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Abstract

This paper examines whether violent conflict in one area has discernible impacts in distant locations. To document such spatial spillover effects, we focus on food prices as a propagation mechanism in Somalia. Using geo-coded data on the food distribution network, we link food prices and human capital in different locations to conflict occurring within a narrow geographical corridor around food transportation routes supplying those areas. Our results show that conflict along transportation routes significantly increases food prices, even if markets are located hundreds of kilometres away. Evidence suggests increased transportation cost due to uncertainty and risk as a possible pathway of impact. We further find that conflict along transportation routes decreases food security, nutrition, health, and education for households living in far-away market areas. All effects are robust to controlling for local conflict.

JEL Classifications: D74, I15, I25, Q18.

Keywords: Conflict, Spillover Effects, Food Security, Health, Education

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1 Introduction

A large number of studies has documented the link between conflict, food security and human capital (see Blattman and Miguel, 2010; Verwimp et al., 2019; for overviews). Recently, the problem of conflict-induced food insecurity has also been highlighted by UN Security Council Resolution 2417. A common assumption when analysing conflict is that its effects are highly localized. However, if there exist propagation mechanisms through which conflict affects individuals far away from its location (which we refer to as *spatial spillover effects*), this can have profound consequences for both policy and research. The geographical reach of conflict determines, for instance, not only the scope of humanitarian interventions but also refugee status eligibility of displaced populations. Moreover, spatial spillovers can invalidate research designs that compare individuals close to and far from conflict. Yet, the exact reach of conflict and the spatial propagation of its effects have remained under-explored.

In this paper we estimate spatial spillover effects of conflict on nutrition and human capital by focusing on food prices as a propagation mechanism. The setting for our analysis is Somalia, which experienced a stark increase in violence during the al-Shabaab insurgency from the mid-2000s onwards. We start by estimating spatial spillover effects of conflict on food prices and then go on to explore whether such spillovers further affect the human capital (nutrition, health and education) of households living in those areas where prices go up.

To document spatial spillover effects of conflict on food prices, we estimate whether conflict along the food transportation network changes prices in markets located hundreds of kilometres away. This can be the case, for instance, because conflict along the food transportation network can drive up transportation costs or cause shortages in market regions. We focus on the price of maize, a staple food widely eaten throughout Eastern Africa. In Somalia, maize is produced domestically in three growing regions and transported on roads to selling points. Following research on transportation networks (Dell, 2015; Korovkin and Makarin, 2021b), we identify the exact geographical location of maize transportation routes by combining the geographical coordinates of growing regions, markets, and overland roads with detailed information on the exact routes used for transportation from NGOs working on the ground. For each market in our sample, we draw a corridor five kilometres either side of the transportation route supplying that market with maize. Using the exact geographical coordinates of incidences of conflict from the Armed Conflict Location & Event Data Project (ACLED), we estimate the effect of violent events occurring within this corridor—and far away from markets—each month whilst also controlling for conflict in the proximity of markets. Thus, our approach is very different from the existing literature (see Martin-Shields and Stojetz, 2019) focusing on conflict in proximity to respondents.

By exploiting the exact geographical structure of the food logistics network our research design rules out many common endogeneity concerns. In our case, the 'treatment' (i.e. conflict along the transportation route) occurs far away from the market regions where the outcomes are measured. Identification issues, such as omitted variable bias or reverse causality, by contrast, would typically induce spurious correlation between violence and outcomes *in the same local area*, with little reason why they should increase conflict at a considerable distance away along specific overland routes. Moreover, precisely defined geo-coordinates and monthly price data provide us with rich spatial and temporal variation, which allows us to control flexibly for unobserved regional characteristics and region-time interactions.

Based on monthly maize price data for ten markets in Somalia provided by the Food and Agricultural Organisation (FAO), the results show that each incidence of conflict along transportation routes (and at some distance to markets) increases the price of maize by around 0.7 percent. Our estimates imply that for the most affected regions at the height of the al-Shabaab insurgency violent incidences occurring very close to transportation roads *alone and irrespective of any other conflict* increase maize prices by around 11 percent over sustained periods of time. During this time, the standardized effect size is around half as large as the one of rainfall, highlighted as one of the most important determinants of food prices in general (Food and Agricultural Organisation, 2011; Chavas et al., 2014) and of maize in particular (Berry et al., 2014). Exploiting the fact that markets are located at different distances from where violence occurs, we further show that the effects of conflict along the transport route can still be detected in markets up to 900 kilometres away, corresponding to 17 hours driving time on Somali roads. By contrast, attacks occurring in close proximity to markets, but not along the transportation route, only have a small and statistically insignificant effect on maize prices.

We probe our identification strategy in a number of ways. First, we provide evidence against the concern that our results are contaminated by generalized waves of violence or omitted variables at a supra-regional level. For instance, since Somali territory is controlled by different fractions, it could be that supra-regional institutions introduce spurious correlation between market prices and conflict including—crucially—conflict further away from markets. Using the precise geo-coordinates of attacks, we show that our effect is precisely driven by attacks happening along the transportation network. By contrast, other attacks that occur between growing regions and markets, but not along transport roads, have no effect. Our results are robust towards controlling for these other attacks, as well as for local attacks in the region where the outcome is measured. Second, we use the price of rice, which is transported along other routes, and find no effect of conflict. Neither do we find effects when we estimate the impact of conflict on the price of maize during the lean season, when less maize is transported. Third, we address the issue that ACLED might not capture all relevant incidences of violence by replicating our results using information on terrorist attacks from the Global Terrorism Database (GTD). We find remarkably similar effects. We also subject our estimates to a battery of robustness checks and the results remain robust.

In terms of mechanisms, using rich information contained in the GTD on characteristics of each attack, we test whether conflict increases prices through infrastructure damage, such as the destruction of roads, for instance. Results suggest that effects are not driven by terrorist attacks using explosive weapons, attacks resulting in property damage or attacks aimed specifically at destroying the food or transportation network. An effect of conflict operating through infrastructure destruction, thus, is unlikely.

The second part of our analysis provides evidence that conflict occurring hundreds of kilometres away from individuals affects their food security and that food prices are a likely propagation mechanism. We implement the same research design based on conflict along maize transportation routes using the 2016 and 2017 waves of the Somali High Frequency Survey (SHFS), which contain rich information on food consumption, food security, health and education. We find not only that conflict en route increases self-reported purchase prices but also that households report having to adjust eating patterns due to food price shocks, thus suggesting that food prices are indeed a mechanism through which far-away conflict can affect food security. The results further show that households attempt to mitigate the increase in maize prices by changing their consumption patterns. We find that conflict along transportation roads leads households to substitute more expensive maize with sorghum, increase spending out of savings and reduce non-food expenditures, particularly on health and education. Despite such strategies, we nevertheless find that conflict along transportation routes reduces households' food security, decreases nourishments available and forces households to change eating habits.

Turning to child outcomes, we also find negative spatial spillover effects on health and education, which tally with the expenditure patterns highlighted above. Our results show that conflict along maize transportation routes (and far from respondents) increases the incidences of infectious diseases, such as gastroenteritis, malaria and typhoid, in line with well-known links between malnutrition and infectious diseases (see Scrimshaw, 2003; Black et al., 2008; Calder, 2013; for instance). These effects are stable when controlling for local conflict. As a placebo, we also analyse illnesses unrelated to nutrition and find no effects. Schooling information further shows that far-away conflict along routes decreases school enrolment of primary aged children. All the above results are robust to excluding migrants thus suggesting that selective migration is not biasing the results.

This study is the first to estimate whether agricultural prices play an important role in enabling conflict to affect food security and human capital hundreds of kilometres away. A large number of studies have documented a negative effect of conflict and violence on education (León, 2012; Justino et al., 2013; Brown and Velásquez, 2017; Bertoni et al., 2018; Fransen et al., 2018; Brück et al., 2019; Foureaux Koppensteiner and Menezes, forthcoming), health (Bundervoet et al., 2009; Akresh et al., 2011; Minoiu and Shemyakina, 2014; Arcand et al., 2015; Valente, 2015; Dagnelie et al., 2018; Phadera, 2021) and nutrition (D'Souza and Jolliffe, 2013; Dabalen and Paul, 2014; Serneels and Verpoorten, 2015). Whilst many of these studies mention direct effects such as infrastructure destruction, forced displacement or fatalities (see Brück and Schindler, 2009; Justino and Verwimp, 2013; Williams, 2013; for instance), other, indirect mechanisms have received considerably less attention. We contribute to this knowledge base by highlighting that food prices can be a mechanism through which conflict affects human capital with the potential of affecting not only individuals in conflict areas but also those living further away.

Our study also speaks to a small but growing literature on spatial spillovers of conflicts, which thus far has mainly focused on production in firms (Hjort, 2014; Korovkin and Makarin, 2021b), trade (Korovkin and Makarin, 2021a; Qureshi, 2013), crime (Di Tella and Schargrodsky, 2004; Draca et al., 2011), and gun laws (Dube et al., 2013). The channels of propagation in these papers are the erosion of social capital (Hjort, 2014; Korovkin and Makarin, 2021a), the need of trade partners outside the conflict area to rebalance their trade relationships (Qureshi, 2013; Korovkin and Makarin, 2021b), the diversion of police presence following violent attacks (Di Tella and Schargrodsky, 2004; Draca et al., 2011), and U.S. legislation in a border state (Dube et al., 2013). Our novelty is to focus on the role of food prices as a propagation mechanism, and to document spatial spillover effects on important human capital outcomes (nutrition, health and education), which so far have remained under-explored.

