D2 Project Description

PROJECT TITLE: Political Conflict, Inefficient Markets, and Food Crises

PROJECT AIMS AND BACKGROUND
The problem
Political conflict, in some form and to some extent, defines the daily life of people in many low- and middle-income countries. The root causes of conflicts typically vary and can be linked, among other factors, to insurgency against the local and central governments or to people's protest in response to governments' actions (or inactions). Regardless of the source, a common attribute of conflict is that it happens—by design or as a side-effect—where people are. As such, it impacts—directly or indirectly—the wellbeing and, indeed, livelihoods of people. A suicide truck bombing in a market of Mogadishu (Somalia) on 14 October 2017, for instance, killed more than 500 people and had an immediately chilling effect on marketplace activity (Burke and Ahmed, 20 December 2017).

People living in poor, marginalised states with dysfunctional formal institutions often struggle to source and 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. Markets may remain surprisingly functional in the face of these adversities, however, particularly in places where the rule of law is scarce but informal institutions are prominent. Commenting on the resilience of Mogadishu after the truck bomb, one Somali noted that, "There is a blast in Mogadishu destroying whole buildings and you see the next day people start renovating. Life goes on. Those who died have died. We have to think about those who live now. They need life." (Burke and Ahmed, 20 December 2017).

Conflict and food insecurity are intrinsically linked. This project will study food markets in many locations, large cities as well as smaller towns, across Africa and Southeast Asia to address two interrelated overarching questions: (i) **How does conflict affect consumers' well-being by altering the proper functionality of food markets?** (ii) **How does conflict alter farmers' well-being by impacting their decision to strategically store their produce over the course of the post-harvest period?** In addressing these questions, this study will prepare an answer to two highly relevant policy-oriented questions: (iii) **Can we predict when, where, and how conflict will lead to food insecurity?** (iv) **How can informal institutions mitigate conflict-related food insecurity?**

Aims
First, we will develop an innovative spatiotemporal framework that links market integration with (1) the rule of law and ethnic disparity within and between conflict-affected states; and (2) different types of conflict initiated by different types of conflict actors. **Second, we will use this framework to understand the effects of conflict on food security** in places that are geographically or ethnically detached from the rest of the country or region. **Third, we will apply the framework to elicit early warning signals of food crises and famines** in response to elevated levels of conflict and violence.

Background
With efficient movement of goods and information between markets, we would generally expect prices for the same goods to be similar in different cities thus eliminating opportunities for arbitrage. Likewise, with capacity to store non-perishable goods, such as cereal grains for example, we would expect that prices for the same goods to only increase at par with storage costs over the crop marketing year. Any deviations from these "law of one price" states, both in spatial and temporal contexts, would indicate market inefficiencies.

In the spatial context, studies of market integration are oriented to finding the barriers that mean that prices are *not* the same (or do not adapt sufficiently swiftly) within the same countries, or between adjacent countries within a region. The primary suspects, as a barrier to market integration and full price transmission, are typically borders and distance. Dillon and Barrett (2016), for example, examine markets across East Africa and report an average elasticity of 0.42 of the local maize prices with respect to the global maize price, with the measure ranging from 0.22 in Kenya to 0.82 in Ethiopia. Baquedano and Liefert (2014) analyse price transmission for the same four cereal grains that we consider in the present study, concluding that although local markets tend to be integrated with global markets, aggregate (cross-country) elasticities of price transmission from global to local markets range from 0.16 for sorghum to 0.32 for wheat, with country-specific elasticities ranging from indistinguishable from zero (e.g., for maize in Burkina Faso, Niger, and Zambia) to well in excess of 0.5 (e.g., 0.76 for rice in Senegal, or 0.73 for wheat in Ethiopia). Mengel and Cramon-Taubadel (2014) find that markets within country are more likely to be co-integrated than markets between countries, while markets separated by great distances (both within and between countries) are slower to adjust prices and have lower co-integration. Distance has negligible effects between international markets. Borders do not always or necessarily align with sovereign dividers between countries. Ethnic division, which may segregate smaller regions within a country, or extend a region across two or more countries, may be a more apparent barrier to trade and, therefore,

for market integration (Aker et al., 2010, 2014). Likewise, distance is not only and necessarily measured in kilometres. For instance, a hundred-kilometre road connecting two cities may be associated with small or large amounts of transaction costs, depending on whether potential perpetrators tend to raid the people—traders in this instance—travelling the road.

In the temporal context, the lack of storage has been an ongoing issue for decades in many low- and middle-income countries (e.g., Kadjo et al., 2018; Channa et al., 2022; Ricker-Gilbert et al., 2022). So much so that is has been dubbed as the "storage puzzle" (e.g., Cardell and Michelson, 2023). Even if it is seemingly more profitable to retain the crop for a later resale, for example during the lean season, farmers opt for immediate disposal of the harvest. The lack of storage technology and liquidity constraints have been considered two key reasons for this. Empirical evidence points to a more complex issue, with other possible factors contributing to the lack of storage. Kadjo et al (2018), for example, find that households in Benin store less when they expect to lose more during storage. We suggest conflict and violence may have something to do with it. Farmers may choose to dispose of harvest as soon as possible to mitigate the risk of becoming a target of an attack by perpetrators.

