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Abstract

How integrated are agricultural markets in conflict-affected states? We answer this question by examining the dynamics of monthly price series of rice, maize, and sorghum across eleven cities (markets) of Somalia. Using conflict as a source of transaction costs between spatially connected markets, we examine its role in price transmission between the markets in a panel smooth transition regression framework. We find that in the case of rice—an imported cereal grain—conflict tends to mitigate the speed of price transmission between markets. By contrast, we find no evidence of conflict-related transaction costs in the case of maize and sorghum—commodities that are locally produced, particularly in the central and southern parts of Somalia. In all instances, we find that there is some degree of spatial integration among cereal markets around the country, perhaps partly due to informal institutions that can bridge the divides created by conflict, distance, and internal political fragmentation. These findings add crucial detail to the literature concerned with the role of commodity prices on poverty and food security in conflict-affected states.

Keywords: cereal prices, market integration, panel smooth transition regression, price transmission, Somalia

* Replication material available at: https://github.com/dubilava/somalia
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Introduction

Internal conflicts not only devastate people's lives, but they also negatively affect the ability of markets to function, particularly across battle lines and internal political divisions. Indeed, if there is any country where we might intuitively expect to see disrupted markets, it would be Somalia, given the degree to which its state institutions and territorial integrity have fragmented over decades of intermittent civil war. People living in states with weak institutions, such as Somalia, often struggle to buy food and other necessities, or to move around their own countries, stymied as they are by conflict, territorial fragmentation, and failures in transport, communications, and market enforcement. Entrenched violent conflicts are typically associated with a lack of market integration, which has repercussions for how efficiently people, goods, and information are transferred between markets. Commercial leaders in these countries frequently complain that without a central government to provide basic security and infrastructure (like roads, energy, and water) they must fund these essentials themselves just to stay in business (see Phillips 2020, 129).

This article asks how conflict influences price transmission across markets in a conflict-affected, institutionally fragmented state—in this case Somalia.[1] We propose that conflict intensity is an important source of the transaction costs that determine levels of market integration across Somalia's markets. To answer this question, we use monthly time series of market prices for maize, sorghum, and rice across eleven cities/markets of the country, and apply a panel smooth transition regression framework to examine the role of conflict intensity on staple cereal market linkages in Somalia.

We find that conflict tends to mitigate the speed of price transmission across (imported) rice markets, but it has no impact on price transmission across (locally produced) maize and

[1] We follow Gretchen Helmke and Steven Levitsky (2004, 727) by defining institutions as the formal or informal rules and norms that order people's shared expectations.

sorghum markets. We also find that amid conflict and internal political fragmentation, there is evidence of price transmission among cereal markets around the country. That is, despite a lack of effective formal institutions, Somalia's markets are relatively well integrated. In the conclusion, in discussing options for further research, we suggest that this may be because Somalia's informal institutions (including things like customary law, informal security arrangements, and clan-based codes of reciprocity and representation) are quite effective at bridging the divides created by conflict, distance, and internal political fragmentation.

In our analysis, we build on previous research that looks at market integration, both within countries and between countries, as measured by price co-integration, price transmission speeds, or both (Dillon and Barrett 2016; Hood and Dorfman 2015; Goodwin, Holt, and Prestemon 2011). Across all countries, the primary barriers of interest to price co-integration and transmission are typically borders and distance. Mengel and Cramon-Taubadel (2014) conduct a meta-analysis of 57 market integration studies, and find that markets within countries are 23% more likely to be co-integrated than markets separated by an international border, while markets separated by 1000 kilometers within a country are between 6% and 20% slower to adjust prices and have 7% lower co-integration, while international markets are 13% slower to adjust prices. Distance has negligible effects between international markets.

The prevailing assumption across many studies of states with fragmented, dysfunctional, or non-existent formal economic institutions is that there will be considerable price dispersion in different markets across relatively large distances (Aker and Mbiti 2010; Aker 2010; Aker and Fafchamps 2014). That is, the lack of market integration in such states is both an assumption and a common finding in these studies. The lack of market integration in states without robust formal institutions could be for one of several reasons. First, the ability to broadcast state power in Africa has been measured by the extent and location of road networks (Herbst 2000), with the implication that states that are unable to exercise effective control are unable to build or maintain roads across the territory within their internationally defined borders. A lack of roads would increase transaction costs between different markets, resulting in a difference in market prices. Indeed, the cost of transport is a major consideration in developing countries, particularly landlocked African countries. Versailles (2012) finds that distance causes significant price dispersion in eastern African markets, whereas border effects are small though significant. Transport costs account for most of the internal price variation between producer regions within the Democratic Republic of the Congo, with road quality being a particularly important factor in variation (Minten and Kyle 1999). Likewise, Dillon and Barrett (2016) examine cross-border and within-country price transmission among selected cities in Ethiopia, Kenya, Tanzania and Uganda, and find that transport costs play an instrumental role in spatial price transmission.

Second, political fragmentation and violence mean that different, often hostile actors govern markets in different parts of a country, and that traveling between markets, as well as outsider involvement in markets, is difficult due to poor security and barriers to moving between markets. Moreover, the lack of functioning formal state institutions means that state enforcement of contracts and resolution of disputes is patchy or uneven (Scott 2010; Börzel, Hönke, and Thauer 2012; Krasner and Risse 2014). While there are ways around a lack of state dispute arbitration, these methods do not necessarily scale well, or operate across larger distances or with strangers, including among ethnically or linguistically diversified groups, making arms-length inter-city trade difficult, and resulting in differential prices (Haggard, Lee, and Noland 2012; Greif 1993; Robinson 2016). A meta-analysis of market integration studies in African countries (Rashid et al. 2010) finds that food prices are generally co-integrated across markets within countries, with distance and road quality determining greater or lesser co-integration. It also finds that the time for markets to adjust to price changes varies, but that market liberalization generally increases market integration within countries. The authors conclude that the main reasons for lack of market integration are risk, lack of information, poor infrastructure, and lack of government capacity. Outside of Africa, Schulze and Wolf (2008) find that the Hapsburg Empire had internal "borders decades before" it broke up, with internal border effects delineated by ethnolinguistic groupings rather than political borders. Conversely, market price variation within a country can be used to determine the extent to which different parts of the country are integrated over time. Interwar Poland, for instance, integrated two post-partition segments surprisingly quickly (within half a decade), as measured by market prices (Trenkler and Wolf 2005).

Somalia suffers from all these problems – conflict, political fragmentation, poor transportation infrastructure, and a lack of formal institutions with sway over large parts of the country. Through our analysis, we make several contributions to the study of market integration, conflict, and institutions in states with low formal state capacity, and scarce governance data. First, we provide specific and rigorous updated evidence for the effect of conflict intensity on cereal market integration in states with fragmented institutions. We show that market integration can be responsive to violence between opposing groups—particularly for commodities that are not produced locally wherein spatial arbitrage is one of the main sources of adjustment to market shocks—and that conflict can have specific effects on markets around a country, over and above the death and dislocation they cause.

