12)



Source: Authors' calculations based on WFP data.

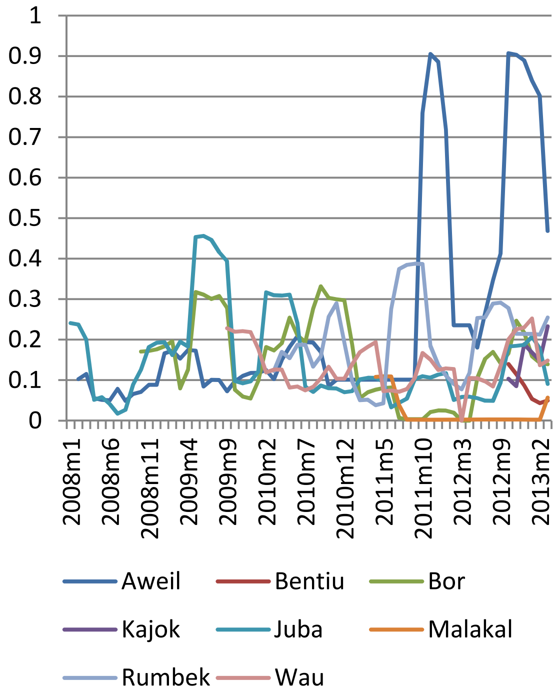
Figure 22: Rolling Standard Deviation of Rates of Change of Fuel (Diesel)
(2012m6-2013m12)



Source: Authors' calculations based on WFP data.

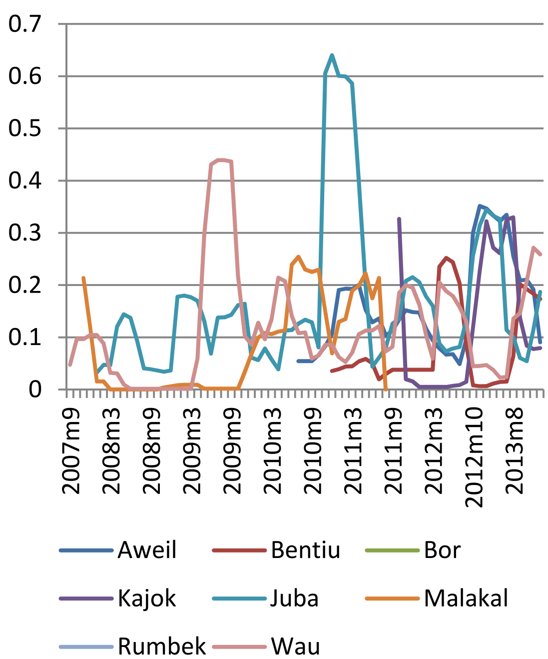
Figure 23: Rolling Standard Deviation of Rates of Change of Maize
(2008m1-2013m3)

Figure 24: Rolling Standard Deviation of Rates of Change of Millet
(2006m6-2013m12)

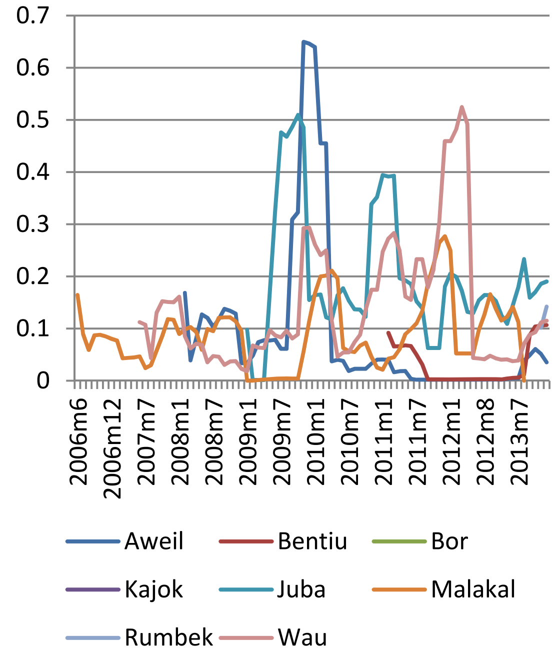


Source: Authors' calculations based on WFP data.