Connecting market integration to institutional and other factors has been more tentative. Market integration of prices across a putative territory is a plausible method of determining whether the markets are operating as if they are within a single country. The prevailing assumption and finding 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, 2010; Aker and Fafchamps, 2014; Aker and Mbiti, 2010). Indeed, the main reasons for lack of market integration in Africa are risk, lack of information, poor infrastructure, and lack of government capacity (Bouët et al., 2010). The lack of market integration in states without robust formal institutions could be for one or several reasons. First, the ability to broadcast 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 over low-quality roads is a major consideration in developing countries and is often a larger source of price dispersion than borders in many landlocked African countries (Dillon and Barrett, 2016; Minten and Kyle, 1999; Versailles, 2012).

Second, political fragmentation and violence mean that different, often hostile actors govern food 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 (Hastings et al., 2022), thus leading to an inability to efficiently move food around, to, or from a country. To that end, the presence of roads will not necessarily result in a spatial equilibrium between the markets—the presence of conflict actors along the road may serve as a barrier too big to overcome. Moreover, the lack of functioning formal state institutions means that state enforcement of contracts and resolution of disputes is patchy or uneven (Börzel et al., 2012; Krasner and Risse, 2014; Scott, 2010). 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 diversified groups, making arms-length inter-city trade difficult, and resulting in differential prices (Greif, 1993; Haggard et al., 2012; Robinson, 2016). Non-political boundaries can also decrease market integration. In Africa, for example, ethnic boundaries serve as a barrier to integration (Aker, 2010; Aker et al., 2014). Thus, political fragmentation and conflict can affect market integration, which in turn can imperil populations' food security.

INVESTIGATORS/CAPABILITY

The project team is structured so as to bring the project to a successful conclusion. Because the links between social conflict, commodity markets, and food security are inherently interdisciplinary, we draw investigators from both political science and economics, and bring in expertise in multiple theoretical perspectives, methodologies, and geographic areas.

CI Ubilava has a strong background and an extensive list of publications in agricultural economics. He has studied causes and consequences of disrupted commodity markets with emphasis on regime dependencies in international commodity price behaviour, and price co-integration within commodity groups. He will serve as project manager and take the lead on be particularly involved in econometric analysis of price and conflict data. CI Hastings has published extensively on security issues, political economy, and fragile states in both Africa, (primarily Somalia) and in East and Southeast Asia (primarily North Korea and Indonesia, as well as other countries in peninsular and archipelagic Southeast Asia). Hastings will be especially involved in providing substantive knowledge of countries in Africa and Southeast Asia, as well as developing methods to characterize the links between market integration, conflict, institutions, and food insecurity. CI Vasnev is an expert in forecasting and business statistics, with a special interest in forecast combinations and model sensitivity. He will contribute to the assessment of time-series models and their forecasting performance. He will take the lead on managing and delivering the forecasting tool website. CI Amarasinghe has worked extensively on the spatiotemporal dispersion of conflict and economic shocks, particularly in the African context, as well as for the world as a whole. In her recent work, she has demonstrated the importance of using massive

datasets, with fine spatial and temporal granularity, in precisely measuring the effects of economic shocks. She will bring this expertise in to the econometric analyses within this project and will collaborate with Ubilava on handling this aspect of the project.

All members of the team will be involved in the publication and dissemination process. Hastings, Ubilava, and Vasnev in particular also already have experience co-authoring with each other, which will ease the team's ability to publish in high-quality international publications. All have extensive domestic and international collaborations and will use the project to further build Australian and international collaborations.

PROJECT QUALITY AND INNOVATION

Importance and innovation

We make several contributions to the study of market integration and food insecurity in conflict-affected states. First, we demonstrate the use of readily available data on both market prices and conflict as a way to understand internal dynamics in states with otherwise poor, biased, or non-existent data. Such data offer insights into the political processes that underpin either change or stasis within markets, such as the capacity to enforce rules, uphold contracts, and resolve disputes. Given that market prices are usually collected in daily or monthly increments in individual markets, and recent conflict data is collected to relative specificity, even in fragile states, this approach can also give us much greater granularity in understanding political and economic events in data-poor countries than has previously been the case. Most state capacity measures are on a yearly basis, with a country-level unit of analysis. More generally, governance data are simply often not available for many fragile states, and only states with data are being measured, which leads to an upward bias in data. That is, governance indicators may appear to be higher on average across the globe than they actually are because the lowest performing countries are not included (Coggins, 2016). Moreover, the governance indicators that are available for virtually every country (such as the World Bank Governance Indicators) tend to exist only at the national level. While this is not a problem for countries that have relatively robust central governing institutions, it is a problem for those that do not, precisely because they are also more likely to have internal divisions that can hinder consistent levels of governance being applied across the entire country. Conflict and market integration analysis is, therefore, a means of drawing out and measuring intra-country differences in governance.