Second, by finding price transmission even with internal political fragmentation, conflict, and poor transport, we offer an alternative lens through which to view emergent political order—and do so in the absence of the political and economic indicators that are typically used to measure a state's effectiveness, given the lack of such data in such states. Commodity price data is more often available in states without robust formal institutions than is most other types of governance-related data. We propose that measuring market integration over time gives us clues about changes to the capacity of institutions—whether formal or informal—to establish rules, resolve disputes, uphold contracts, or provide enough security for people and businesses to move information, goods, money, and people across the country.

Our findings suggest that, in further research, there may be a benefit in understanding governance in Somalia—though presumably more broadly as well—through the lens of informal institutions as they may encourage market integration throughout the country, and allow internal trade to continue despite conflict. While it is not uncommon to find that informal institutions are extremely important to governance across Somalia's territories (for example Little 2003; Menkhaus 2007; Renders 2012; Hastings and Phillips 2018; Phillips 2020), looking at market integration may be a way of rendering these informal governance processes more legible across time and space.

The Model and Econometric Framework

To measure the level of market integration across the selected markets of Somalia, we rely on the law of one price hypothesis in the spatial context. The basic principle of this hypothesis suggests that prices of the same commodity in two spatially separated markets will co-move if the commodity can be transported between the markets. Otherwise, price dynamics in the two markets are likely to be disentangled.

Several factors can disrupt market integration, and therefore price transmission, between two markets. The "usual suspect," as alluded above, is the cost of transportation. Because of transportation costs—or, more broadly, transaction costs—the price dynamics in the two markets can be disentangled episodically (e.g., Barrett and Li 2002). That is, to the extent that transportation costs mitigate the profitable arbitrage opportunities, there can be no arbitrage opportunities unless the price discrepancy between the two markets is "large enough." This leads to the so-called "transaction costs band" hypothesis. See, for example, Goodwin, Holt, and Prestemon (2011)

To briefly illustrate, consider a pair of markets, denoted by i and j. Let the prices in these markets in period t be p_{it} and p_{jt}, respectively. For the sake of illustration, suppose the transaction costs are paid in form of a barter. To that end, we can introduce the so-called "leakage" factor, θ, which is a share of the commodity that is lost during its transportation from i to j. Thus, the further apart (typically geographically, but also politically, institutionally, etc.) are the two markets, the higher are the transaction costs, and the closer is θ to one.

The per-unit profit of an arbitrageur from i to j is given by $(1-\theta)p_{jt} - p_{it}$. It follows that the no profitable arbitrage condition is given by $p_{it}/p_{jt} \geq (1-\theta)$. Similarly, the no profitable arbitrage condition from j to i is given by $p_{it}/p_{jt} \leq 1/(1-\theta)$. In these arbitrage conditions, θ captures all the transaction costs, including a normal economic return for all the work involved in the process. Combining the two inequalities, and taking natural logarithms gives the transaction costs band: $[-ln(1-\theta), ln(1-\theta)]$. Thus, if the log price differential, in absolute terms, is less than $ln(1-\theta)$, it is not worth an effort and a risk for arbitrageurs to engage in trade; otherwise, the trade will happen, and we will observe adjustment in the prices.

The concept of "leakage" is particularly well-suited for a conflict-affected state, such as Somalia, where the transportation cost may not even be the most substantial component of transaction costs. For example, there is always a chance that a military group can seize some or all the cargo from an arbitrageur, leading to the partial or complete leakage. Thus, the leakage factor can be a (nonlinearly) increasing function of conflicts. To the extent that the intensity of conflicts can (and does) vary over time, the transaction costs band can expand or shrink accordingly. That is, the same log price differential may or may not prompt the arbitrageurs to engage in trade, depending on the degree of conflict intensity in the region, for example. The corollary is that the asymmetric dynamics of price transmission between two markets can vary over time as well.

Let $y_{ijt} = \ln p_{it} - \ln p_{jt}$ denote the log price differential between the two markets (for the sake of brevity we omit the commodity specific subscript in this presentation). Then the basic linear specification, that can allow us to econometrically measure the extent of spatial price transmission, is given as follows:

$$\Delta y_{ijt} = \beta_0 y_{ijt-1} + \theta_{ijt} + \delta_{ij} + \varepsilon_{ijt}, \tag{1}$$

where Δ is the first-difference operator, β_0 is the speed-of-adjustment parameter that is expected to lie within the range of negative one and zero (otherwise, $\beta_0 < -1$ and $\beta_0 > 0$ would indicate explosive process, with and without oscillation, respectively); the closer is this parameter to negative one the less persistent is the process and the faster is the reversion to the long-run equilibrium, suggesting that the two markets are linked; when $\beta_0 = 0$, there is no adjustment to the long-run equilibrium, suggesting that the two markets are not linked. δ_{ij} is the dyad-specific fixed effect, and θ_{ijt} is (potentially) a vector of control variables; ε_{ijt} is the zero-mean constant-variance error term.

It may be that the linkage between the markets is of episodic nature, for reasons outlined above. If so then adjustment to the long-run equilibrium can be of different speed, conditional on a factor that may govern such nonlinearity. A measure of conflict intensity, c_{ijt-d}, which can be conflict incidents in the previous period, or the average value of conflict incidents during the previous several periods, can be such a factor. To incorporate this nonlinearity into the model, we adopt the panel smooth transition regression (PSTR) framework of Gonzalez et al. (2017). The PSTR, applied to our modeling exercise, takes the following form:

$$\Delta y_{ijt} = \beta_0 y_{ijt-1}\left[1 - G\left(c_{ijt-d}; \gamma, \kappa\right)\right] + \beta_1 y_{ijt-1} G\left(c_{ijt-d}; \gamma, \kappa\right) + \theta_{ijt} + \delta_{ij} + \varepsilon_{ijt}, \tag{2}$$

where δ_{ij} is the dyad fixed effect, and θ_{ijt} is (potentially) a vector of control variables; $G\left(c_{ijt-d}; \gamma, \kappa\right)$ is the so-called transition function which is bounded by zero and one. More specifically, we apply a logistic transition function:

$$G(c_{ijt};\gamma,\kappa) = \{1 + exp[-\gamma(c_{ijt-d} - \kappa)]\}^{-1} \quad (3)$$

the values of which depend on the realization of the transition variable, c_{ijt-d}, which is the measure of conflict intensity in this instance, as well as the smoothness, γ, and centrality, κ, parameters. The transition function varies over time (and across space) due to the transition variable; the smoothness parameter determines the rate of change of the transition function around the centrality parameter.