This study also provides—to the best of our knowledge—the first causal evidence of conflict on food prices. As pointed out in a recent overview article (Brück and d'Errico, 2019) research thus far has mainly focused on the reverse causal flow, from the level or volatility of food prices to conflict (Berazneva and Lee, 2013; Smith, 2014; Bellemare, 2015; Bessler et al., 2016; Bush and Martiniello, 2017).

Our findings also have a number of wide-ranging policy implications. The mere presence of spillovers implies that the adverse effects of conflict on human capital might be larger than commonly assumed thus strengthening the case of humanitarian interventions. Moreover, the effects on food prices and food security suggest nutritional subsidies as an example of such policies. Crucially, however, the spatial spillovers on far-away locations we document have important implications for the regional targeting of interventions. For example, the World Health Organisation (WHO) provides emergency medial supplies to areas affected by conflict.[1] However, our findings that individuals far away from conflict are impacted by it suggest to also extend aid to other areas of Somalia.

The next section describes the data and background to our study. Section 3 lays out our empirical strategy. The results are discussed in section 4 and Section 5 concludes.

2 Data, Background and the Food Logistics Network

In this section we present the data and some background information on maize, food logistics and conflict in Somalia.

2.1 Data

Violence: Our main source of conflict data is the Armed Conflict Location & Event Data Project (ACLED), which collects the dates, actors involved, fatalities and modalities along with the exact geographical coordinates on all reported political violence and protest events across Africa and other continents.[2] We complement these data with information drawn from the Global Terrorism Database (GTD), an event database of terrorist attacks, which gathers information on, among other things, the geographic coordinate, number of casualties and group responsible.[3] To disentangle the mechanisms of impact, we use detailed information in the GTD on the type of weapon used, whether an attack resulting in property damage and the target of terrorist attacks.

Maize prices: Monthly maize retail price data for ten markets between 2001 and 2018 are drawn from the Food and Agricultural Organisation (FAO) food price monitoring and analysis tool, which contains information and analysis on domestic prices of basic food items for many low income countries. These data are used by the FAO in its early warning systems on high food prices for vulnerable countries.[4] For ten markets, monthly maize prices are available for years before and after the al-Shabaab insurgency, 2001 to 2018.

Food security, education, health, and expenditures: The main data sources are the two rounds of the Somali High Frequency Survey (SHFS), which was collected and funded by the World Bank in collaboration with Somali statistical authorities. The first wave was

[1] For example: http://www.emro.who.int/images/stories/somalia/documents/technical_programme_update_septmeber_december_2018.pdf?ua=1, accessed December 2021.

[2] The data are available at https://acleddata.com.

[3] The data are available at https://www.start.umd.edu/gtd/about/.

[4] The data are available at https://fpma.apps.fao.org/giews/food-prices/tool/public/#/home.

implemented between February and March 2016 and interviewed 4,117 households across 9 regions.[5] The second round interviewed 6,092 households in 17 regions during December 2017.[6] Both rounds contain information on economic conditions, food security, education, employment, and health, as well as detailed consumption expenditure data.

We complement these survey data with the percentage of children aged 6 to 59 months who are classified with low weight-for-height and/or oedema as collected by the Food Security and Nutrition Analysis Unit (FSNAU) in collaboration with the FAO. The FSNAU divides Somalia into livelihood zones and collects nutrition infomation twice yearly (after the Deyr and Gu harvests).[7] A livelihood zone is classified as *critical* if the proportion of malnourished children exceeds 0.15.

2.2 Maize in Somalia

Maize is a staple food in Somalia. Usually prepared as a flour it is inexpensive, high in energy and widely eaten throughout the country. For many Somalis maize along with other staple foods are the only affordable nourishments (WFP, 2019).

Maize is produced in three areas. These, along with Somalia's 16 administrative areas—so-called regions—are shown in figure 1a. Maize production is mainly rainfed and concentrated predominantly in the Lower Shebelle region, which accounts for 80 percent of production. In an average year, Somalia produces around 130,000 mega tonnes of maize, which suffices to meet domestic demand making the country largely self-sufficient regarding maize (FEWS, 2017; WFP, 2019). Appendix Figure A.2 shows a relatively low importance of international trade in maize for Somalia. Maize imports make up around 8 percent of domestic maize production evaluated at the average retail price. Moreover, imports and exports appear uncorrelated with conflict and follow droughts instead.

In sum, the bulk of maize consumed in Somalia is produced domestically. Moreover, imported cereal price fluctuations are not expected to affect much the prices of locally produced food (WFP, 2011).

2.3 Food logistics network in Somalia

We identify transportation routes for maize by combining the geographical coordinates of maize growing areas (Figure 1a) and the ten markets for which we have monthly prices from the FAO (Figure 1b) with information on transportation routes for maize provided by

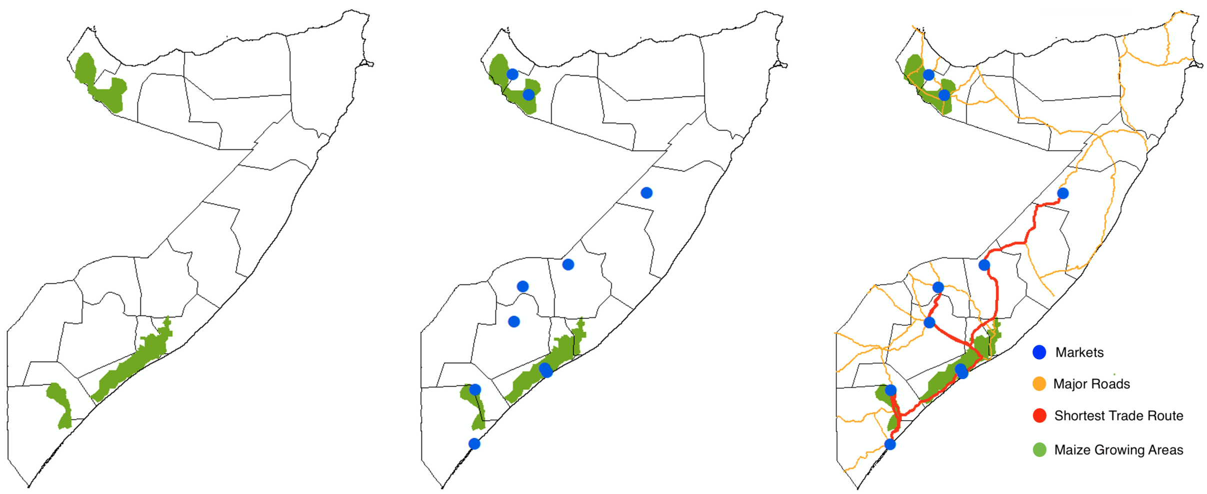
[5] The data are available at `https://microdata.worldbank.org/index.php/catalog/2738`.

[6] The data are available at `https://microdata.worldbank.org/index.php/catalog/3181`.

[7] The data are available at `http://fsnau.org/nutrition/`.

Figure 1: Maize growing areas, markets and transportation routes

(a) Maize growing areas (b) Maize selling markets (c) Transportation routes



Notes: Maps report geographical location of maize growing areas (panel a), markets selling maize (panel b) and most frequently used transportation routes for maize in a typical year (panel c). **Data sources:** FAO, FEWS NET.

practitioners and NGOs working locally.

Maize is mainly cultivated by small-scale farmers in the three producing regions shown in Figure 1a. After harvests, farmers store the maize locally, usually in underground storages (FAO, 2018). The maize is subsequently transported to markets via road, which is the main source of transport. There is no railway and water or air transportation are not generally feasible. Only major roads, of which there are only few, are paved, see Figure 1c. Smaller roads are not paved and not usable for parts of the year at least (Government of Somalia, 2018).

Information on maize transportation routes is provided by the Famine Early Warning Systems Network (FEWS NET). Funded by the United States Agency for International Development (USAID) and collaborating with the FAO, FEWS NET is a leading provider for the analysis of food insecurity throughout the world. In collaboration with local government ministries, market information systems, NGOs, and private sector partners, FAO and FEWS NET produce maps denoting the roads along which maize is transported from growing areas to markets in Somalia.[8] These maps also contain information on food scarcity and are used by the FAO to monitor nutrition and to plan humanitarian interventions.

We overlay the trade route maps provided by FEWS NET with the Somali road network to identify the exact geographical locations of the roads via which maize is most frequently

[8]Food transportation networks are available under `https://fews.net/east-africa/somalia`. Accessed July 2021.

transported to each of the markets in a typical year (see Figure 1c in red). To identify incidences of conflict occurring along transportation routes, we draw a corridor of 5 kilometres either side of the route to each of our ten markets. Our definition also excludes the administrative area each market is located in and any violent incidences occurring in towns or cities along the route; see section 3 for a detailed description. Subsequently, we match these ten corridors to the geographical coordinates of violent incidences (either the ACLED or the GTD) and sum the number of incidences occurring within each corridor per month. Two examples of trade routes to individual markets are provided in parts (b) and (c) of Appendix Figure A.1, and part (d) of that figure provides an example of attacks falling within the 5 kilometre corridor.