Second, differing levels of market integration are generally seen as the *result* of impediments (such as distance, transport costs, and borders) to the transfer of information, goods, and people between markets. Our innovation is to take market integration as a *measure* of other concepts at work in fragile states, including the potential for food insecurity. This is innovating on the idea that food prices in markets in particular are good indicators of a population's welfare and have been connected to instability and conflict in developing countries (Arezki and Bruckner, 2011; Hendrix and Haggard, 2015). Measuring the extent to which markets across a country or between countries are integrated, in terms of the dispersion or convergence of prices for the same items, or in terms of the extent to which prices change over the post-harvest season, can tell us about the nature, relevance and magnitude of potential barriers, notably conflict, to trade and to storage.

Third, by establishing regular spatiotemporal patterns connecting conflict, market integration, and food trade and storage, our project will lead to an early warning platform for potential food crises in the face of conflict. Each of these two dimensions—i.e., spatial that measures the economic integration between markets, and temporal that measures the seasonality of locally produced commodity prices—is important in and of itself. But they offer a potential for additional insights when assessed in combination. A presence of locally produced crops (such as maize and sorghum in Africa, or rice in Southeast Asia), whether it is a subsistence farming or an export-oriented endeavour, adds a crucial aspect to our research, both conceptually and from a modeling standpoint. Price dynamics within sub-regions—e.g., comprising ethnically homogenous locations within a single country, or across several adjacent countries—can take peculiar patterns, particularly with respect to the integration of the region with the "outside world." In the context of political conflict—which, in most instances, varies over time—this entails possibility of regime-dependent dynamics vis-à-vis the conflict intensity. Hastings et al (2022) demonstrate this in the context of spatial integration using Somalia as the case study. That work, while pioneering in its own right, is geographically focused, and only addresses one, spatial dimension of the issue. The intra-year variability of prices, introduced in this project, is another important dimension that can contribute to creating a wealth of knowledge inferred from price behaviour over time and across space.

Approach

We take a three-fold approach to address the link between conflict and food security. The approach combines rigorous time series analysis of market integration and agricultural price forecasting, with a conceptual framework that links conflict, market integration, institutions, food security (and insecurity) and substantive knowledge of the formal and informal institutions across Africa and Southeast Asia.

First, we examine the role of conflict and political institutions on market integration within and across countries. Using local market price data, available via the Food and Agricultural Organisation of the United Nations, we can track price dispersion across markets and changes in price dispersion over time, conditional on distance between markets,

transport costs, and formal and informal geographic boundaries. This analysis builds on established research that looks at market integration, both within countries and between countries, as measured by price co-integration, price transmission speeds, or both (Goodwin et al., 2011; Dillon and Barrett, 2016). In a world where information about markets and prices is easily available, where transport costs are low, and where formal institutions provide minimal impediments and are well functioning, we would expect the difference in prices between cities to be low, inasmuch as traders would otherwise use the differences as an opportunity for arbitrage. In such instance, which depicts the case of integrated markets, prices across two spatially separated but linked markets will co-move. Otherwise, price dynamics in the two markets are likely to be disentangled. Thus, by examining the features of the time series of price differentials in any two markets—i.e., whether the price differentials meander, thus resembling a random walk process, or follow a mean-reverting process, thus indicating price adjustments to the spatial equilibrium—we can present suggestive evidence about potential economic linkage between the markets.

When a transaction cost of some sort is present—which is virtually all the time insofar as the commodity needs to be transported from one location to the other—there will be the so-called transaction cost band within which the difference between the two market prices will behave seemingly disentangled. This is because the arbitrage opportunity will not manifest due to the transaction cost. But the moment the price difference deviates beyond the band, the trade will happen, so long as the markets are integrated, and the adjustment in the prices will follow.