For the relatively small values of the smoothness parameter—which is bounded from below at zero—the transition between the two extreme regimes are somewhat gradual. For sufficiently large values of the smoothness parameter, the transition functions take on the form of the indicator function, in which case the switches between the two extreme regimes happen instantaneously. Moreover, at that point, the centrality parameter—which typically serves as the inflection points of the transition function—turns into the threshold parameter. Indeed, a threshold regression—a modeling framework that has been successfully applied in the literature to examine episodic market integration due to transaction costs—is the special case of the smooth transition framework. There are several potential benefits to this latter model. First, to the extent that people differ from each other in their risk aversion, different degree of conflict prevalence may serve as a deterring factor for trade if an arbitrage opportunity were to present itself. Price dynamics in the two markets aggregate the behavior of said agents; therefore, a gradual switch between the regimes may better mimic the heterogeneity around the transaction cost band. Second, because we consider several market pairs within the panel, it is quite likely that thresholds identifying transaction costs vary across dyads—while markets trade the same commodity, the specificity of the transactions can vary across markets. In this instance as well, the smooth transition function might be a better approximation for the transaction cost band.

In using the conflict intensity as the transition variable, we rely on the assumption that conflict is weakly exogenous to price differential (between two markets). Moreover, we use lagged conflict as the transition variable. While, lagging a variable does not necessarily resolve the potential issue of endogeneity, particularly when such variable is serially correlated (e.g., Bellemare et al. 2017), we presume that, at the very least, it mitigates the issue. Notably, we do not observe trade between the markets; instead, we assume that the trade is possible if arbitrage opportunity presents itself. As a result, we rely on the dynamic properties of price differential to conclude that there is evidence of certain degree of price transmission—and therefore a good chance for market integration—in the considered city dyads.

Whether heterogeneity vis-à-vis candidate transition variables is, indeed, the characteristic feature of the relative price dynamics in the data, is a testable hypothesis. The conventional tests cannot be carried out due to the presence of unidentified nuisance parameters under the null hypothesis of homogeneity. To circumvent the issue, the hypothesis testing is carried out on an auxiliary regression—a linearized variant of equation (2)—as per approach put forward for time series models by Luukkonen, Saikkonen, and Teräsvirta (1988), and adopted for panel models by Gonzalez et al. (2017). The auxiliary regression is as follows:

$$\Delta y_{ijt} = \alpha_0 y_{ijt-1} + \alpha_1 y_{ijt-1} c_{ijt-d} + \alpha_2 y_{ijt-1} c_{ijt-d}^2 + \theta_{ijt} + \delta_{ij} + v_t, \quad (4)$$

where the parameters here are functions of the original PSTR parameters, including those of the transition function, while v_t combines the original error as well as the approximation error, This auxiliary regression offers an opportunity to test for parameter homogeneity in the original PSTR model; it is equivalent to testing H_0^*: $\alpha_1 = \alpha_2 = 0$. If we fail to reject this null hypothesis, we estimate the panel regression model, as in equation (1). Otherwise, we estimate the PSTR model as in equations (2) and (3). Refer to Gonzalez et al. (2017) for further details.

Data

The analysis is based on price and conflict data from eleven Somali cities/markets across Mogadishu, Southern Somalia, Puntland/Galmudug, as well as the city of Lasanod, which is claimed by both Somaliland and Puntland (and has stronger clan-based connections to the latter). Each can be considered a separate region for the purposes of governance, with a relatively distinct, though fluid, border with other regions, particularly during times of conflict.

Mogadishu is the capital of the Federal Republic of Somalia (FRS), established in 2012, but the FRS has only exercised nominal sovereignty—let alone actual control—over a small portion of the country—mostly Mogadishu and its environs—since the inception of the Transitional Federal Government in 2004. Southern Somalia—the area between Kenya and Galmudug on the central coast—is the region with the greatest amount of conflict, as control has been contested since 2004 by the (transitional and then permanent) Somali federal government and the allied African Union, and the Islamic Courts Union and then al-Shabaab. Galmudug on the central coast and Puntland on the northeastern coast are separate regions which have experienced relatively little internal conflict (with the exception of incursions by Islamist groups) and technical loyalty to the Mogadishu government, although they function as autonomous regions, and both have, as of 2020, pockets of al-Shabaab control. Both Galmudug and Puntland produced considerable levels of piracy between 2005 and 2012, with both regions home to a number of pirate ports (Bank 2013; Bahadur 2011).

In the current analysis, Lasanod is the only city included in the dataset that is claimed by Somaliland (Borama and Hargeysa are omitted from the analysis). Somaliland is a self-declared but officially unrecognized republic in the northwest corner of Somalia that has, for the most part, experienced little activity from either pirates or insurgents since the mid-1990s (Hastings and Phillips 2018), other than some relatively brief but violent episodes with Puntland in 2007 and 2018. The two regions maintain a hostile relationship. As a result, there is no question (and, indeed, hardly any evidence) whether those cities in Somaliland (Borama and Hargeysa) can be considered to be politically integrated with those of Somalia—they are not. Since we are interested in internal conflict in this analysis, we treat Borama and Hargeysa as external to the rest of Somalia, and exclude them.

Armed Conflict

Conflict is detrimental, both because of its direct effects on lives, and because of the disruption it can cause in inter-market exchange, which can become intertwined with food insecurity challenges (Brinkman and Hendrix 2011; Hendrix and Brinkman 2013). In terms of the ability of (informal) institutions to function in the face of conflict, however, not all conflicts are the same. For example, conflicts where government or rebel forces are actively attempting to take over territory, as well as different types of armed violence, is anticipated to be more disruptive to the existing linkages among the markets, than protests and riots, that typically are localized in central districts of a city, and often are seen as a consequence rather than the cause of price dispersion among the markets (e.g., Bellemare, 2015).

We source the data on conflict incidents across Somalia from Armed Conflict Location & Event Data (ACLED) Project, available at https://acleddata.com (see, for example, Raleigh et al. 2010). This database is, arguably, the most comprehensive of available conflict data, and has been increasingly applied in the area of conflict economics, broadly defined, in the region (e.g., Maystadt and Ecker 2014; Raleigh, Choi, and Kniveton 2015; Smith 2014).

For the reasons outlined above, in this study we consider the following three conflict types: battles, violence against civilians, and explosions/remote violence; that is, we discard riots and protests, as well as events associated with strategic developments from the data; the omitted conflict types represent smaller share of the events across Somalia during the study period. To the extent that not all reported incidents are measured with precision, we discard events which are, by default, assigned to a provincial capital; we maintain all time-precision levels, however, as the least accurate entry still gives the correct month. Therefore, we retain 21,252 incidents for the analysis (of which, 11,179 are battles, 5,003 are violence against civilians, and 5,070 are explosions/remote violence). From these, we further discard events that are plausibly irrelevant for the analysis—i.e., those events that occur further than 0.1 arc-degree (approximately 11km) away from the considered cities and the roads connecting these cities. By taking this approach, we discard conflict incidents that are unlikely to be the source of transaction costs for trade between the cities. As a result, in the econometric analysis we use 17,053 conflict incidents, of which 8,751 are battles, 3,913 are violence against civilians, and 4,389 are explosions/remote violence.