Figure 25: Rolling Standard Deviation of Rates of Change of Sesame
(2007m9-2013m12)

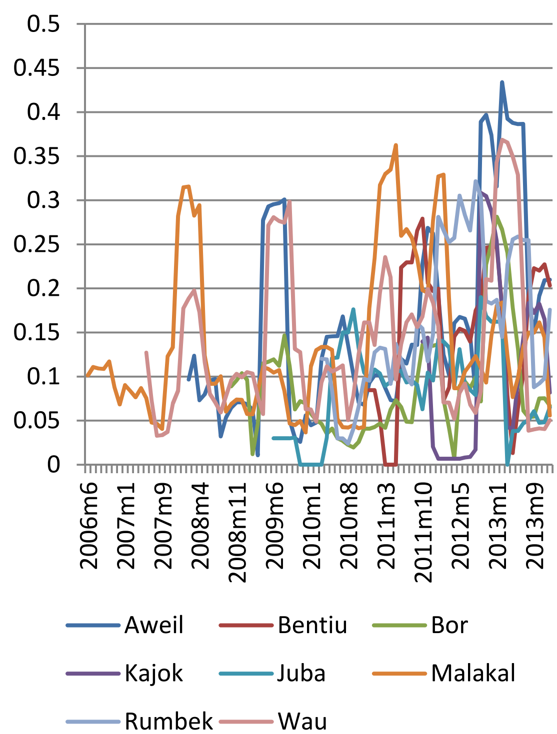


Source: Authors' calculations based on WFP data.



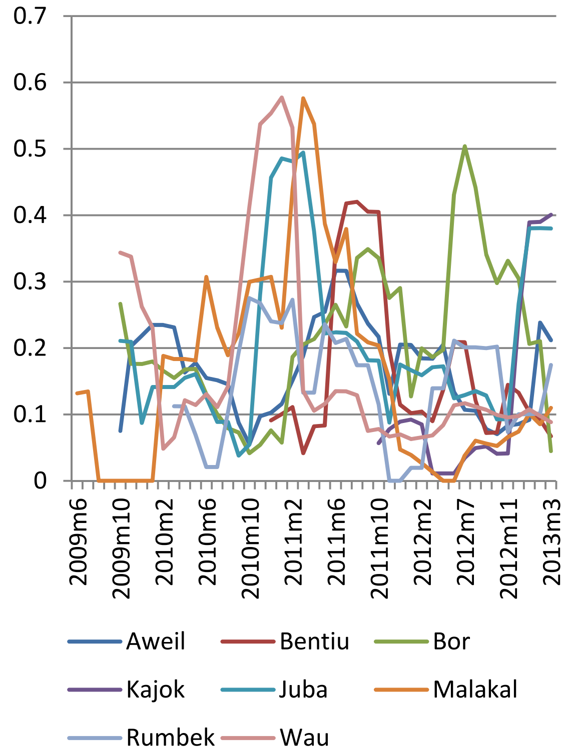
Source: Authors' calculations based on WFP data.

Figure 26: Rolling Standard Deviation of Rates of Change of Sorghum
(2006m6-2013m12)



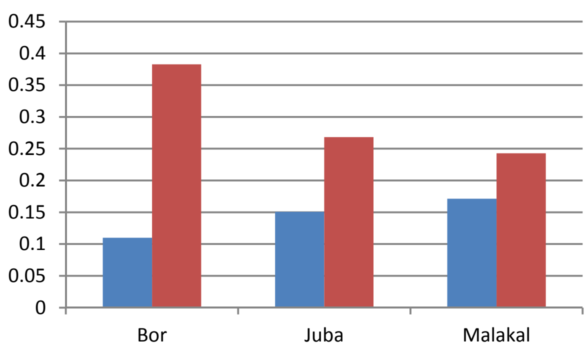
Source: Authors' calculations based on WFP data.