In addition to the transportation costs, distance between markets, the existence of internal and external borders, extreme weather, and terrible transport infrastructure are all likely to impede the smooth flow of people, information, and goods between markets, leading to slowdowns in price transmission, and dispersion of the prices of the same commodities across different markets. Conflict, which is common in fragile states, can pose particularly significant impediments to flows between cities, either because the markets themselves are destroyed, because the market participants are killed or dislocated, or because warring factions create borders between markets that are difficult to cross (Hastings et al., 2022). Moreover, because conflict intensity usually changes over time, so will the transaction costs band. Figure 1 illustrates this.
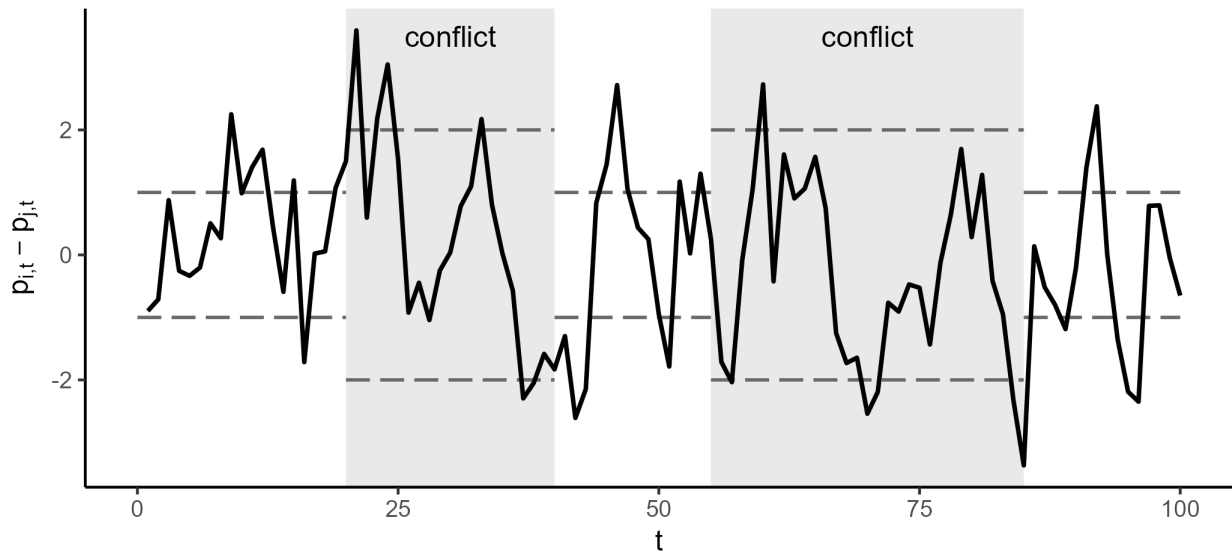

Figure 1: An illustration of a time-varying transaction costs band due to conflict (shaded regions).

The graph features the time series of a price differential between two spatially separated markets (*i* and *j*). When there is no conflict, the transaction costs band, depicted by dashed lines centred on zero, is narrow. During conflict (shaded regions), the band widens. Thus, by estimating the size of the transaction costs band, in times of peace and conflict, we are able to present evidence of conflict-related impediments to market integration. This example is intuitively appealing. Indeed, at the extreme, during the most severe forms of conflict such as wars, for instance, the transaction cost is insurmountable, leading to complete disconnect between the markets.

The foregoing illustration alludes to our main approach for measuring market integration, or lack thereof, in absence of the trade data. By observing the features of the time series, comprising the price differentials between any two geographically linked markets, we will be able to present suggestive evidence of whether the markets are also economically linked, and to estimate the pass-through, that is, the extent to which a price change in ne market results in a price change in another market, as well as the speed at which this price transmission happens.

Distance, borders, weather, and transport infrastructure can all lead to a permanent or temporary slowdown in price transmission or an increase in price dispersion. However, conflict also leads to disruptions, which is associated with a decrease in market integration, and food insecurity. Conflict incidents, which are common in both Africa and Southeast Asia, can pose significant problems to flows of people, information, and goods (particularly food) between cities. The markets themselves might be destroyed, the market participants might be killed or flee, and battle lines may make movement difficult (Hastings et al., 2022). Conflicts initiated by civilians, such as protests and riots, are likely to have

different impacts on market integration, and thus food insecurity, than those started by armed groups (the state, militias associated with elites, or armed rebel groups), such as battles, explosions, or attacks on civilians (Raleigh et al., 2010). In Southeast Asia, for instance, farmers might initiate protests (which may or may not turn into riots) to pressure governments to buy their rice (as they have in Thailand and the Philippines), which could increase market integration, but could protest the government allowing rice imports (as they have in Indonesia and the Philippines), thus decreasing integration with foreign markets. Certain conflict incidents are also likely to cause food insecurity more directly, particularly given that conflict may increase during harvest seasons (Ubilava et al., 2022): state forces or rebel groups might attack civilians for the purpose of seizing or destroying food supplies of their enemies or enemies' supporters, or harassing (and thus disrupting) food supply chains between markets, as has happened repeatedly in Myanmar during the current civil war (Htay, 2022).

Second, we examine the effect of conflict on seasonal patterns of prices in crop-producing regions. Storage theory suggests a steady increase in prices of storable commodities, such as cereal grains, from the harvest month onward and into the lean season, leading to the next harvest season. Absence of such patterns would imply some deviation from the expectation. Empirical evidence points to such discrepancies (e.g., Cardell and Michelson, 2023). Conflict and political violence may play the role in this. If the availability of storable crops, such as cereal grains, attracts perpetrators (McGuirk and Burke, 2020; Ubilava et al., 2022), then it may explain farmers' incentives to sell their product at the earliest convenience—which is immediately after harvest. But the act of selling, as alluded above, can be associated with risk of being raided—*en route* to the market, for example. So, we could expect heterogeneity in the patterns, conditional on the prevalence of paramilitary groups in the region, the strength of the state institutions, and the distance of the agricultural region from the nearest city—the likely market for agricultural goods.