2.4 Conflict in Somalia

Somalia is a violent country. According to ACLED, between the years 2001 and 2018 the country experienced 27,169 incidences of conflict, see panel A of Table 1. The majority of conflict in Somalia consits of *battles* (13,343), defined as 'violent clashes between at least two armed groups' and *violence against civilians* (6,374) defined as 'violent attacks on unarmed civilians'. According to the GTD, Somalia experienced 4,498 terrorist attacks during the same time period, see panel C of Table 1. Figure 2a shows the geographical distribution of attacks. While there is a higher concentration in the more populated southern part of the country, no region has been spared.

The evolution of attacks over time (Figure 2b) reveals a sharp increase of violence in Somalia from the mid-2000s onwards. This drastic increase coincided with the rise of al-Shabaab, an Islamist terror organisation founded in the early 2000s with the aim of overthrowing governments in the Horn of Africa region and to install Islamic rule. In the next section we explain our empirical strategy that exploits both the regional and temporal variation in attacks, together with the geo-coded information on market location and the food transportation network.

3 Empirical strategy

Effects on food prices. We estimate spatial spillover effects of conflict on maize prices using the following regression of the log price of maize in USD ($log(price_{itm})$) in market i,

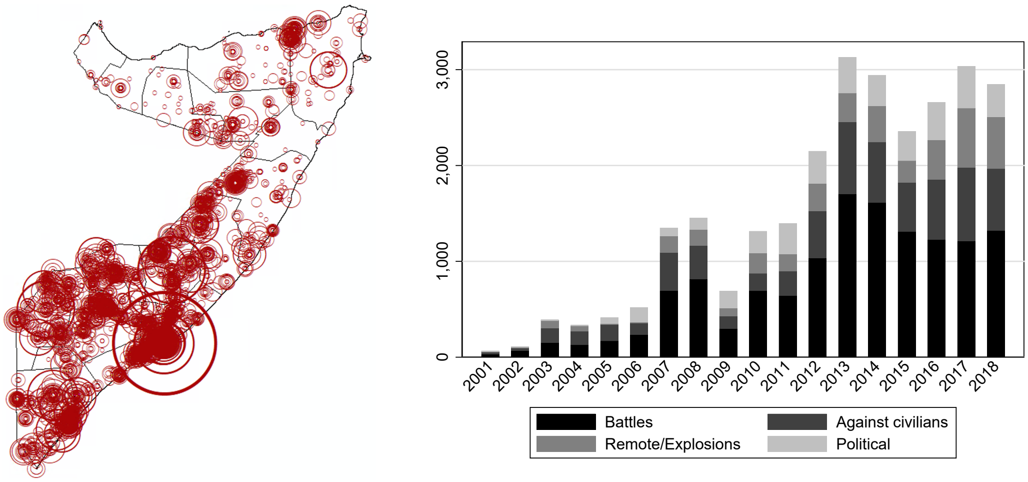
Table 1: Summary statistics

	A: All violent incidences (ACLED)				
Type of incidence	All	Battles	Against Civilians	Explosions	Other
Nr of incidences	27,169	13,343	6,374	3,761	3,691
% of total		49.1%	23.5%	13.8%	13.6%
	B: Conflict along transportaiton routes (ACLED)				
Type of incidence	All	Battles	Against Civilians	Explosions	Other
Nr of incidences	1,334	781	225	157	171
% of total		58.5%	16.9%	11.8%	12.8%
	C: Terrorist attacks (GTD)				
Type of incidence	All	Aimed at Military	Aimed at food transport	Aimed at other	Involving barricades
Nr of incidences	4,498	1,890	53	2,555	12
% of total		42.0%	1.2%	56.8%	0.3%
	D: Terrorist attacks along transportation routes (GTD)				
Type of incidence	All	Aimed at Military	Aimed at food transport	Aimed at other	Involving barricades
Nr of incidences	180	114	5	61	0
% of total		63.3%	2.8%	33.9%	0%
	E: Household and child characteristics (SHFS)				
	Below poverty line	Not enough food	Literacy	School enrollment (age 6-14)	Access to improved sanitation
Mean	0.47	0.25	0.57	0.53	0.10
Observations	6,417	6,417	6,417	8,134	n.a.

Notes: Table reports summary statistics on conflict and characteristics of households in Somalia. Panel A: reports incidences of conflict in Somalia by type (based on ACLED); Panel B: reports incidences of conflict within 5 kilometres either way of transportation routes by type (based on ACLED); Panel C: reports terrorist attacks in Somalia by target (based on GTD); Panel D: reports terrorist attacks within 5 kilometres either way of transportation routes by target (based on GTD); Panel E: the first four columns report summary statistics from own calculations based on the SHFS survey data for 2016 and 2017. The literacy rate covers adults and children from the age of 6 onwards. The fifth column reports access to improved sanitation taken from Table B.3 of The World Bank (2017) based on SHFS data. The World Bank defines an improved sanitation facility as one that hygienically separates human excreta from human contact. **Data sources:** ACLED, GTD, SHFS, The World Bank (2017).

Figure 2: Conflict in Somalia - Geographical and temporal variation

(a) Geographical variation (b) Temporal variation



Notes: Figure reports geographical and temporal variation of incidences of conflict in Somalia between 2001 and 2018. Panel a: shows geographical location of incidences of conflict; radii are proportional to number of fatalities. Panel b: shows temporal variation in incidences of conflict by classification. **Data source:** ACLED.

in year t and month m:

$$
\begin{aligned}
log(price_{itm}) &= \alpha_1 conflict_{route_{itm}} + \alpha_2 conflict_{local_{itm}} + \alpha_3^T X_{itm} \\
&\quad + \eta_i \times \tau_t + \eta_i \times \mu_m + \epsilon_{itm}. \qquad (1)
\end{aligned}
$$

Our main focus lies on estimating the effect of $conflict_{route_{itm}}$, capturing violent incidences occurring along the maize transportation route at some distance from markets. This variable counts the number of violent incidences in year t and month m occurring five kilometres either side of the transportation route used to supply market i with maize, but excluding any violent incidences occurring in the same administrative area that market i is located in.[9] We further exclude from $conflict_{route_{itm}}$ any violent incidences which occur in cities or towns located along the transportation route.[10] The main reason to exclude this is that typically there are multiple routes that allow crossing an urban area, making the definition of the transportation route ambiguous in these areas. The coefficient α_1 captures the spatial spillover effect of violence occuring hundreds of kilometres away along transport routes on prices at the markets served by these routes.

[9] See section 2.3 and Figure 3c for detailed descriptions and the maps in figures A.1b and A.1c as two examples.

[10] We take the city or town centre and exclude any violent incidences within a 15 kilometre radius.

In line with previous research, we also examine the role of violent incidences occurring in the vicinity of markets. For this, we define the variable $conflict_{local_{itm}}$, which counts the number of violent events in year t and month m occurring in the same administrative area as market i. As an alternative definition of $conflict_{local_{itm}}$, we also identify all violent incidences occurring within a 15 kilometre radius of market m.

In X_{itm} we include growing season specific rainfall as a control given its importance as a determinant of food prices (see Food and Agricultural Organisation, 2011; for instance).[11] In extended versions of eq. (1), X_{itm} will be augmented to include variables such as lagged values of conflict, or conflict in additional geographical locations.

Finally, we control flexibly for unobserved regional characteristics, which are allowed to vary by year and calender month using market-by-year ($\eta_i \times \tau_t$) and market-by-month ($\eta_i \times \mu_m$) fixed effects. This implies that estimation of (1) exploits variation in the regressors that consists of deviations from the yearly and calendar month averages for each particular market. Our flexible specification thus allows for two types of unobserved heterogeneity. First, equation (1) differences out any unobserved factors particular to each of our ten markets in each year from 2001 to 2018. This, for instance, would account for a drought in a particular year to affect each of our ten markets differently. Second, our specification also allows for any unobserved heterogeneity specific to each market and calendar month thus accommodating that prices may fluctuate differently throughout the calendar year in each market. As a result, the specification in equation (1) can flexibly control for a number of sources of potentially confounding variation.

Identification. For causal identification of the spatial spillover effect we do not only rely on the tight control strategy described above, but we additionally exploit the structure of the food transportation network. The incidences of conflict captured by $conflict_{route_{itm}}$ occur along maize transportation routes and exclude conflict in proximity to markets. As a result, the spillover effect α_1 is identified by incidences of conflict that occur far outside of the market region where the price is measured. This research design rules out a range of common endogeneity concerns. For example, a common problem in analysing the effect of conflict on food prices is reverse causality where high prices cause dissatisfaction amongst the population and lead to violence. Such types of conflict, however, would be expected to occur in proximity to markets, and reverse causality would thus be unlikely to explain violence that occurs along transportation routes hundreds of kilometres away, as captured

[11] We use cropland-specific rainfall data from the United Nations' World Food Programme to calculate harvest specific rainfall for each market by averaging precipitation in the growing area supplying maize over the previous growing season (either Gu or Deyr).

by $conflict_{route_{itm}}$.[12]

A possible identification concern, however, relates to omitted variables at a supra-regional level, which could introduce a spurious correlation between market prices and conflict, including further away from markets. As an example, the Somali territory is under the control of three separate entities: the Somali government together with its AMISOM allies, al-Shabaab and Somaliand. Institutions specific to each faction could differ in terms of their efficiency, and inefficient institutions could cause both, high prices (because of less efficient markets) and more violence (because of lack of institutions or enforcement, or in protest to high prices). As such, those parts of the country characterised by less efficient institutions are likely to experience both higher prices and generally more incidences of conflict, including along transportation routes.

In fact, our baseline specification (1) in parts already addresses the aforementioned concern. By controlling for local violence in market i's administrative area and for market-specific year and month effects, our specification allows for changes in general levels of violence at the supra-regional level.