Figure 27: Rolling Standard Deviation of Rates of Change of Wheat Flour
(2009m6-2013m3)



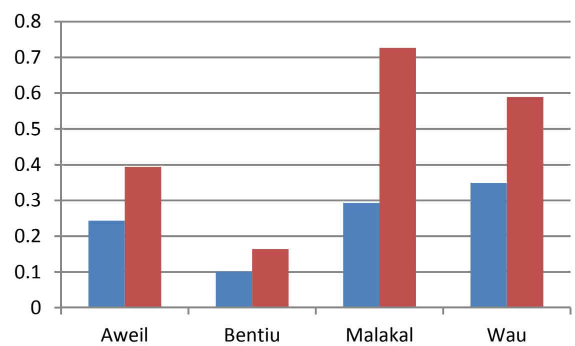
Source: Authors' calculations based on WFP data.

Figure 28: Differences in Price Volatility – Broad Beans (pre-closure in blue, post closure in red)



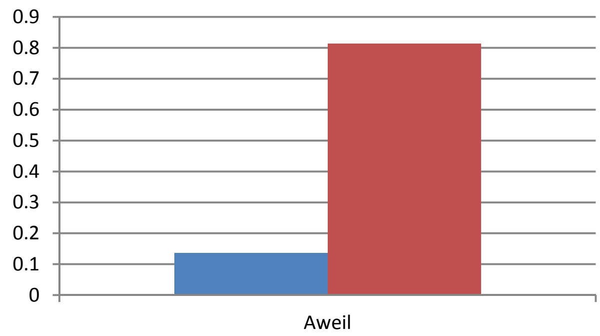
Source: Authors' calculations based on WFP data.

Figure 29: Differences in Price Volatility – Groundnuts (pre-closure in blue, post closure in red)



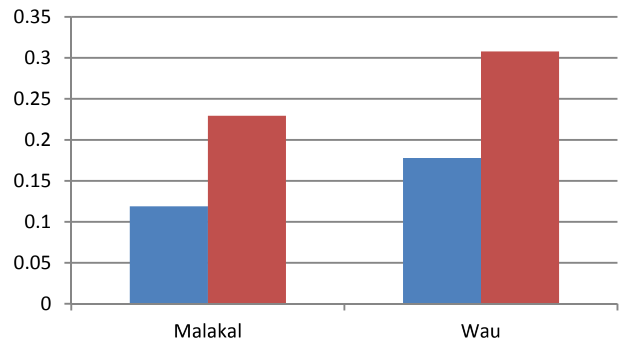
Source: Authors' calculations based on WFP data.

Figure 30: Differences in Price Volatility – Maize (pre-closure in blue, post closure in red)



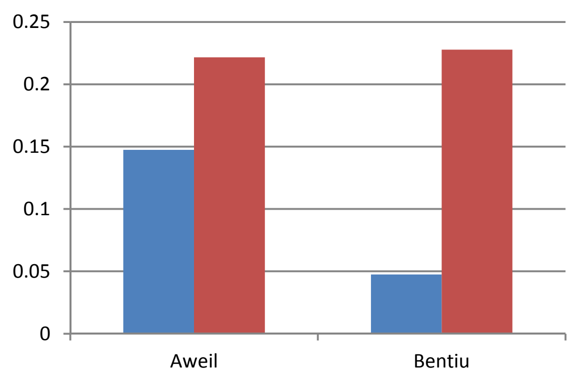
Source: Authors' calculations based on WFP data.