Observational data on farmers' storage (like it was in the case of the trade data) are largely unavailable. But we can use price data, observed at monthly frequency, to elicit suggestive evidence of storage practices in the region. One of the key effects of storage is that it stabilizes prices over time (Wright, 2001). Figure 2 illustrates this.
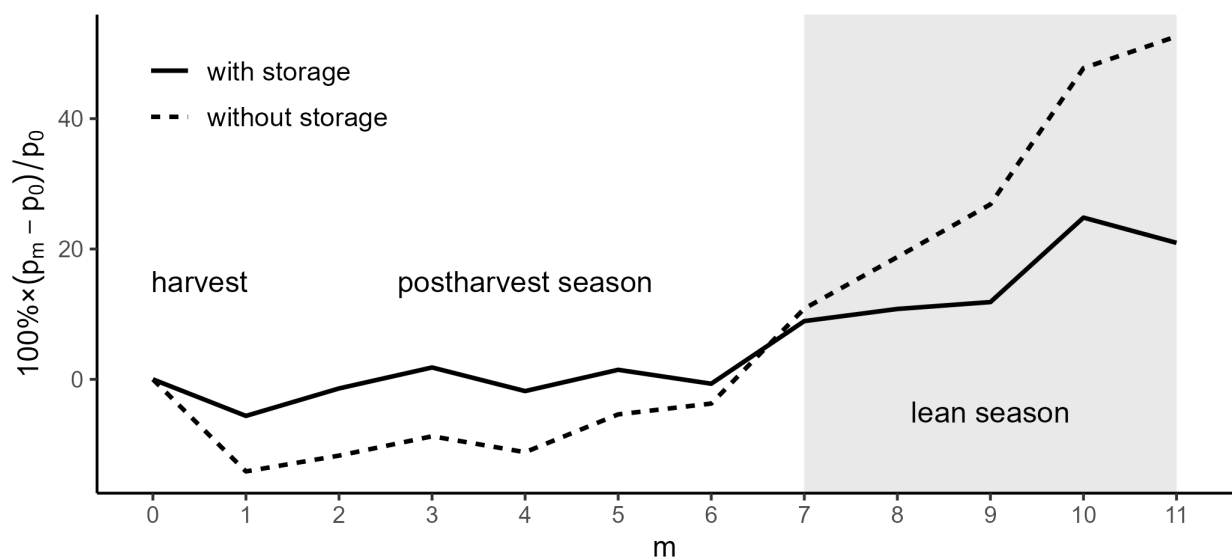

Figure 2: An illustration of seasonal patterns of price with (solid) or without (dashed) storage.

The graph presents prices in percentage terms relative to that during the harvest-month (denoted by zero on horizontal axis). In absence of storage, there will be an abundance of the agricultural commodity just after harvest, which would push prices down, and scarcity during the lean season—before the next year's crop is harvested, which would push prices up. Such seasonal pattern is given by the dashed line on the figure. With storage, both the post-harvest price drop and the lean-season price surge will be mitigated, as illustrated by the solid line on the figure.

In our empirical exercise, we can compare the seasonal patterns of locally produce commodity prices between high-conflict and low-conflict regions, to find out if conflict motivates or discourages storage, all else held constant.

Third, we bring in the concept of informal institutions as potentially mitigating the links between conflict and food insecurity. We understand informal institutions, particularly in fragile states, to be mechanisms that constrain or enable behaviour but that do so outside of public or officially sanctioned channels (Helmke and Levitsky, 2004, 727). This includes the capacity to enforce contracts, resolve disputes, and sanction behaviour outside of state-based mechanisms. Non-state institutions can fulfill these roles by providing information about traders to potential and actual counterparties, building reputations for traders so they can minimize transaction costs with people they do not know, and punish defecting traders through damage to their reputations (Clay, 1997; Greif, 1993; Johnson et al., 2002; McMillan and Woodruff, 1999a, 1999b; Milgrom et al., 1990). Informal institutions (or more accurately, informal ties that are not captured by formal state-based institutions) can mitigate the problems created by the lack of formal institutions, or even those caused by conflict (Aker et al., 2014), for instance, in a paper on agricultural prices in Niger and Nigeria find that the interaction between ethnicity and borders can lead to drastic price dispersion: close-by markets on either side of the

border showed large price dispersion. This dispersion was mitigated when the cross-border markets were controlled by the same ethnic group. Conversely, markets within Niger controlled by different ethnic groups had the same price dispersion as markets in different countries, suggesting that co-ethnicity can function as an important informal lubricant in market transactions in situations where formal institutions are not strong.