To further address this concern, we will show results where we augment equation (1) with an additional covariate $conflict_{all_{itm}}$. This variable measures all incidences of conflict between market i and its supplying growing region *excluding* those incidences along the transportation route already included in $conflict_{route_{itm}}$. The covariate $conflict_{all_{itm}}$ acts as a further control for generalised conflict and helps us to establish whether the effect is driven by more general incidences of conflict, or specifically by those occurring along transportation routes.

To further rule out any spurious correlations between conflict and prices, we carry out a placebo check. Any spurious relation between conflict and prices would affect prices of a range of goods, not just of maize. The mechanism we wish to investigate, by contrast, implies that conflict along transportation routes for maize should very specifically affect the price of maize. We show that this is indeed the case by regressing incidences of conflict along the transportation route for maize on the price of rice. Rice is transported along different routes and, consequently, its price should not be directly affected by violence along the transportation route for maize. Taken together, our approach allows us to show that it is conflict along the transportation route for maize (as opposed to other generalised conflict) which has a very specific effect on the price or maize, but not of rice.[13]

[12]Moreover, because our definition of violent attacks along the transportation route excludes violent attacks in towns and cities along the route, $conflict_{route_{itm}}$ would not pick up the confounding variation even if there was a mechanism that would spread violent protest due to dissatisfaction with high prices from the market regions to other towns further away along the transportation route.

[13]Conflict along the transportation route for maize could of course affect the rice price indirectly via

Effects on human capital. To estimate spatial spillover effects on human capital we use the 2016 and 2017 rounds of the SHFS. The regression equation for outcome y_{jtr} for individual or household j in year t and region r is given by

$$\begin{aligned} y_{jtr} &= \beta_1 conflict_{route_{jtr}} + \beta_2 conflict_{local_{jtr}} + \beta_3^T Z_{jtr} \\ &+ \mu_r + \tau_t + \nu_{jtr} \end{aligned} \tag{2}$$

As outcomes we consider survey information on nutrition, health, and education measured at the household or the individual level. Equation (2) employs a similar research design as equation (1), based on conflict occurring along maize transportation routes. For each Somali region of residence r we determine from which maize growing area the markets in the region are supplied. As before, we combine the geo-coordinates of growing areas and roads with information on transportation routes provided by FEWS NET and define $conflict_{route_{jtr}}$ as all incidences of conflict occurring within a 5km corridor either side of the the transport route from the respective growing areas to the markets in region r. From this we exclude violent incidences in region r itself, which form our measure of conflict in the own local area, $conflict_{local_{jtr}}$. We typically define the conflict variables by counting violent incidences in the month preceding the SHFS survey date for each of the rounds. However, for retrospective questions asked over a longer period (such as, for instance, expenditure items over the past year), we adjust the period over which we measure incidences of conflict accordingly. When doing so, we state the definition in the results tables.

As control variables Z we include household size, gender of the household head, the proportion of literate household members, indicators for the household having at least one economically active member, and whether the household is below the poverty line. For individual outcomes, Z also includes age fixed effects.

Due to the inclusion of region fixed effects μ_r and year fixed effects τ_t, the variation exploited by equation (2) to identify the spatial spillover effect β_1 is a difference-in-differences type of variation that nets out common year effects and time-constant unobserved differences between regions.[14] In contrast to standard difference-in-differences approaches used in previous studies, however, our 'treatment' consists of conflict occurring along roads located far away from households and children. Thus, similarly to equation (1), specification (2) exploits the transport network structure to isolate conflict occurring far away from respondents and

consumer demand, if rice is an important substitute for maize. We investigate spillover effects on the demand for other staples in section 4.3, where we find some evidence for substitution of maize with sorghum, but not rice.

[14]A small number of outcomes is only available in one of the survey rounds. In these cases we estimate equation (2) as a cross-sectional regression without region and year effects. We indicate these cases in the results tables.

also along a narrow corridor around transportation routes. Hence the same arguments for identification as discussed above apply.

4 Results

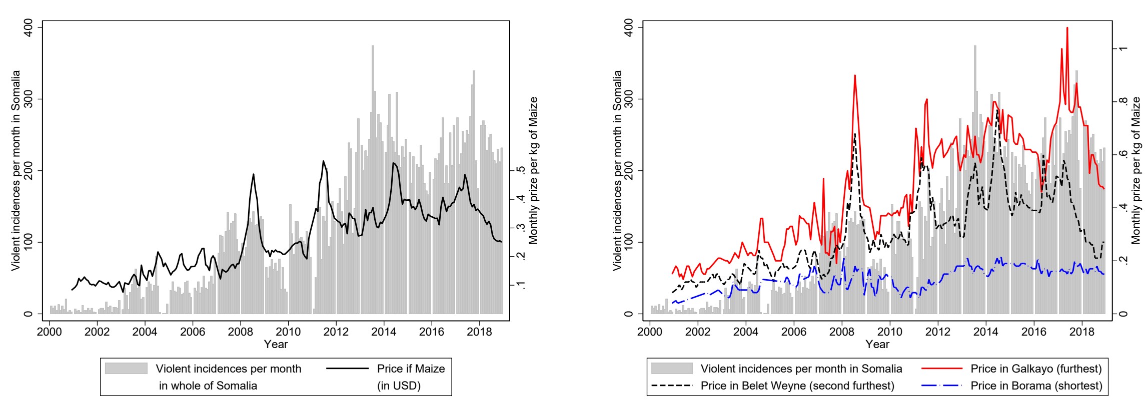
4.1 Spatial spillover effects of conflict on food prices

Descriptive evidence. Figure 3a shows that both the average price of maize across our ten markets and countrywide conflict in Somalia increase over the sample period. In Figure 3b, we exploit the sudden increase in violence during the al-Shabaab insurgency to provide preliminary evidence that conflict along the transportation route increases prices. The illustration compares prices in three markets located at different distances to growing areas. Before the al-Shabaab insurgency in the early-2000s, prices are similar and show parallel trends. After the insurgency, price increases are strongest in Galkayo (transportation route of 900 kilometres, with many attacks en route), followed by Belet Weyne (transportation route of 400 kilometres, with fewer attacks en route) with no changes in Borama (located next to a growing area, therefore no attacks along the road). These descriptive results provide preliminary evidence of a positive association between market prices and attacks along the transportation routes serving the markets. Appendix Figure A.1a provides a map of the geographical location of the three markets.

Figure 3: Price of maize over time

(a) In Somalia

(b) By distance to growing area



Notes: Figure reports conflict and maize prices over time in Somalia. Lines denote monthly maize prices and bars monthly incidences of conflict. Panel a: shows average monthly maize price for all ten markets; Panel b: shows monthly maize price for three selected markets: Borama in blue (an example of a short transportation route), Belet Weyne in black (an example of a medium length transportation route), and Galkayo in red (an example of a long transportation route). **Data sources:** ACLED, FAO.

Regression results. Column (1) of Table 2 reports our main result, which shows that one incidence of conflict along the transportation route ($conflict_{route_{itm}}$ in equation 1) increases the price of maize by 0.37 percent. The high R-squared suggests that our model captures variation in maize prices well. Given that our sample consists of ten markets, we also estimate p-values using the Wild Cluster Bootstrap method, which shows that our estimates remain statistically significant throughout.[15] In column (2), we focus on the years 2016 to 2018, which are around the height of the al-Shabaab insurgency and also close to the time period covered by the SHFS survey that we will use in section 4.3. For this time period, each attack increases maize prices by 1.1 percent. At an average number of around 10 incidences of conflict for the most affected markets, our results imply that conflict occurring within a 5km corridor either side of roads along and independent of any other conflict raises maize prices by around 11 percent. Column (3) compares this effect to rainfall, highlighted as one of the most important determinants of agricultural prices (see Food and Agricultural Organisation, 2011; for instance). The estimates based on z-scores show that conflict is around half as important as rainfall for maize prices.

Columns (4) and (5) investigate the importance of conflict occurring in proximity to markets ($conflict_{local_{itm}}$ in equation 1). We use two separate measurements for this variable: incidences of conflict occurring in the same region as market i (column 4) and 15 kilometres around market i (column 5). In both cases, the parameter estimates for violent incidences occurring adjacently to markets are small in size. The coefficient on conflict along transportation routes, by contrast, remains virtually unchanged.

Alternative measure of attacks. Next we explore the question whether our results might be affected by ACLED not recording all violent incidences that may be relevant for the price of maize. Al-Shabaab employs a number of terrorist tactics, such as bombings, hijackings or abductions, which might not be recorded by ACLED. To address this concern, we use information drawn from the GTD and re-define the variable $conflict_{route_{itm}}$ as *terrorist attacks* occurring 5 kilometres either side of the shortest transportation route. As column (6) in Table 2 shows, each terrorist attack en route increases the price of maize by around 1.6 percent.

Controlling for generalised violence. We now probe our main specification further against potential endogeneity concerns. Column (7) of Table 2 shows the results when we augment equation (1) by including $conflict_{all_{itm}}$, capturing violence anywhere between mar-

[15]We carry out hypothesis testing using Wild Bootstrap with 1000 replications. We bootstrap at the market level with 1,000 replications using the command *boottest* (Roodman et al., 2018).