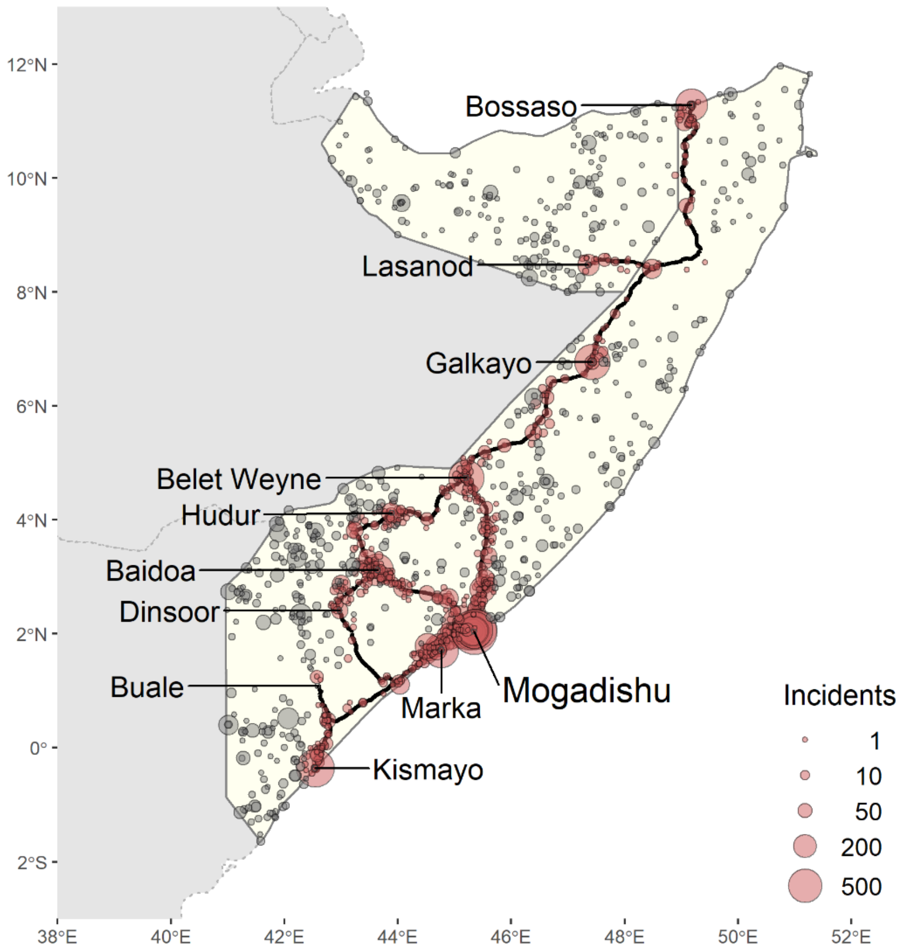

Figure 1: Conflict prevalence in the cities and the routes between the cities of Somalia from January 2009 to December 2019

Note: Circles illustrate the geographic location of incidents and their size is proportional to the number of conflict incidents from the ACLED dataset during the 2009-2019 period. The econometric analysis uses conflict incidents within approximately 10 km distance of a road that connects the cities, given by red circles; gray circles are incidents not used in the analysis.

The events are recorded daily, each accompanied by the longitude–latitude information. Figure 1 summarizes the conflict intensity across Somalia, and illustrates the network of the primary and secondary road system. The data on Somalia roads are obtained via Geofabrik at: http://download.geofabrik.de/africa/somalia.html, based on the OpenStreetMap project. While the majority of conflict incidents appear within or near the cities, they are also likely across the routes between the cities, which is particularly apparent in Southern Somalia. Table 1 presents details on distance between the markets and total number of conflicts along those routes.

Table 1: Route distance, travel time, and the number of conflict incidents on the route across selected city dyads of Somalia

Dyad	*Same Region*	Distance (km)	Travel Time (hr:min)	Conflict Incidents
Marka—Mogadishu	N	93	2:19	9,588
Mogadishu—Baidoa	N	244	5:44	9,017
Mogadishu—Belet Weyne	N	342	6:32	8,548
Marka—Baidoa	Y	231	4:25	5,316
Kismayo—Marka	Y	400	7:01	2,823
Buale—Marka	Y	395	6:51	1,928
Marka—Dinsoor	Y	343	8:56	1,872
Belet Weyne—Galkayo	N	391	8:24	1,697
Galkayo—Bossaso	Y	670	11:21	1,594
Baidoa—Hudur	Y	130	1:52	1,240
Lasanod—Bossaso	N	573	8:11	1,135
Kismayo—Buale	Y	224	3:26	1,086
Galkayo—Lasanod	N	354	6:36	1,072
Hudur—Belet Weyne	Y	205	8:17	1,020
Dinsoor—Baidoa	Y	120	4:58	901

Note: Distance and travel times are obtained from Google maps (accessed on 04 Oct 2020). The dyads are presented in a decreasing order of the total number of conflict incidents. The total number of conflict incidents is computed over the January 2009 – December 2019 period.

Commodity Prices

We obtain the data on prices for three key cereal grains—rice, maize, and sorghum—from the Food and Agriculture Organization of the United Nation's (FAO) Food Price Monitoring and Analysis (FPMA) Tool database of Global Information and Early Warning System on Food and Agriculture (GIEWS) (henceforth referred to as the GIEWS price data), available at http://www.fao.org/giews/data-tools. Of the considered cereal grains, rice is an imported commodity, while maize and sorghum are locally produced, primarily in the Southern Somalia. While some of the data on these cereal prices are available since the 1990s, the data used in this paper range from January 2009 to December 2019 due to more fragmented data in the prior period. For any given city in consideration, we omit a commodity price series with missing observations of more than five percent during the study period; in the remaining cases, i.e., the series were some observations were missing, we interpolate prices using a simple linear interpolation method.

Figure 2 illustrates the retained price series for the three cereal grains in the selected cities/markets; the prices are denominated in US Dollars per kilogram. The graphs, for the most part, illustrate co-movement of prices of the same commodity across different markets, with some exceptions, such as Hudur (which is a smaller city in Southern Somalia) and Bossaso (a port city in the northern Somalia where local crop production is virtually non-existent).