Figure 31: Differences in Price Volatility – Millet (pre-closure in blue, post closure in red)



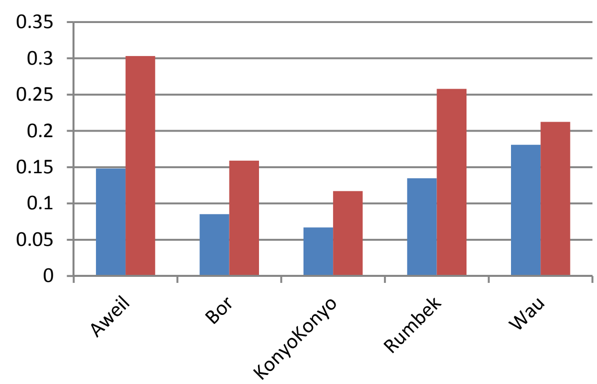
Source: Authors' calculations based on WFP data.

Figure 32: Differences in Price Volatility – Sesame (pre-closure in blue, post closure in red)



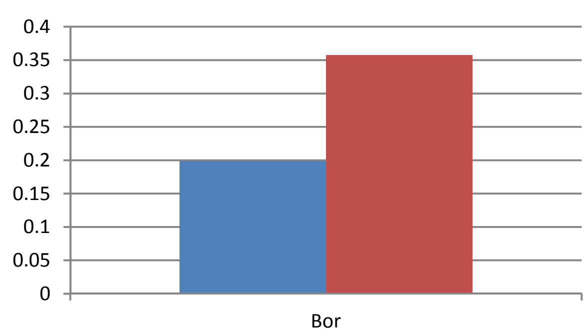
Source: Authors' calculations based on WFP data.

Figure 33: Differences in Price Volatility – Sorghum (pre-closure in blue, post closure in red)



Source: Authors' calculations based on WFP data.

Figure 34: Differences in Price Volatility – Wheat Flour (pre-closure in blue, post closure in red)



Source: Authors' calculations based on WFP data.

Table 9: Market Integration Tests for Broad Beans

		Long Run Relationship				Error Correction		
Broad Beans	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	37	0.300	6.344	0.534	0%	-1.398	-4.328	0.501
Bentiu	16	0.385	1.360	0.103	28%	-4.984	-1.337	0.651
Bor	37	0.421	3.079	0.328	4%	-0.005	-0.017	0.115
Malakal	43	0.366	2.987	0.187	19%	-0.505	-3.653	0.388
Rumbek	27	1.221	12.909	0.804	34%	-0.262	-1.410	0.593
Wau	41	0.825	5.860	0.618	0%	-0.267	-1.874	0.413

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 10: Market Integration Tests for Groundnuts

		Long Run Relationship				Error Correction		
Groundnuts	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	49	0.209	1.418	0.030	4%	-0.475	-3.006	0.461
Bentiu	23	0.395	1.705	0.037	57%	-0.077	-1.124	0.319
Bor	57	0.570	7.214	0.373	1%	-0.232	-1.251	0.169
Kajok	22	0.251	1.189	0.057	0%	-0.710	-2.215	0.526
Malakal	61	0.642	4.056	0.190	10%	-0.587	-1.673	0.348
Rumbek	40	0.357	1.679	0.123	8%	-0.383	-1.948	0.385
Wau	48	0.846	3.982	0.254	3%	-0.353	-1.962	0.281

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 11: Market Integration Tests for Maize

		Long Run Relationship				Error Correction		
Maize	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	50	0.291	2.052	0.091	0%	-0.458	-2.777	0.485
Bor	51	0.450	3.132	0.241	3%	-0.186	-1.683	0.271
Rumbek	36	1.160	3.531	0.361	4%	-0.209	-1.305	0.217
Wau	43	0.719	4.877	0.336	1%	-0.076	-0.791	0.140

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 12: Market Integration Tests for Millet

		Long Run Relationship				*Error Correction*		
Millet	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	43	0.462	6.564	0.427	1%	-1.524	-4.743	0.772
Bentiu	16	0.827	9.015	0.701	22%	-0.327	-0.762	0.311
Malakal	67	0.604	3.983	0.353	94%	-0.107	-1.776	0.608
Wau	72	0.645	5.816	0.482	0%	-0.054	-0.399	0.086

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 13: Market Integration Tests for Sesame