Table 2: Effect of conflict along transportation route on price of maize

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Dependent variable: log price of					
	Maize	Maize	Maize	Maize	Maize	Maize	Maize	Rice	Maize
Conflict en route (excl. same region)	0.0037	0.0108		0.0035	0.0038	0.0158	0.0032	0.0012	
	(0.0010)	(0.0040)		(0.0011)	(0.0016)	(0.0066)	(0.0012)	(0.0011)	
Conflict en route (z-score)			0.0569						
			(0.0209)						
Rainfall in growing region (z-score)			−0.0999						
			(0.0666)						
Conflict in same region as market				0.0012			0.0011	0.0017	
				(0.0010)			(0.0010)	(0.0012)	
Conflict 15km around market					0.0019				
					(0.0031)				
Conflict betw. growing area and market							0.0007	0.0000	
							(0.0004)	(0.0006)	
Conflict en route out of lean season									0.0105
									(0.0052)
Conflict en route in lean season									0.0023
									(0.0007)
Observations	1,965	357	357	1,965	1,965	1,965	1,965	1,794	1,965
R^2	0.925	0.944	0.944	0.926	0.926	0.926	0.926	0.968	0.925
Wild Bootstrap p-value	[0.026]	[0.037]	[0.037]	[0.034]	[0.013]	[0.026]	[0.031]	[0.426]	[0.081]
Data source	ACLED	ACLED	ACLED	ACLED	ACLED	GTD	ACLED	ACLED	ACLED
Years	2001-18	2016-18	2016-18	2001-18	2001-18	2001-18	2001-18	2001-18	2001-18

Notes: Table reports effect of incidences of conflict occurring along transportation routes on food prices. Estimations are based on equation (1). *Conflict en route (excl. same region)* denotes incidences of conflict occurring 5 kilometres either side of the transportation route supplying maize to each market and not located in the same administrative unit as the market; *Conflict in same region as market* denotes incidences of conflict occurring in the same sub-national administrative area each market is located in; *Conflict 15km around market* denotes incidences of conflict occurring within a 15 kilometre radius of each market; *Conflict betw. growing area and market* denotes incidences of conflict occurring in any administrative region located between each market and its growing area *excluding* any incidences within 5 kilometres of the transportation route to that market; *Conflict en route out of lean season* denotes incidences of conflict along the transportation route outside of the lean season (January, February, March, April, August, September); *Conflict en route in lean season* denotes incidences of conflict along the transportation route during the lean season (May, June, July, October, November, December); all regressions control for rainfall (in mm) during previous growing season; Standard errors are clustered at market and reported in parentheses; Wild cluster bootstrap p-values for *Conflict en route* (999 replications) are reported in brackets. **Data sources:** ACLED, FAO, GTD.

ket i and its supplying growing region, except those incidences along the transportation route included in $conflict_{route_{itm}}$. Together with the inclusion of local violence close to markets, this additional variable helps to control for generalised violence in the wider area or part of Somalia in which a given market and its transportation routes are located. The results show that the effect of violence along the transportation route remains robust and that there is no effect of violence between growing areas and markets that does not occur along the transportation route. Violence close to markets also continues to have no statistically significant effect. This implies that the effect of violence along transportation routes is unlikely to be driven by a spurious correlation induced by supraregional differences in generalised violence across different parts of the country. Instead, it seems to be driven by something very specific to transportation routes.

Placebo treatments. As a placebo check, we estimate the effect of attacks along the transportation route for maize on the price of another staple food, rice, which is transported along different roads.[16] Rice is not grown in Somalia but imported by sea through four ports: Bernera and Bossaso in the north of the country and Mogadishu and Kismayo in the south from where it is transported to markets throughout the country. We obtained rice price data for 9 of our 10 markets. As column (8) of Table 2 shows, attacks along the transportation route for maize do not affect the price of rice. By contrast, the coefficient estimate on violence in the region each market is located in remains very similar to the analogous specifications for maize (see columns 4 and 7). Thus, not only is our main effect an effect specific to transportation routes, it is also a very specific effect of the transportation route *for maize* on the prize of maize, but not of rice.

High and lean seasons. As a further check, we exploit the fact that the production of maize and thus the amount transported along roads varies along the crop calendar. Somalia has two lean and two high seasons, determined by its two rainy seasons, the Deyr and the Gu. During lean seasons, less maize is transported along roads and consequently the effect of attacks should be less pronounced. Distinguishing violent incidences during lean and high seasons in column (9), we find that the effect of conflict occurring during high seasons is five times as large as the effect of violent incidences occurring during lean seasons.[17]

[16] There is a small overlap in routes as two roads are used for both maize and rice.
[17] The lean seasons are May to July and October to December.

4.2 Length of reach and pathways of impact

After having documented significant spatial spillover effects on the price of maize, we turn to exploring conflict's length of reach, potential mechanisms of the effect and possible implications for food security classifications.

4.2.1 Length of reach

To illustrate the long reach of violence, we identify conflict along the transportation route *located in growing areas only* and estimate their effect on prices in markets hundreds of kilometres away. Matching each market with its growing region, we count per year t and month m the number of violent incidences that occur 5 kilometres either side of the transportation road located within the growing region only.[18] Since we are focusing on a narrow corridor along paved roads, our definition excludes violent incidences in growing fields. Consequently, the estimated effect is likely to reflect transportation costs and not the supply of maize. The left panel of Figure 4 shows that each attack occurring on the road in growing regions increases the price of maize by 0.7 percent.

Exploiting the fact that markets are located at different distances to their supplying growing areas, we then examine how far in distance from growing areas we can detect the effect of violence, and whether the effect size depends on the distance. A common implicit assumption in the analysis of conflict is that entities far away from conflict remain unaffected (see Blattman and Miguel, 2010; Verwimp et al., 2019; for overviews). In our study context the assumption that distant markets are unaffected would only be plausible if more distant markets had better access to alternative maize supplies (e.g., from other growing areas). In absence of alternative sources of supply to distant markets, the effect of conflict would be propagated through space and remote markets would be affected by incidences of conflict occurring far away. If conflict causes scarcity of produce or transport capacity, markets closer to growing areas might be served first, which could in principle even lead to more distant markets experiencing higher scarcity and stronger price rises than less distant ones.

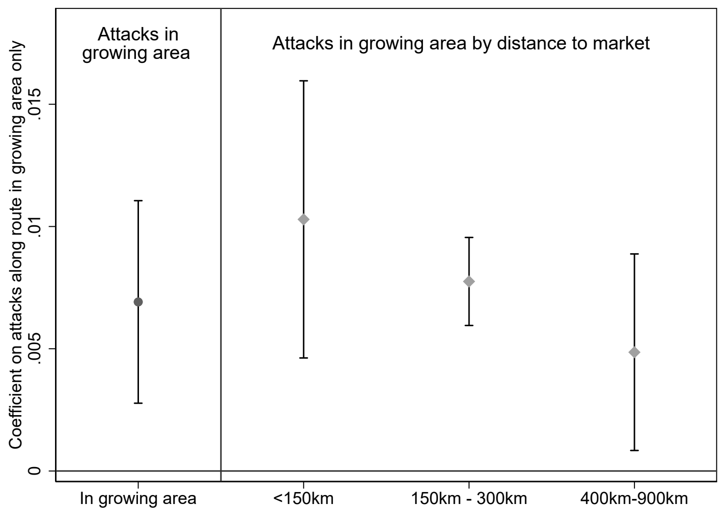
The right panel of Figure 4 shows the results obtained from grouping markets into three bins: markets located less than 150km (an 2 hour drive in Somalia), 150km to 300km (a drive of between 2 and 4 hours), and between 400 and 900 kilometres from the growing area (corresponding to a 8 to 17 hour drive on Somali roads).[19] For the nearest markets, the

[18] The growing region in Lower Shebelle serves the following markets: Baidoa, Belet Weyne, Galkayo, Hudur, Qorioley, and Marka. The growing region in Middle Juba serves the following markets: Buale and Kismayo. The growing region in Woqooyi Galbeed serves the market of Hargeisa. The growing region in Awdal serves the market of Borama.

[19] We used Google Maps to calculate driving times.

effect of violent incidences in growing regions is very strong, around 1 percent per attack. The strength of the effect decreases monotonously across the groups, reaching around 0.5 percent per attack for the markets furthest away from the growing areas, although the effect differences are not statistically significant. The main conclusion from this exercise is that there remains an important and statistically significant effect on maize prices even from violent attacks that occur up to 900 kilometres away from the market.

Figure 4: Effect of conflict in growing area by distance to market



Notes: Figure reports effect of conflict occurring within a 5 kilometre corridor either side of transportation routes *in maize growing areas only*. Dots and diamonds denote point estimates and vertical lines 95% confidence; regressions also control for market-by-year and market-by-month fixed effects and rainfall in growing area. Left panel: reports parameter estimate for conflict occuring on transportation route in the growing area supplying each market with maize only. Right panel: groups markets into three bins (less than 100 kilometres, 150 to 300 kilometres and 400 to 900 kilometres). **Data sources:** ACLED, FAO.

4.2.2 Mechanisms of impact

One possible way through which violent incidences along the road can increase the price of maize is by destroying transportation infrastructure such as roads, for instance. Three pieces of evidence suggest that the effects are not primarily driven by destruction of transport infrastructure. First, the descriptive patterns shown in Table 1 suggest that the majority of violent incidences in Somalia are unrelated to the food and transportation network. As can be seen from panels A and B, the majority of conflict in Somalia consists of 'battles', which typically do not target food logistics. Explosions, which would have the potential of major infrastructure destruction, make up a minor share of the overall violent incidences, accounting for around 12 percent of violent incidences along transportation routes (panel

B). Detailed information on the target of terrorist attacks from the GTD in panel C shows that the majority of attacks were aimed at the military. Only 53 attacks, corresponding to around 1 percent, targeted either the food supply or transportation. Moreover, only a very small proportion of attacks (12, corresponding to 0.3 percent) involved barricades, which might block roads.