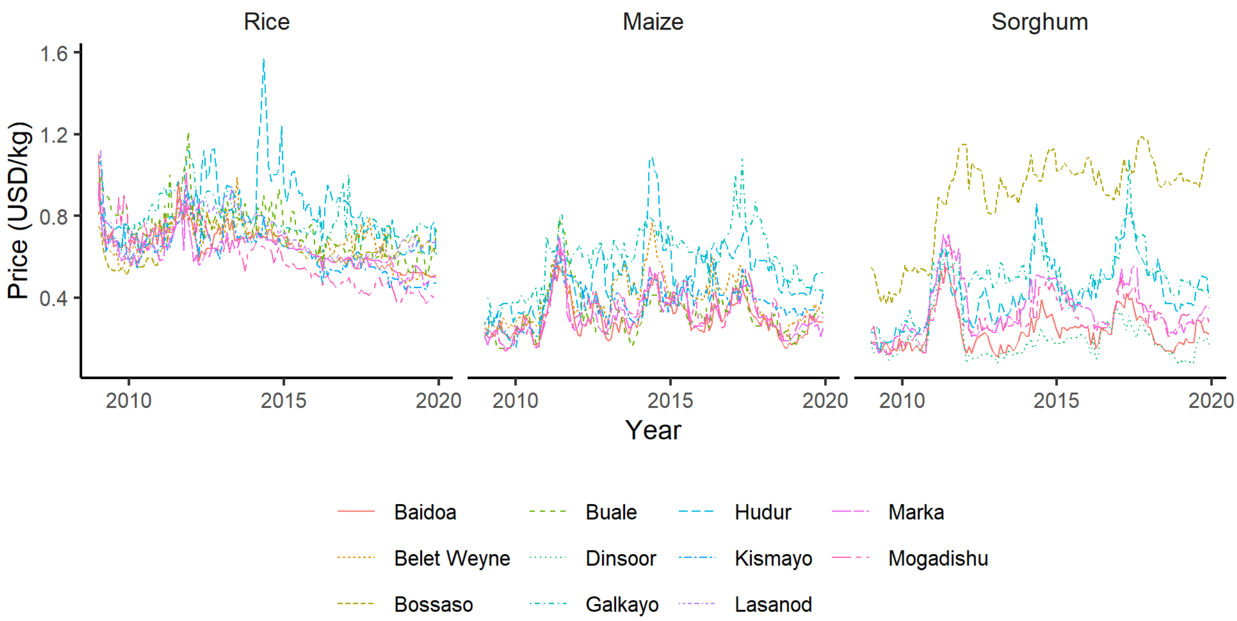

Figure 2: Comparison of cereal prices across the cities of Somalia during 2009-2019 period

Note: The price series are denominated in US Dollars per kilogram of the cereal grain. The cities are indicated by the specific line-type and color; each graph only features the subset of cities with available price series for a given crop; see, also, Table 2 for data availability and the average price.

Table 2 complements the foregoing figure and presents the average prices in cities for which the commodity price series are available. Notably, prices of the imported rice tend to be higher in the cities that are located at some distance from port cities; whereas prices of locally produced maize and sorghum are higher in the cities that are in the northern regions, away from Somalia's breadbasket—southern Somalia, specifically Bay (most of the sorghum production), and the Shabelle districts.

Table 2: Cities used in the analysis and average prices of cereal grains

Region	City	*Average Price (USD/kg)*		
		Rice	*Maize*	*Sorghum*
Somaliland/Puntland	Lasanod	0.71	-	-
Puntland/Galmudug	Bossaso	0.66	-	0.90
	Galkayo	0.79	0.59	0.48
Southern Somalia	Baidoa	0.65	0.30	0.24
	Belet Weyne	0.67	0.39	-
	Buale	0.74	0.32	-
	Dinsoor	-	-	0.20
	Hudur	0.83	0.51	0.43
	Kismayo	0.63	0.38	-
	Marka	0.62	0.31	0.34
Mogadishu	Mogadishu	0.60	0.34	0.30

Note: The averages are obtained for the time series over January 2009 – December 2019 period.

In the analysis, we apply log price differentials between city-pairs, dyads, that are directly connected with each other; meaning that they are not linked via another city in the data. For example, we consider the Mogadishu–Belet Weyne dyad and the Belet Weyne–Galkayo dyad, but we do not consider the Mogadishu–Galkayo dyad. That is, we examine price transmission among the neighboring potentially trading cities/markets, subject to at least 50km driving distance between the markets (such restriction only resulted in dropping from the dataset of only one market, Qorioley, which is located "just across the road" from Marka). Finally, because the price series are not available for all cities and cereal grains in the dataset, the rice panel consists of 13 dyads, the maize panel consists of 10 dyads, and the sorghum panel consists of seven dyads.

Estimation, Results, and Discussion

Table 3 presents the results of the homogeneity tests. In all instances, the alternative specification is a PSTR, where the transition variable, $c^*_{ijt-1} = c_{ijt-1}/\left(T^{-1}\sum_t c_{ijt-1}\right)$, is the normalized number of incidents along the trade route during the previous month, wherein the number of incidents in a given period is divided by the average number of incidents along the trade route during the study period. This normalization allows us to assess the relative effect of conflicts across high-intensity and low-intensity routes (Appendix Figure A1 presents distributions of the raw and normalized incidents along the considered trade routes).

Table 3: Homogeneity test results

	Crop		
Null hypotheses	Rice	Maize	Sorghum
$H_0^*: \alpha_1 = \alpha_2 = 0$	*0.117*†	0.378	0.582
$H_0^1: \alpha_1 = 0 \mid \alpha_2 = 0$	***0.041***†	0.201	0.303
$H_0^2: \alpha_2 = 0$	0.949	0.398	0.549

Note: the entries are probability values (p-values) associated with the null hypotheses of interest; p-values less than 0.05 (or 5% statistical significance) are given in bold and indicate the rejection of the corresponding null hypothesis based on heteroskedasticity and autocorrelation consistent F test; † indicates the rejection of the null hypotheses (at 5% statistical significance) using heteroskedasticity robust wild bootstrap test (with 999 bootstrap iterations).

Only in the case of rice we found evidence for parameter heterogeneity, conditional on the conflict intensity during the preceding period, meaning that conflict may be playing role in rice price transmission. Thus, for maize and sorghum we estimated a basic fixed effects panel regression as per equation (1), and for rice we estimated the panel smooth transition regression as per equation (3); for rice, we also estimated a basic fixed effects panel regression as a reference. For completeness, and as part of the robustness check, we also estimated a linearized variant of the PSTR for all three crops, wherein the transition variable—the lagged conflict intensity—replaces the transition function in equation (2). Table 4 presents the estimated speed-of-adjustment parameters for these specifications.