Since it is difficult to measure the functioning of informal institutions directly, we look at whether levels of market integration (or dispersion), or the changes in levels of market integration over time, are more or less than expected given the structural impediments to integration, including across battle lines in the case of conflict. Our earlier work (Hastings et al., 2022), for instance, finds that price transmission in Somalia is surprisingly robust, which hints at the extent to which informal institutions are functioning, or even obviating formal institutions. A potential explanation for this is that informal institutions that allow Somalis to build trust, exchange information, and enforce contracts have flourished in Somalia in the wake of the collapse of centralized political authority, and that allow Somalis to do business across barriers that retard, but do not completely sever, the movement of information, goods and people between markets. Somalis' ability to soldier on in the face of conflict is notable. Conversely, some types of conflict may themselves be examples of informal links and ties that may mitigate market disruptions. For example, farmers' protests across a country may show a network of people and communication across a country's territory, and even a rebel group's activity within a given territory may suggest alternative governance in part of a country that could facilitate market integration within a part of a country.

Methodology

Using the approach outlines in the previous section, we will conduct market integration analysis for Africa and Southeast Asia. The two regions, as well as countries within these regions, differ from each other considerably, with widely ranging socio-economic characteristics. The most marginalized of the states do not even make the list of countries ranked by the United Nations Development Programme (UNDP) Human Development Index, and, particularly in Africa, those that do make the list, do not rank very high. We chose these two regions for several reasons. Africa as a region is the frequent subject of studies on conflict and climate (Maystadt and Ecker, 2014; Koren, 2019; McGuirk and Burke, 2020), and separately, on market integration (Hastings et al., 2022; Abay et al., 2023), and has a wealth of data on conflict, food markets, climate, and market integration. As such, it is useful as a baseline with which to compare the results of this project with others' results. Southeast Asia, by contrast, is relatively understudied, partly due to data limitations. For its part, Southeast Asia has extensive, varied conflict throughout the region, but also a high level of variation in human development across countries, ranging from Singapore and Brunei at the top to Myanmar and Timor Leste at the bottom. Southeast Asia is also largely a food-exporting region, which presents differing food security problems than Africa. It is useful to look at Southeast Asia as a region with varying conflicts and development levels to see whether conflict's effects on market integration, and thus food security, varies depending on type of conflict, development, governance, or ethnic cleavages. Southeast Asia is also a region of critical strategic importance to Australia. We then link the market integration results with quantitative and qualitative data on conflict, border, policy changes, and exogenous shocks, and market participants' perceptions of all these issues.

Geography and data

We will source the data on conflict incidents from Armed Conflict Location & Event Data Project (ACLED), available at https://acleddata.com, which tabulates several categories of daily conflict incidents, such as armed clashes, violence against civilians, changes of territory control, etc, and includes the types of actors involved. This dataset has been increasingly used in conflict studies. We will supplement this dataset with highly granular, both spatially and temporally, event data sourced from the GDELT Project, available at https://www.gdeltproject.org, which gathers information from global news media articles to provide a real time open data global graph of the human society. This data set enables the quantification of activities by various socioeconomic agents at very fine temporal intervals, for example at the hour, day week or month level, as demonstrated in Amarasinghe (2022, 2023). We will use food price data collected by international organizations (the World Food Program and the Global Information and Early Warning System) across a large set of cities, covering regions that include countries that are apparently economically integrated (among each other as well as the world) as well as countries with sub-regions that are for the purposes of governance, with a relatively distinct, though fluid, border with other regions, particularly during times of conflict. Such geographic heterogeneity will allow us to examine several interesting hypotheses related to spatial and temporal market integration. We will use data on the homelands of ethnic groups in Africa from Murdock (1959), which will allow us to examine the effect of the rich ethnic roots of informal institutions.

Research plan

1. Collect and impute time series data; map out markets and networks in Africa and Southeast Asia (Year 1).
The data in fragmented economies are often incomplete or insufficient for traditional time-series analysis. We can deal with a small proportion of missing observations using a Kalman filter of Hamilton (1994). For relatively short series

we need to extend our modelling to the class of global models. Global models emerged as winners in the recent M4 and M5 forecasting competitions by Makridakis et al (2018) and Makridakis et al (2022). They fit a single model for a wide range of the available time series. The model is still univariate, but the parameters are fitted using neural network method to achieve good out-of-sample performance for all series. Once the model is estimated it can be used for forecasting very short time series.

Global models have a variety of applications, for example, Amazon DeepAR use them to predict the sales of the new products based on the previous launches of similar products. This methodology had an explosive development in the 'big data' era with the recent advances in artificial intelligence and machine learning. To the best of our knowledge global models are not yet applied for fragmented economies. The benefits could be enormous as global models will allow prediction using much smaller data than the traditional models. Since data availability is one of the biggest challenges in low- and middle-income countries, the global model will allow us to deal with this challenge in the most effective way.