Second, we re-estimate the effect of conflict en route whilst also controlling for two months' lags and find that the effect of conflict along transportation routes is driven by contemporaneous conflict (see column (1) of Table 3). Occurrences of conflict in the two months before, by contrast, have no effect on maize prices. The absence of lagged effects is an indication that the effect is driven by mechanisms that tend to reverse themselves within a month after the attack, which makes major infrastructure destruction which would take longer to rebuild an unlikely channel.

Third, we exploit the rich information on type of attacks, their target, and their damage caused contained in the GTD to identify attacks that could plausibly destroy infrastructure. We start by distinguishing terrorist attacks, which use explosives (and are thus more likely to damage infrastructure) and attacks which do not. The parameter estimates in column (2) of Table 3 show that the effect of attacks that do not use explosives is markedly larger than attacks with the use of explosives. Moreover, in column (3) we use information in the GTD to distinguish terrorist attacks that do and do not damage property. Again, the effect of attacks not resulting in property damage is considerably larger. Finally, in column (4) we distinguish terrorist attacks aimed at the food and at the transportation network to any other attacks. As before, the effect of attacks aimed at the food or transportation network are less pronounced than other attacks.

Overall, the patterns of results in this section suggest that conflict's effect on food prices does not predominantly operate through infrastructure destruction or intentional targeting of the food distribution network. Effects are thus more likely to be driven by indirect consequences of violent conflict. These may include disruption of supply or increased transport cost that arise as a result of risk mitigation or compensation in response to conflict.

4.3 Spatial spillovers of conflict on human capital

Descriptive evidence. The summary statistics based on the SHFS in panel E of Table 1 highlight the very low socio-economic status of respondents. Almost half of respondents across the 2016 and 2017 surveys were classified to be below the standard international poverty line, earning less than $1.90 a day evaluated at 2011 purchasing power parities. Moreover, the literacy rate among adults and school-aged children and children's school

Table 3: Effect of conflict along route on maize price - mechanisms

	(1)	(2)	(3)	(4)
	Dependent variable: log price of maize			
Conflict en route:	0.0036			
(excl. same region)	(0.0009)			
Conflict en route:				
1 month lag	0.0008			
	(0.0012)			
2 months lag	0.0009			
	(0.0020)			
Not using explosives		0.0203		
		(0.0064)		
Using explosives		0.0059		
		(0.0082)		
Not damaging property			0.0386	
			(0.0183)	
Damaging property			0.0036	
			(0.0058)	
Not targeting transport				0.0170
				(0.0079)
Targeting transport				−0.0081
				(0.0399)
Observations	1,965	1,965	1,965	1,965
R^2	0.925	0.926	0.926	0.926
Data source for conflict	ACLED	GTD	GTD	GTD
Data source for outcome	FAO	FAO	FAO	FAO
Years	2001-18	2001-18	2001-18	2001-18

Notes: Table reports effect of conflict along maize transportation routes on the price of maize. *Conflict en route* counts number of incidences of conflict occurring within a 5km radius either side of the most frequently used route between maize growing area and market per month. Estimations are based on equation (1). Dependent variable is the log of the price of maize. **Data sources:** ACLED, FAO, FSNAU, GTD.

enrolment (at age 6-14) are low at 57 and 53 percent respectively. Finally, only 10 percent have access to improved sanitation.

Self-reported purchase prices. We start by replicating the spatial spillover effect on prices documented in Table 2 using purchase prices as reported by SHFS respondents. The SHFS inquires about food purchases of households within the 7 days before the interview, which allows us to calculate food prices per kg. Columns (1) and (2) of Table 4 report estimates of equation (2) with logs of prices of maize and of rice as the dependent variables. The results from the survey data in column (1) replicate our previous findings using FAO price data with a positive effect of 2 percent per attack en route for maize. The effect is larger yet still comparable to the one reported in column (2) of Table 2 using FAO data on similar years as the implementation of the SHFS. One explanation for the larger effect in column (1) is that self-reported prices include intermediary markup, which might also respond to conflict. As before, we cannot detect any effect on the price of rice in column (2).[20]

Consumption of food staples. Columns (3) to (6) of Table 4 report the effects of conflict along the transportation route for maize on the consumption of maize and of three other food staples that can serve as potential substitutes for maize. The point estimates suggest a reduction in the consumption of maize, accompanied by an increase in the consumption of sorghum and rice, yet only the effect on sorghum is statistically significant. The relatively small sizes of the substitution effects in columns (3) to (6) of Table 4 might appear surprising at first, especially considering the low economic status of SHFS respondents. However, the slow changing nature of nutritional preferences and behaviour has already been documented. For instance, studies show habit formation for food preferences (Atkin, 2013) and also show how culture can constrain caloric intake (Atkin, 2016). As such, it remains an open question whether these consumption changes suffice to mitigate the effect of the price shock. We therefore go on to investigate further knock-on effects of conflict along transportation routes of maize on food security, spending patterns, and on health and education outcomes.

Food security. In this section we exploit information on food security from two different sources: self-reported food security information from the SHFS household survey, and the official classification of food security that we digitized from the FSNAU. The results from the self-reports show that conflict along transportation routes (and at some distance from

[20]The small effect difference between FAO and survey data is unlikely to be due to differences in the time periods covered. In column (6) of Appendix Table A.1 show that the results remain very similar when we re-estimate the price effect in the FAO data using exactly the months between both survey dates.

Table 4: Effect of conflict along transportation routes on food prices and consumption

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variables:					
	Log price of		Log quantity consumed per household of			
	Maize	Rice	Maize	Sorghum	Rice	Pasta
Conflict en route	0.023	−0.001	−0.018	0.034	0.015	−0.001
(excl. same region)	(0.010)	(0.013)	(0.017)	(0.012)	(0.020)	(0.011)
Observations	3,170	5,176	8,137	8,113	10,057	6,531
R^2	0.33	0.36	0.12	0.10	0.05	0.15
Mean HH consumption (kg / 7 days)			1.51	0.95	*2.70*	*2.15*

Notes: Table reports effects of conflict along transportation routes on the log of self-reported food prices and on the log of quantity of food staples consumed per household over the past 7 days. All specifications are based on equation (1) and include region and year fixed effects and control for attacks in own area, household size, proportion literate in household, gender of household head, and household below poverty line. Violent incidences are averaged over the survey month. Sample sizes vary across columns because not all households were asked about all food items, and because columns (1) and (2) are conditional on having made a purchase of the food item. Robust standard errors clustered at the region level are in parentheses. **Data source:** SHFS.

households) decreases food security and also suggest food prices as a mechanism through which this effect operates. Moreover, the official FSNAU data shows that conflict along transportation routes increases the likelihood of an area being classified as 'food insecure'.

The results are reported in Table 5. In this part of the analysis, we adjust our conflict measures in accordance with the time horizon each question or classification refers to.[21]

Column (1) of Table 5 shows that conflict along transportation routes increases the probability that households experience high food prices and change their eating patterns as a result. The remaining columns further corroborate significant effects on food security and indicate that far-away conflict along the route increases the probability that a household is lacking enough food to eat by about 2.8 percentage points (column 2) and the probability that a household member had to eat elsewhere by 0.4 percentage points per incidence of conflict (column 3).

Table 5: Effect of conflict along transportation routes on food security

	(1)	(2)	(3)	(4)
	High food prices affecting eating pattern (past year)	Not enough food to eat in house (past 4 weeks)	HH member ate elsewhere (past 30 days)	= 1 if nutrition classified as critical
Attacks period	Past year	Past month	Past month	Past growing season
Conflict en route (excl. same region)	0.008 (0.003)	0.028 (0.006)	0.004 (0.001)	0.015 (0.002)
Observations	5354	6417	2541	190
R^2	0.017	0.141	0.031	0.695
Mean Dep. Variable:	0.01	0.25	0.08	0.49
Data Source:	SHFS	SHFS	SHFS	FSNAU

Notes: Table reports effect of conflict along maize transportation route on food security. Conflict en route is either averaged over the month preceding the survey month, the year preceding or the growing season prior to the survey month as indicated (see row 'attack period) in accordance with the time period to which the respective outcome refers. columns (1) to (3): are based on SHFS, were asked only in 2016 and exploit cross-sectional variation only. Regressions are based on equation (1) and control for the number of incidences of conflict occurring within region of residence. Column (4): is based on FSNAU data we digitised for the years 2009 to 2018 and is based on equation (1) with market-by-season and market-by-year fixed effects. Robust standard errors clustered at region (columns 1 to 3) and market (column 4) level are in parentheses. **Data source:** SHFS, FSNAU.

[21] As the column titles indicate, some of the outcomes refer to the past month, and others to the past year prior to the survey interview. We therefore define the explanatory variable of conflict en route accordingly as either the average incidences over the past month, or the average monthly incidences over the past year.