Table 4: The speed-of-adjustment parameter estimates

	Crops					
	Rice		*Maize*		*Sorghum*	
	estimate	*half-life*	*estimate*	*half-life*	*estimate*	*half-life*
(a): linear panel regression						
	-0.108*	6.1	-0.393***	1.4	-0.337***	1.7
	(0.057)		(0.072)		(0.027)	
(b): panel smooth transition regression						
Low Conflict Intensity	-0.236***	2.6				
	(0.074)					
High Conflict Intensity	-0.108**	6.2				
	(0.053)					
(c): interacted panel regression						
Low Conflict Intensity	-0.204***	3.0	-0.441***	1.2	-0.372***	1.5
	(0.059)		(0.070)		(0.015)	
High Conflict Intensity	-0.124**	5.2	-0.408***	1.3	-0.343***	1.7
	(0.055)		(0.065)		(0.022)	

Note: Table entries are the speed-of-adjustment parameter estimates, with the associated standard errors in the parentheses, where ***, **, and * denote statistical significance at $\alpha = 0.01$, $\alpha = 0.05$, and $\alpha = 0.10$ levels, respectively; and the half-lives (in months), derived from these estimates. Panel (a) presents the parameter estimates from a linear specification; panel (b) presents these parameter estimates for rice from the PSTR model. In this panel, the *Low Conflict Intensity* depicts the parameter estimate for the regime associated with $G(\cdot) = 0$, and the *High Conflict Intensity* for $G(\cdot) = 1$; that is, in the case of the PSTR, the speed-of-adjustment parameter estimates are $\hat{\beta}_0$ and $\hat{\beta}_1$, respectively, for periods with low conflict intensity and periods with high conflict intensity. Finally, panel (c) presents estimates from a linear specification where the lagged price differential is interacted with the transition variable (that is used in the PSTR model); here the *Low Conflict Intensity* depicts the speed-of-adjustment parameter estimates associated with zero conflict incidents on the trade route in the preceding month, while the *High Conflict Intensity* depicts those associated with an average number of incidents along the trade route during the study period.

Several features of interest emerge from these results. Across all three cereals, there is evidence of market integration, albeit of different degrees. For example, for maize and sorghum—the two locally produced cereals—the half-life measures are in the vicinity of one-to-two months, which is the amount of time it takes for one-half of a shock resulting in a movement away from equilibrium to dissipate. In the case of rice, this measure varies from just over two months (during the relatively peaceful conditions) to up to six months (when conflict and violence are intensified). This is based on the estimated PSTR model. Omitted from the table are the estimated smoothness and centrality parameters of the transition function, which we illustrate in the Appendix Figure A2. Panel (c) of the table serves as the 'sanity check' of some sort, where for all three crops we estimate the linearized variant of the panel smooth transition regression—i.e., the transition functions are replaced by the transition variable. The results presented in this panel emphasize the role of conflict intensity in price dynamics of rice, and the lack of it in the case of the other two considered crops.

That conflict intensity does indeed have a negative effect on speed of price transmission is not surprising, given that conflict is likely to disrupt market activity and perhaps communications, lead to involuntary population movements, and slow down or halt transport of goods between cities. Interestingly, while it is true that in the case of rice conflict disrupts the linkages, it also appears to be the case that, by and large, prices are linked among the markets despite the conflict. One possible explanation, if not a speculation, is that people "learn" (adapt) how to operate in conditions where conflict is the defining feature of the daily routine.

We check robustness of our main result by altering the control variables in equation (2). Figure 3 presents the results of the robustness checks, alongside with the main result. Broadly speaking, these results confirm the robustness of our main finding. In all instances, the speed of price transmission is higher (the parameter estimate is more negative) in low conflict intensity regime relative to the high conflict intensity regime. However, the magnitude of these effects appears to be sensitive to omission of some of the cities/markets in consideration. For example, when we exclude the trade routes to Mogadishu from the analysis, the estimated speed-of-adjustment measures nearly double, relative to the status quo; we observe the opposite—i.e., lower speed of price transmission—when we omit the cities of the northern region of Puntland/Galmudug. Notably, while this study captures smaller and somewhat remote cities/markets of Somalia (e.g., Buale, Dinsoor, Hudur), it is still possible that linkages between urban markets and rural markets not included in our analysis (due to data limitations) are even less pronounced than what we report here; to that end, an argument can be made that our estimates are the upper bounds, but speculation is best we can offer in that regard.