Using the publicly available data on prices and roads (OpenStreetMap), we will map the network of markets across Africa and Southeast Asia. This exercise will set the stage of subsequent econometric analysis of the data. We will construct the roads network so that each market (city or town) is linked to at least one other market. We will determine the most likely "trade partner" based on the type and quality of the road connecting the two markets, supplemented by any available auxiliary information about the existing patterns of trade. We will complement these road networks with networks based on geographic and ethnic connectivity, expanding on methods developed in Amarasinghe et al. (2020).

2. Examine markets and food insecurity in presence of conflict, ethnic linkages, and informal institutions (Years 1-2).

We will use market integration across locations and over time as a means of accounting for the functioning of formal and informal institutions, and to see how a decrease in market integration and shocks to prices can lead to potential food insecurity. In the quantitative analysis, we treat factors (internal and external) that can impede the flows of information, people, and goods between markets as shocks that may slow down price transmission speed or temporarily cease market integration entirely. In terms of the ability of (informal) institutions to function in the face of conflict, however, not all conflicts are the same. Conflict 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 (Bellemare, 2015). Moreover, because ACLED maintains records of the change of control (either peaceful or due to an armed conflict), by tracing such datapoints, we will be able to recover the timeline of a territory's control by the central government or the rebel group. This will allow us to identify the subset of regions under common governance, be that formal or informal.

In the presence of conflict, the effect is essentially to create borders between markets that may or may not be permeable, and to change market participants' behaviour. The extent to which market price integration responds to these shocks or continues even across the borders serves as an indicator of both food insecurity in different areas, and to suggest the presence (or lack thereof) of informal institutions. To overcome these barriers, social networks, which provide credit, information, and dispute resolution to reduce transactions are perhaps the underlying factor in the functioning of informal institutions. We can bring in narrative data on specific countries from secondary sources to explore the mechanisms by which market participants change behaviour and decrease costs associated with moving people, goods, and information between markets within the country, and between the country and overseas markets, in the face of dysfunctional formal institutions and the shocks.

In all cases where data allows, we will measure how forecastable the time series is and benchmark it against the markets of the developed economies. The working hypothesis that emerged from the preliminary analysis is that the time series in fragmented states can still be predicted using standard statistical models. Different economic environments can generate prices that exhibit similar statistical properties. To the best of our knowledge, this analysis was never performed for fragmented economies.

3. Disseminate the results to stakeholders (Years 2-3).

We will disseminate the results to stakeholders in accessible ways designed to maximize uptake of the findings and the framework. **For scholars**, we will (i) organize workshops as a platform for sharing the knowledge; (ii) present the findings at international conferences; and (iii) publish journal articles in high-impact journals. **For government policymakers and non-governmental organizations in the humanitarian aid and governance sectors**, we will develop (i) a briefing and a white paper outlining the results and the framework; and (ii) a forecasting website tool for generating short- and intermediate-term forecasts of local food prices, which will serve as an indicative measure for food affordability. The team has experience in creating high-quality public websites (e.g., our previous website business-forecast-lab.com). The website is an intuitive tool that makes the outcomes of this project accessible to the wider community. Anyone with internet access can easily obtain predictions of grain prices and market integration measures together with the uncertainty around them. This feature is especially important for the two regions in

consideration as there are fewer websites that cater for the needs of this part of the world. The website will include classical forecasting models as well as the novel methods developed by the team. The website will visualize and summarize the forecasting results in an easy-to-understand manner. The forecasts will be updated regularly to account for the latest available information.

BENEFIT
Significance
This project is significant for several reasons. First, it provides a new way to understand how the political economies of conflict-affected fragile states actually function—through informal institutions that are always there but are often unseen and unmeasured. Much of the international community's aid for marginalised, developing states is oriented, understandably, toward improving and consolidating formal institutions—courts, law enforcement, finance and trade ministries, customs, and the like. However, in states with high levels of conflict or other impediments to internal governance, buttressing informal institutions—building trust networks, encouraging information flows, and finding informal ways to enforce agreements—may be more immediately effective than programs focused on formal institutions. Second, the project, which links integration of cereal markets across and between countries with state capacity, and in turn links those with positive and negative outcomes, will be useful to development organizations such as the World Bank, the United Nations Development Program, and the World Food Program in targeting their programs and understanding the connection between market functionality and governance within a country.

Benefit to Australia
This project falls within the Science and Research Priority of "Food" and addresses the Practical Research Challenge of "Knowledge of global and domestic demand, supply chains and the identification of country specific preferences for food Australia can produce." As such, the project and its outcomes have several specific benefits for Australia. First, by developing alternative ways of understanding governance and market function in developing countries, the project will improve the ability of the Australian government to target its aid for maximum practical effect, and for maximum influence, in Africa and Asia, particularly Southeast Asia.