Column (4) provides evidence on spatial spillover effects on a food security classification system, which is widely employed by policy makers, such as the FAO, for instance. The Integrated Food Security Phase Classification (IPC, 2021) system divides Somalia into livelihood zones and evaluates each twice a year (after the Gu and Deyr harvests). We digitised data between 2009 and 2018, matched the livelihood zones to the ten markets for which we have price information, and estimate a specification analogous to equation (1).[22] The dependent variable takes the value one if at least 15 percent of children aged 6 to 59 months exhibit low weight-for-height and/or oedema, which the IPC defines as 'critically food insecure'. Column (4) of Table 5 shows that each incidence of conflict along transportation routes increases the probability of critical levels of malnutrition by 1.5 percentage points on a mean of around 47 percent.

Household expenditures. Using detailed information on household expenditures, our results also show that households adjust to higher food prices by changing their spending patterns, which may have consequences on children's health and education. As reported in column (1) of Table 6, an additional incidence of conflict along transportation routes increases the probability of spending out of a household's savings by 0.4 percentage points. It also reduces the number of non-food categories within which households have made an expenditure over a 12 month period by about a quarter of a category (column 2).[23] In columns (3) to (6) we focus on human capital investments in the form of expenditures on health and education. For general healthcare (column 3) and educational (column 5) expenses, point estimates are negative but not statistically significant. However, for the more specific items of spending on health and other insurance (column 4) and books and newspapers (column 6) there emerge sizeable and statistically significant effects. Overall, this suggests that the apparent substitution of maize by sorghum (see Table 4) is not sufficient to avoid adverse effects on food security and on non-food expenditure.

Health and education. The results in Table 7 show that conflict occurring on far-away transportation routes worsens children's health and educational outcomes. These findings tally with the reductions in some health and educational expenditures documented in Table 6. Throughout the table, conflict en route is defined as the average monthly attacks over the year preceding the interview. An increase by one in the average monthly attacks over one year is a sustained event that implies 12 more attacks over the whole year.

[22] Because the IPC evaluates livelihood zones only twice a year, each market contributes only two observations per year.

[23] This index ranges from 0 to 8 and is constructed as the sum of eight dummies indicating any spending in eight important non-food categories (see table notes for details).

Table 6: Effect of conflict along transportation routes spending patterns

	(1)	(2)	(3)	(4)	(5)	(6)
	HH spent savings (past 30 days)	Index of non-food spending (past 12 months)	Any spending over the past 12 month on. . . . Health-care	Health and other insurance	Educational expenses	Books, newspapers
Attacks period	Past month	Past year	Past year	Past year	Past year	Past year
Conflict en route	0.004	-0.259	-0.081	-0.117	-0.03	-0.048
(excl. same region)	(0.002)	(0.048)	(0.093)	(0.049)	(0.043)	(0.012)
Observations	2442	5759	6542	4372	6542	5751
R^2	0.019	0.111	0.111	0.192	0.184	0.013
Mean Dep. Variable:	0.07	6.72	0.31	0.64	0.27	0.72

Notes: Table reports effects of violent incidences along maize transportation route on food security and expenditure outcomes. Conflict en route is either averaged over the month preceding the survey month, or the year preceding the survey month as indicated (see row 'attack period) in accordance with the time period to which the respective outcome refers. The outcomes in column (1) was asked only in 2016 and exploit cross-sectional variation only. All other specifications are on the combined 2016 and 2017 sample and include region and year fixed effects. Further control variables in all specifications are attacks in own area, household size, proportion literate in household, gender of household head, and household below poverty line. The index in column (2) is the sum of eight dummies indicating any spending in the non-food categories public transport, soaps/toiletries/cosmetics, energy/utilities, donations, domestic help/repair/maintenance, music/entertainment, clothing, and homeware. All other outcomes are dummy variables. All regressions are based on equation (1) and control for the number of incidences of conflict occurring within region of residence. Robust standard errors clustered at the region level are in parentheses. **Data source:** SHFS.

Columns (1) to (7) of Table 7 report health outcomes of children aged below 10 years. The most likely reason why health outcomes could be affected by conflict along transportation routes is malnutrition as a result of the reduced food availability documented above. In column (1), we find no general effect on having suffered any illness over the past two months. We therefore break up illnesses into infectious illnesses and non-infectious ones, motivated by the well-known links between malnutrition and infectious diseases (Scrimshaw, 2003; Black et al., 2008; Calder, 2013). The results show that an increase in conflict en route and at some distance from respondents indeed increases infectious illnesses by about half a percentage point (column 2), an effect of five percent relative to the mean. On non-infectious illnesses, however, which are much less likely to be affected by malnutrition, we find no effect (column 3), as might be expected.[24] In columns (4) to (7) we show effects on the individual health conditions that make up the infectious illnesses. All effects are statistically significant. The largest effect is for gastro-enteritis, which counts among the leading causes of death among children in Sub-Saharan Africa (Jamison et al., 2006; Table 5.11). While the absolute effect sizes on these health outcomes are relatively small, they are more sizable in relative terms. Across all the outcomes in columns (4) to (7) relative effects sizes range between 3 and 12 percent of the mean of the dependent variable.

Column (8) shows that sustained conflict along the transportation routes also reduces the probability of children's primary and middle school enrolment (age 6-14) by five percentage points. Given that the conflict en route occurs some distance away, the mechanism is unlikely to be one of safety concerns, but more likely to be related to the economic effects of price rises, which make schooling less affordable. To test whether this goes in hand with children being more likely to engage in child labour to supplement the household's income, we also report results on whether children are in paid work (column 9). While the point estimate is positive, the effect is not statistically significant.

4.4 Robustness

We submit our estimates to a battery of robustness checks and find that the effects documented in this paper remain stable throughout.

Spatial spillover effects on maize prices. Columns (1) to (6) in Appendix Table A.1 show that our effects are stable to the exclusion of various subsamples. Column (1) drops markets located in Somaliland, since these locations may be subject to different institutions.

[24] One channel by which non-infectious illnesses could be affected, would be if the reduction in healthcare insurance and expenditure documented in Table 5 would reduce preventative health care. Yet, this is not very likely in our study context, because among very poor households in Somalia preventative health care is likely to be at very low levels anyway.

Table 7: Effect of conflict along transportation routes on health and education

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	In the past 2 months child (age $<$ 10) suffered from								
	Any illness	Infectuous illness	Non-infectuous illness	Gastro-enteritis	Malaria	Typhoid fever	Chest infection	Not enrolled in school (age 6-14)	Paid work past 7 days (age 10-18)
Conflict en route	0.004	0.005	0.0007	0.002	0.004	0.0002	0.0001	0.051	0.034
(excl. same region)	(0.002)	(0.001)	(0.000)	(0.001)	(0.001)	(3.1E-05)	(3.4E-05)	(0.021)	(0.033)
Observations	8180	8180	8180	8180	8180	8180	8180	8134	6380
R^2	0.04	0.06	0.00	0.05	0.03	0.004	0.003	0.43	0.14
Mean Dep. Variable:	0.18	0.11	0.02	0.08	0.04	0.002	0.003	0.47	0.08

Notes: Table reports effects of violent incidences along maize transportation route on children's health and education outcomes. Health outcomes are for children aged 0-10, schooling outcomes for children 6-14 and work outcomes for children 10-18. Infectious illness is an indicator for having suffered from any of the four infectious illnesses reported in columns (4)-(7). Non-infectious illness is an indicator for having suffered from dental problem, fracture, wound, mental disorder, asthma, headache, fainting, eye problem, backache, or an unspecified long-term illness. The outcomes in columns (1)-(7) were asked only in 2016 and exploit cross-sectional variation only. All other specifications are on the combined 2016 and 2017 sample and include region and year fixed effects. All specifications control for child age dummies, household size, proportion literate in household, gender of household head, and household below poverty line. All regressions are based on equation (1) and control for the number of incidences of conflict occurring within region of residence. Robust standard errors clustered at the region level are in parentheses. **Data source:** SHFS.

Column (2) and (3) drop markets located close to the Kenyan and Ethiopian border respectively, since these areas may import maize from those countries. Columns (4), (5) and (6) restrict the analysis to the years 2009 to 2018, to 2012 to 2017 and to February 2016 to December 2017 (the dates of the two rounds of the SHFS), respectively.

Spatial spillover effects on human capital. For some of the effects on food security, health and education, we measure conflict along the transportation route over the year prior to the survey date. For households that have migrated over the past year this would introduce measurement error in the conflict variables, because at their previous place of residence they would have been exposed to a different level of conflict along the route. This might not be just random error, but could be systematically related to violence, if the effects of conflict cause households to migrate. To check to what extent this is likely to be a problem, we run robustness checks where we exclude households that have migrated in the past.[25] The results are in Table A.2 in the Appendix and show that our main conclusions carry through and are quite robust in terms of their magnitudes in the sample that excludes migrated households.

5 Conclusion

Our analysis has documented that conflict occurring in one part of Somalia can affect food prices, food security, health and education in areas located far away. Despite much of the fighting being concentrated in the Southwest of Somalia, our analysis shows that the effects of conflict are felt in areas located almost 1,000 kilometres away. These findings potentially have far reaching consequences for both policy makers and researchers.