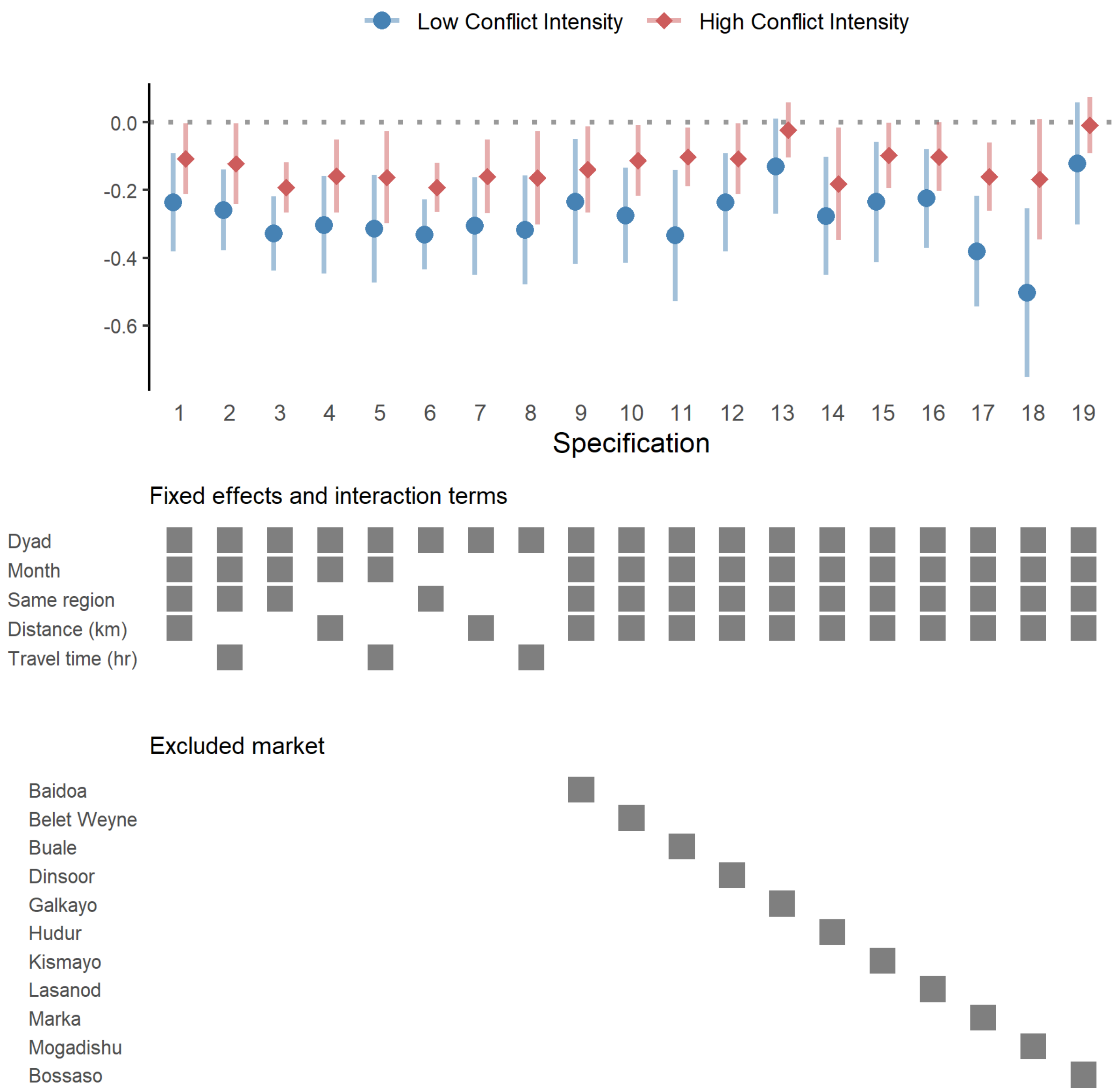

Figure 3: Robustness check of the speed-of-adjustment estimates in low conflict intensity and high conflict intensity regimes

Note: The top panel gives point estimate and 95% confidence interval in each of the considered specifications. Specifications 1-8 consider different explanatory variables indicated in the middle panel, while specifications 9-19 exclude observations related to a particular market indicated in the bottom panel. Each specification is of the form given by equation (2), where control variables, θ_{ijt}, include those depicted by filled boxes in the middle panel under the 'Fixed effects and interaction terms' sub-heading; to form the time-varying controls, variables 'Same region' (binary), 'Distance (km)' and 'Travel time (hr)' are interacted with the lagged price differential (see Table 1 for further details on these three variables). Specification 1, which controls for seasonality as well as region and distance, is our preferred specification. Specifications 2 through 8 use different compositions of these variables, as well as travel time in place of distance, to check the robustness of our main specification. In addition, we check whether the main results are robust to excluding some markets from the data; in particular, we sequentially drop cities indicated in the bottom panel and re-estimate the PSTR parameters; these are depicted in specifications 9 through 19.

The finding that the conflict intensity (along the trade route) alters the degree of price transmission would serve as a 'litmus test' that indeed, markets are integrated (albeit imperfectly). If markets were perfectly integrated, then in absence of conflict we would have observed nearly instantaneous adjustment to any price deviations (the parameter associated with the lagged price differential would have been close to negative one); we do not observe that. In any case, we find that conflict reduces the speed of price transmission; and this finding is robust to a range of different model specifications, including in subsets of data when we omit some markets.

Conclusion and Future Directions

We examined cereal market integration across cities of Somalia separated by distance, *de facto* political boundaries, and conflict. We applied conflict as one of the key sources of the transaction costs—a barrier that can mitigate market integration above and beyond its more "traditional" predicaments. Despite a lack of functioning formal economic institutions that span the entire country, we found that Somali cereal markets are relatively well integrated or are in equilibrium across distances and internal borders. Civil conflict, and the associated armed violence, slows—but does not eliminate—price transmission of imported rice; conflict does not appear to be a defining element in price transmission of locally produced maize and sorghum. We suggest that it may be fruitful in further research to investigate how informal institutions in Somalia may allow for an economy that is more functional, albeit with higher transaction costs, across the entire country than predicted in the market integration literature.

Much of the literature about governance in Somalia has focused on its informal political and security institutions (Phillips and Hastings 2018; Ken Menkhaus 2003; Kenneth Menkhaus 2004), but there has been far less written on its informal economic institutions, Jamal Mubarak (1997) and Peter Little (2003) being notable exceptions. While the capacity of informal institutions is difficult to measure directly, one can look at the fruits of these informal institutions. In an environment where formal state institutions are clearly lacking, the existence of relatively high market integration, measured by relatively high price transmission between cities for the same commodity, suggests that there are other means for traders in markets in different cities to engage in transactions, make and enforce contracts, exchange information, and resolve disputes.

One of the most obvious means by which all of this occurs is, of course, technology-based: through telecommunications carriers, the internet, and mobile money transfer services. Nearly 90 percent of Somalis own a mobile phone, and 75 percent use mobile money (cashless transfers of funds stored as phone credit), which makes Somalia one of the most active mobile money markets in the world (World Bank 2018, 36). However, information and communications technologies (ICT) require considerable capital investments (and thus reasonable confidence that contracts will be enforced) and large amounts of physical infrastructure. Their viability thus requires adequate physical and network security, and reliable access to both electricity and to the infrastructure that is dispersed across the country.

Viability also depends on the presence of some regulation mechanisms: a lack of network interference between carriers requires coordinated access to bandwidth; different telecommunications carriers need to be able to connect calls between their networks (which is usually the product of delicate political and commercial negotiations – see Phillips 2020, 132); while the presence of cashless money transfers and banking requires consumer confidence in the security of their funds being held by companies that are neither established, nor regulated, as banks (World Bank 2017). In other words, the relatively high levels of market integration over distance and internal borders in Somalia is partly a function of its reasonably robust ICT sector, but that robustness is itself a function of complex technical, commercial, and political regulations carried out in the absence of effective state institutions. These draw from the capacity of informal institutions that include: customary legal institutions (including Shari'a codes and *xeer* deliberations – mediating obligations within and between clan groups); informal security arrangements; and clan-based codes of reciprocity and collective responsibility and proportional representation for clans groups, all of which are well established in the literature as playing crucial roles in dispute resolution and the enforcement of obligations across Somalia (Lewis 1959; Marchal 1996; Le Sage 2005; Interpeace 2009).

The present analysis hints at the extent to which informal institutions are functioning, or even obviating formal institutions, although more research is needed into the mechanisms by which this is happening. As such, it dovetails with other research on Somalia's economy by using different methods that make these processes more legible. A potential explanation for this is that informal institutions that allow Somalis to build trust, exchange information, and enforce contracts have flourished in the wake of the collapse of centralized political authority (see Leeson 2007). This may facilitate business activity across barriers that retard, but do not completely sever, the movement of information, goods and people between markets.