		Long Run Relationship				*Error Correction*		
Sesame	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	40	0.453	3.886	0.378	5%	-0.202	-1.317	0.348
Bentiu	22	0.333	2.507	0.259	48%	-0.386	-1.839	0.596
Kajok	19	0.080	0.263	0.006	0%	-0.279	-1.660	0.750
Malakal	38	0.613	1.487	0.160	94%	0.059	0.374	0.465
Wau	61	0.661	3.899	0.533	0%	-0.469	-3.161	0.257

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 14: Market Integration Tests for Sorghum

		Long Run Relationship				*Error Correction*		
Sorghum	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	74	0.995	15.041	0.708	2%	-0.202	-2.434	0.098
Bentiu	38	1.580	14.956	0.804	7%	-0.033	-0.142	0.228
Bor	64	0.946	17.156	0.828	1%	-0.236	-2.915	0.161
Kajok	21	0.054	0.209	0.003	29%	-0.215	-0.549	0.627

Malakal	88	1.446	20.453	0.821	33%	-0.110	-1.409	0.081
Rumbek	46	0.841	9.724	0.690	1%	-0.458	-2.416	0.336
Wau	79	1.150	16.796	0.751	7%	-0.113	-2.009	0.047

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 15: Market Integration Tests for Wheat Flour

			Long Run Relationship			*Error Correction*		
Wheat Flour	*Obs*	*LR Pass Through*	*T-stat*	*R2*	*Cointegration Test*	*Speed of Adjustment*	*T-stat*	*R2*
Aweil	46	1.424	7.538	0.540	0%	-0.173	-1.792	0.131
Bentiu	29	0.628	2.523	0.188	74%	-0.109	-0.516	0.140
Bor	45	1.117	5.687	0.403	0%	-0.313	-2.154	0.132
Kajok	18	0.729	2.792	0.455	18%	-0.604	-2.053	0.763
Malakal	43	1.276	5.782	0.433	0%	-0.495	-2.925	0.368
Rumbek	36	0.592	2.862	0.168	14%	-0.018	-0.099	0.020
Wau	45	0.741	4.369	0.352	0%	-0.339	-4.731	0.433

Notes: (1) The cointegration test consists in a test for unit roots in the residuals of the long run relationship. The statistic reported is the p-value on that unit root test. Given the reduced sample, the significance level is defined at 20%. Thus, when the statistic is below 20%, we interpret the result as indicative of a rejection of the null of a unit root in the residual, or, evidence in favor of cointegration between prices in a given city and prices in Juba. (2) For the speed of adjustment, a t-stat in the vicinity or lower than -2 in absolute value reflects a significant speed of adjustment toward long run equilibrium.
Source: Authors' calculations based on WFP data.

Table 16: Road Quality Interactions in Price Difference Models

	(1)	(2)	(3)	(4)
Price Differential of Diesel	0.56	0.49		
	(0.36)	(0.36)		
*Distance to Juba*Price Differential of Diesel*	0.00	0.00		
	(0.00)	(0.00)		
Distance to Juba	-0.001***	-0.001***	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Road Grade (to Juba)	-6.61***	-6.13***	-4.2**	-3.56**
	(1.13)	(1.21)	(1.4)	(1.33)
Road Length	-2e-4**	-2e-4**	-1e-4*	-1e-4*
	(0.00)	(0.00)	(0.00)	(0.00)
Differential of Consumption Per Capita	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Cereal Surplus	-4.6e-6**	-4.7e-6**	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Average Monthly Rainfall on the road (to Juba)	0.00	0.002**	0.00	0.003

	(0.00)	(0.00)	(0.00)	(0.00)
Road Grade (to Juba) Average Monthly Rainfall on the road (to Juba)*	0.00	-0.005*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Distance to Juba Average Monthly Rainfall on the road (to Juba)*		-1.9e-06**		-2.6e-6*
		(0.00)		(0.00)
Border Closure			0.03	0.03
			(0.04)	(0.04)
Northern State Dummy			-0.04	-0.05
			(0.13)	(1.31)
Border Closure Northern State Dummy*			0.07	0.08*
			(0.04)	(0.03)
Constant	3.46***	3.21***	2.37 **	2.03**
	(0.3)	(0.34)	(0.7)	(0.63)
Month Fixed Effects	Yes	Yes	No	No
Commodity Fixed Effects	Yes	Yes	No	No
Commodity-City Fixed Effects	No	No	No	No
Commodity-Year Fixed Effects	No	No	Yes	Yes
Observations	557	557	1517	1517
R-squared	0.30	0.30	0.21	0.21