Humanitarian interventions or refugee policies most commonly focus on those locations where the conflict occurs. The Word Food Programme (WFP, 2021), for instance, provides nutritional assistance to areas around Mogadishu, in the Southwest of Somalia where most of the fighting is concentrated. Similarly, when evaluating asylum eligibility, the United Nations High Commission for Refugees report (UNHCR, 2010) highlights the Southwest of Somalia in particular as the area where individuals are *at risk of serious harm*. By contrast, our results provide evidence that individuals can be affected by conflict even if it occurs far away. For instance, the city of Galkayo (located 700km from Mogadishu, corresponding to a 14 hour drive) is part of the northeastern region of Puntland and as such not covered by

[25]We define a household with a migration history as a household in which the household head lives in a different region of Somalia where they were born (information available in both the 2016 and 2017 waves), or if the number of years any of the household members has lived in the current district is smaller than their age (available in the 2016 wave), or if the household counts under the UNHCR Internally Displaced People definition (available in the 2017 wave) of having ever left their usual place of residence due to conflict, violence, human rights violations or disasters.

either the WFP or UNHCR policies mentioned above. Our analysis, however, shows that conflict occurring in the Southwest increases food prices, decreases food security and erodes human capital in Galkayo thus suggesting that policies regarding conflict should broaden their scope.

The spatial spillover effects we document also have important consequences for difference-in-differences-type research designs, where the treatment group consists of a region affected by conflict, and the control group consists of a neighboring or more distant region. In this setup, the presence of spatial spillovers implies that the control group is also affected by conflict, which is likely to attenuate the estimates. Traditional difference-in-difference approaches might thus have provided lower bound estimates. This would imply that the effect even of local conflict is likely to be even larger than thus far assumed hence providing further reasons to invest in humanitarian interventions in conflict zones.

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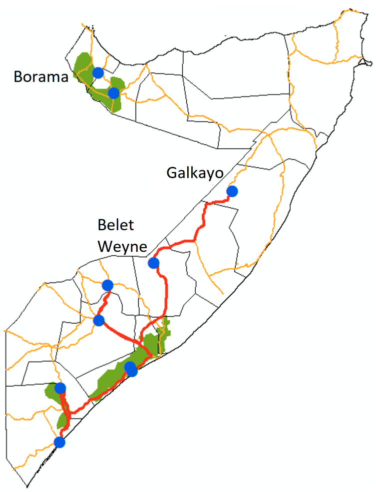
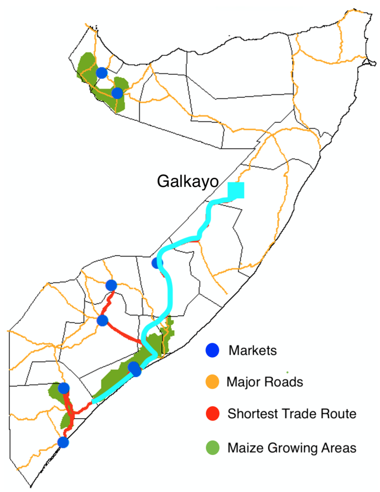
A Appendix figures and tables

Figure A.1: Additional maps

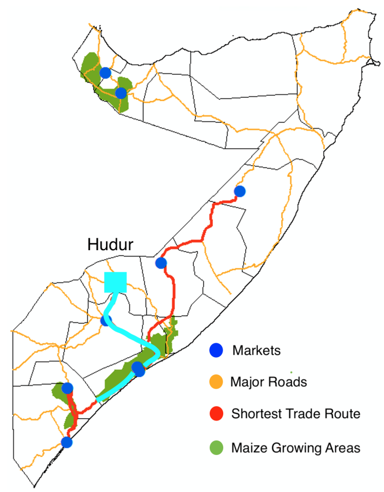
(a) 3 markets used in Figure 3



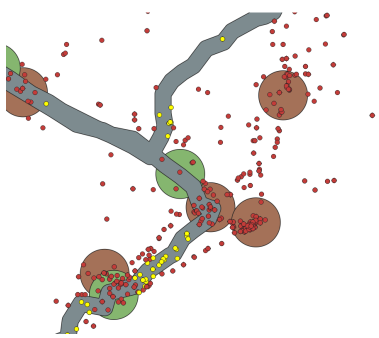
(b) Transport to Galkayo



(c) Transport to Hudur

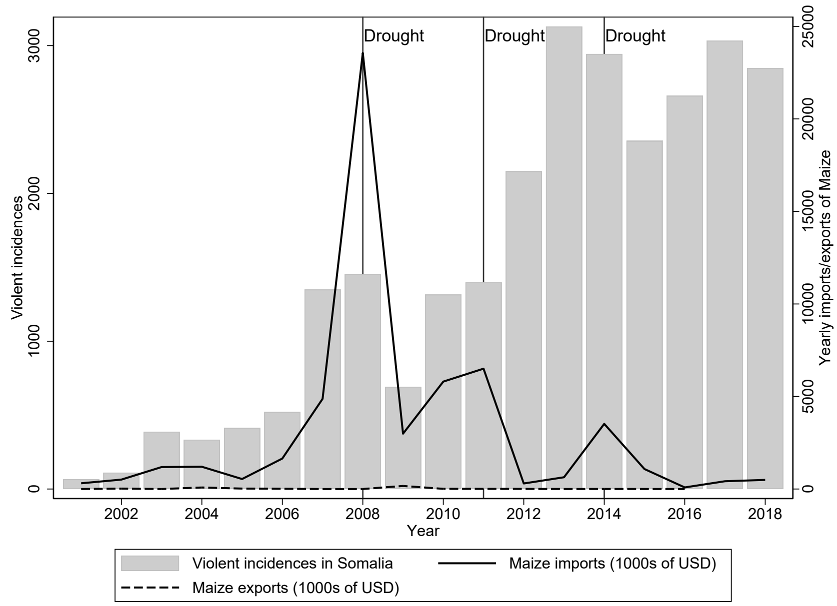


(d) Conflict in 5km corridor



Notes: Map a: shows geographical location of three markets reported in Figure 3; Map b: shows transportation route used to supply market of Galkayo with maize; Map c: shows transportation route used to supply market of Hudur with maize; Map d: shows geographical location of roads (grey), towns (maroon) and cities (green), incidences of conflict falling within 5 kilometres of transportation routes are denoted as yellow dots and incidences falling outside of the corridor as red dots.

Figure A.2: Imports and exports of maize



Notes: Figure reports conflict in Somalia along with imports and exports of maize. Bars indicate yearly incidences of violence drawn from ACLED; solid line refers to yearly imports of maize in 1000s USD drawn from United Nations Conference on Trade and Development (UNCTAD); dashed line refers to yearly exports of maize in 1000s USD drawn from United Nations Conference on Trade and Development (UNCTAD); vertical lines denote incidences of droughts. The UNCTAD trade data are freely available at `https://unctadstat.unctad.org/EN/`

Table A.1: Robustness of the spatial spillover effects on maize prices

	(1)	(2)	(3)	(4)	(5)	(6)
			Dependent variables: Log price of maize			
Conflict en route:	0.0035	0.0029	0.0049	0.0059	0.0057	0.0098
(excl. same region)	(0.0011)	(0.0011)	(0.0016)	(0.0023)	(0.0022)	(0.0041)
Observations	1,588	1,613	1,551	1,192	714	227
R^2	0.917	0.936	0.921	0.926	0.930	0.961
Sample	No Somali-land	Not next to Kenya	Not next to Ethiopia	2009-18	2012-17	Feb 2016 to Dec 2017
Data source	FAO	FAO	FAO	FAO	FAO	FAO

Notes: Table reports effect of incidences of conflict along maize transportation route on the price of maize using different samples. *Conflict en route* counts number of violent incidences occurring within a 5km radius either side of the shortest route between maize growing area and market per month. Dependent variable in columns 1-5 is the log of the price of maize. Column (1) drops markets located in Somaliland (Borama and Hargeisa), column (2) drops markets located close to Kenya (Buale and Kismayo), column (3) drops markets located close to the Ethiopian border (Belet Weyne and Hudur), column (4) uses only years 2009 to 2018, column (5) only uses years 2012 to 2017. **Data sources:** ACLED, FAO.

Table A.2: Robustness against excluding migrant households

	(1)	(2)	(3)	(4)	(5)	(6)
	Log Consumption		Not enough food to eat in house (past 4 weeks)	High food prices affecting eating pattern (past year)	HH member ate elsewhere (past 30 days)	
	Maize	Sorghum				
Conflict en route	-0.019	0.040*	0.029*	0.003	0.005***	
(excl. same region)	(0.025)	(0.021)	(0.013)	(0.002)	(0.001)	
Observations	5551	5516	4367	3636	1975	
R2	0.12	0.103	0.13	0.017	0.031	
	HH spent savings (past 30 days)	Index of non-food spending (past 12 months)	Any spending over the past 12 month on....			
			Health-care	Health and other insurance	Educational expenses	Books, newspapers
Conflict en route	0.006**	-0.274***	-0.06	-0.147**	-0.034	-0.059***
(excl. same region)	(0.002)	(0.072)	(0.102)	(0.053)	(0.063)	(0.017)
Observations	1886	3863	4454	3154	4454	3906
R2	0.019	0.119	0.115	0.143	0.182	0.013
	In the past 2 months child suffered from					
	Any illness	Infectuous illness	Non-infectuous illness	Not enrolled in school (aged 6-14)	Paid work past 7 days (aged 10-18)	
Conflict en route	0.003	0.004***	0.0006	0.068***	-0.018	
(excl. same region)	(0.002)	(0.001)	(0.000)	(0.018)	(0.051)	
Observations	7414	7414	7414	6159	4744	
R^2	0.047	0.069	0.004	0.433	0.123	

Notes: Table replicates the effects of violent incidences along maize transportation routes on key outcomes from Tables 4 - 7 excluding migrant households. All specifications are similar to the corresponding specifications in Tables 4 - 7. Robust standard errors clustered at the region level are in parentheses. **Data sources:** SHFS.