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Appendix

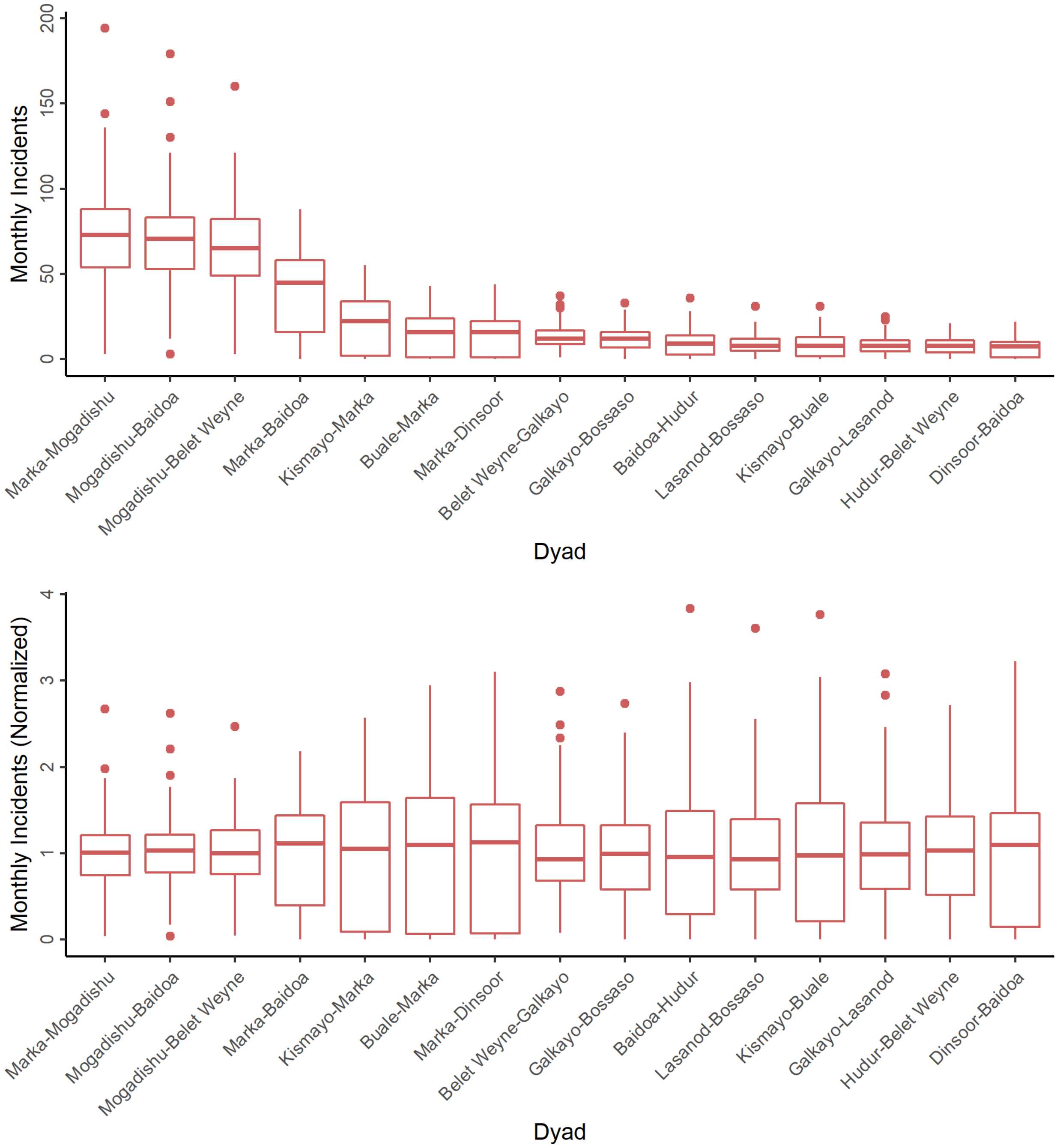

Figure A1: The distribution of incidents across dyads for the original and normalized data

Note: The boxplots present the distribution of monthly incidents along the trade routes between the dyads. The top panel features the monthly count of conflict incidents; the bottom panel features these monthly incidents divided by the average of conflict incidents in a given route during the study period. The two measures of the transition variable used in the analysis are based on these monthly values of conflict incidents.

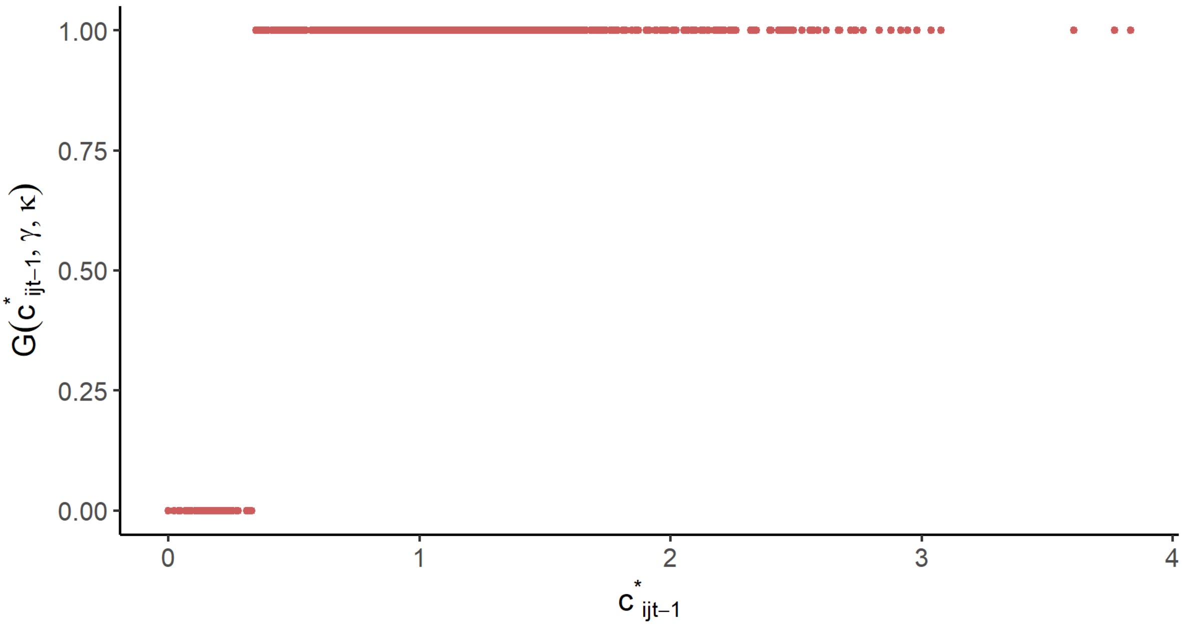

Figure A2: The estimated transition function for the rice equation

Note: The horizontal axis measures monthly incidents along each trade route between the dyads divided by the average of conflict incidents in these routes during the study period, which represents the transition variable in the estimated PSTR model. The vertical axis measures the transition function, which changes from zero to one at about 0.34, which is the estimated centrality parameter; the estimated smoothness parameter is 844, which results in an instantaneous switch between the two regimes.