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 17: South and North-Specific Models for Price Differences

	(South)	(South)	(North)	(North)
Price Differential of Diesel	0.62		-0.11	
	(0.54)		(0.27)	
*Distance to Juba*Price Differential of Diesel*	0.00		0.00	
	(0.00)		(0.00)	
Road Grade (to Juba)	-6.82***		4.59	
	(0.4)		(4.77)	
Distance to Juba	-0.001**	-0.001***	0.01*	-0.01
	(0.00)	(0.00)	(0.00)	(0.01)
Road Length		-3e-4***	0.00	0.00
		(0.00)	(0.00)	(0.00)
Differential of Consumption Per Capita				-0.03
				(0.01)
Cereal Surplus	0.00	2e-6**	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)

Border Closure		0.11**		0.02
		(0.01)		(0.03)
Constant	3.5***	1.7***	-2.93	4.7
	(0.28)	(0.05)	(2.33)	(2.83)
Month Fixed Effects	Yes	No	Yes	No
Commodity Fixed Effects	Yes	No	Yes	No
Commodity-City Fixed Effects	No	No	No	No
Commodity-Year Fixed Effects	No	Yes	No	Yes
Clustered Standard Errors	City Level	City Level	City Level	City Level
Observations	206	544	351	1069
R-squared	0.59	0.5	0.32	0.25

Clustered standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

Table 18: Sorghum and Millet-Specific Models for Price Differences

	(Millet)	(Millet)	(Sorghum)	(Sorghum)	(Millet & Sorghum)	(Millet & Sorghum)
Price Differential of Diesel	-2.13		0.39		0.52	
	(2.02)		(0.48)		(0.6)	
*Distance to Juba*Price Differential of Diesel*	0.00		0.00		0.00	
	(0.00)		(0.00)		(0.00)	
Distance to Juba	0.00	-0.002*	-0.001***	-0.001**	-8e-4***	-7e-4*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Road Grade (to Juba)	24.58*	1.92	-5.83***	-3.57***	-5.38***	-3.03**
	(9.97)	(1.34)	(0.75)	(0.76)	(0.82)	(0.83)
Road Length	0.001**	3e-4***	-1e-4***	-1e-4*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Differential of Consumption Per Capita	-0.01*	-7e-3***	-0.004***	-0.002	-4e-3***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cereal Surplus	1e-5*	0.00	-3e-6*	0.00	-2.5e-6	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Border Closure		-0.62**		0.00		-0.03
		(0.2)		(0.1)		(0.1)
Northern State Dummy				-0.04		-0.1
				(0.11)		(0.15)
Border Closure Northern State Dummy*		0.7		0.03		0.09

		(0.17)		(0.06)		(0.09)
Constant	-9.5**	0.51	2.9***	2.32***	2.4***	1.92**
	(3.53)	(0.65)	(0.29)	(0.47)	(0.25)	(0.55)
Month Fixed Effects	Yes	No	Yes	No	Yes	No
Commodity Fixed Effects	Yes	No	Yes	No	Yes	No
Commodity-City Fixed Effects	No	No	No	No	No	No
Commodity-Year Fixed Effects	No	Yes	No	Yes	No	Yes
Clustered Standard Errors	City Level	City Level	City Level	City Level	City Level	City Level
Observations	38	121	137	372	188	493
R-squared	0.74	0.40	0.53	0.34	0.35	0.28
Clustered standard errors in parentheses						

*** $p<0.01$, ** $p<0.05$, * $p<0.1$