Second, the project develops an accessible framework to understand cereal market integration within and between countries, and to forecast both cereal market prices and the extent to which a country's formal and informal institutions are facilitating (or not) trade between internal and external markets, as well to understand the effects of conflict on food prices and market integration. As such, the outcomes, particularly the framework and the forecasting tools will be useful to industry—such as cereal exporters—that wants to understand the demand for Australian cereals in many developing Asian and African countries, and the effects that political and economic risks, such as conflicts, are likely to have on that demand, and the extent to which those countries are integrated into global supply chains. In practical and intellectual terms, this project will burnish Australia's international development credentials, and improve the ability of the Australian government and industry to build political and economic influence in developing countries, particularly in Africa and Asia. In particular, the results can help Australia understand where there are likely to be food insecurity issues, based on the locations and types of conflict and the effects on market integration, storage, and prices, thus allowing Australian aid organisations to strategically pinpoint where and when to send aid.

FEASIBILITY
The main feasibility concern with any project dealing with marginalised states is obtaining access to those states and collecting reliable and accurate data. Maximizing feasibility is baked into the purpose and design of the project. First, the project's main purpose is to take data that are already relatively widely available, specifically for low- and middle-income countries—cereal market prices and conflict data—and apply an innovative framework to provide insights into conflict, markets, and institutions that would not otherwise be possible due to the nature of the states under study. In this, the poor data environment is an advantage for our project, inasmuch as the value added by our analysis will be greater than for states with better data.

Second, the project is designed to take advantage of data that we have already collected or to which we already have access (e.g. via the Food and Agriculture Organization of the United Nations's Food Prince Monitoring and Analysis tool), obviating problems of data collection that would usually be the case with the study of marginalised states, reducing the susceptibility of the project to travel restrictions, and minimizing the costs associated with data collection and fieldwork.

The implementation of existing methodologies and the use of previously developed tools guarantee the project's feasibility. This includes models and methods already developed by the CIs independently as well as, importantly, in collaboration (Amarasinghe et al., 2020; Hastings et al., 2022, Ubilava et al., 2022). This will be aided by research input from a PhD student, and a Research Assistant with a suitable programming background. In Years 1 and 2, the RA will assist with data sourcing and management, particularly as they relate to "data cleaning" that will facilitate accurate matching of the price and conflict data. In Years 2 and 3, they will integrate and automate new data sources into the

existing website structure, as well as implement Machine Learning methods for global models, and the Kalman filter for missing observations. The University of Sydney provides excellent graduates that can be employed on this project, as well as access to the Sydney Informatics Hub. The CIs have drawn on the Hub's expertise in implementing multiple projects with similar demands.

Implementation plan

	Year 1	Year 2	Year 3
Research	- Framework development - Address missing data issues in commodity prices - Map markets and roads across Africa, Southeast Asia	- Examine hypotheses of spatial and temporal linkage in the wake of conflict - Link market inefficiencies and institutional capacity	- Generating short- and intermediate-term forecasts of food prices in conflict-affected states - Write-up
Publication and dissemination	- Paper 1 (framework) - Presentation, International Studies Association (ISA) Annual Convention (San Francisco) - Organized workshop on markets and institutions in conflict-affected states.	- Papers 2 & 3 (spatial integration & storage) - Presentation, ISA (Chicago) - Presentation, Centre for the Study of African Economies (CSAE), Oxford, UK. - Presentation, Royal Economic Society (RES) Annual Conference, UK. - Presentation, Allied Social Science Associations (ASSA) Annual Meeting (San Francisco) - Organized workshop on markets and institutions in conflict-affected states.	-Paper 4 (institutional capacity and market efficiency) - Presentation, ISA (Columbus) - Presentation, ASSA (Philadelphia) - Organized workshop on markets and institutions in conflict-affected states. - Briefings at DFAT - Web tool online

COMMUNICATION OF RESULTS

Dissemination will be differentiated to maximize uptake by different communities.

1. **For academics**, we will publish at least four articles (one on the framework itself, one on spatial integration, one storage, and one on institutional capacity and market efficiency) in leading, high-impact political science, economics, and development journals such as *World Development*, *Food Policy*, *American Journal of Agricultural Economics, Journal of Development Economics, Journal of Public Economics, International Studies Quarterly*, *Political Geography*, and *African Affairs*. All have previously published our work. We will also commence the series of annual workshops on markets and institutions in conflict-affected states.

2. **For policymakers and aid organisations**, we will prepare and deliver a briefing paper that lays out the framework in accessible terms, presents the results, and gives recommendations for development, targeted aid and foreign policy. In Canberra we will brief DFAT's foreign development and aid programs, and the Southeast Asia and Africa teams, and train government analysts and aid workers in the use of the forecasting tool website.

3. **For a sustainable benefit to analysts and the wider public**, we will write a series of short pieces to be published in high-visibility venues, and create a website that will (1) automatically import market price data for Africa and Southeast Asia as they are produced; (2) visualize market price data; (3) forecast cereal grain prices and market integration within countries and across regions based on different modelled scenarios, including those where conflict intensity varies.

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