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Abstract: Large price increases over a short time period can be indicative of a deteriorating food security situation. Food price indices developed by the United Nations Food and Agriculture Organization (FAO) are used to monitor food price trends at a global level, but largely reflect supply and demand conditions in export markets. However, reporting by the United States Agency for International Development (USAID)'s Famine Early Warning Systems Network (FEWS NET) indicates that staple cereal prices in many markets of the developing world, especially in surplus-producing areas, often have a delayed and variable response to international export market price trends. Here we present new price indices compiled for improved food security monitoring and assessment, and specifically for monitoring conditions of food access across diverse food insecure regions. We found that cereal price indices constructed using market prices within a food insecure region showed significant differences from the international cereals price, and had a variable price dispersion across markets within each marketshed. Using satellite-derived remote sensing information that estimates local production and the FAO Cereals Index as predictors, we were able to forecast movements of the local or national price indices in the remote, arid and semi-arid countries of the 38 countries examined. This work supports the need for improved decision-making about targeted aid and humanitarian relief, by providing earlier early warning of food security crises.

September 15, 2011

Molly E. Brown
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Global Environmental Change: Human and Policy Dimensions

Dear Editor,

Please find enclosed a Letter focused on providing new cereal price indices for local, national and regional food security assessment. The new price indices were compiled for improved food security monitoring and assessment, and specifically for monitoring conditions of food access across diverse food insecure regions. Based on a new and unique cereal price dataset for 38 countries in the developing world, the paper provides new insights into the connection between local production and local food price access. I urge you to consider the manuscript for publication in your journal.

Thank you for your consideration,

Molly E. Brown

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New Local, National and Regional Cereal Price Indices for Improved Identification of Food Insecurity

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*Highlights

- In this study, we use a new, local cereal price database comprised of food prices from 232 markets in 39 countries to estimate local access to food
- We examine the local price dispersion among marketsheds in five regions, East, West and Southern Africa, South Asia and Central America.
- We use the global cereal price indices from the UN Food and Agriculture organization and satellite remote sensing information to estimate future changes of the local food prices, through an understanding of price transmission from global to local markets
- This work shows the value of local, national and regional food price indices that can inform authorities and decision makers in the humanitarian community of the potential for food price-related food insecurity, even before the increases occur.

*Manuscript (without author details, acknowledgements or affiliations)
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Abstract

Large price increases over a short time period can be indicative of a deteriorating food security situation. Food price indices developed by the United Nations Food and Agriculture Organization (FAO) are used to monitor food price trends at a global level, but largely reflect supply and demand conditions in export markets. However, reporting by the United States Agency for International Development (USAID)'s Famine Early Warning Systems Network (FEWS NET) indicates that staple cereal prices in many markets of the developing world, especially in surplus-producing areas, often have a delayed and variable response to international export market price trends. Here we present new price indices compiled for improved food security monitoring and assessment, and specifically for monitoring conditions of food access across diverse food insecure regions. We found that cereal price indices constructed using market prices within a food insecure region showed significant differences from the international cereals price, and had a variable price dispersion across markets within each marketshed. Using satellite-derived remote sensing information that estimates local production and the FAO Cereals Index as predictors, we were able to forecast movements of the local or national price indices in the remote, arid and semi-arid countries of the 38 countries examined. This work supports the need for improved decision-making about targeted aid and humanitarian relief, by providing earlier early warning of food security crises.

Introduction

There have been two sharp rises in food prices around the globe during the past few years. In 2008, prices for grains and oilseeds reached very high levels after production shortfalls occurred in several exporting countries, markets panicked, leading to bans on food crops exports by some major exporters and hoarding by food import-dependent countries. The United Nations Food and Agriculture Organization (FAO) estimated that the food price increase in 2007-08, drove the

number of undernourished people worldwide from 915 million to more than 1 billion, the highest number in more than 40 years (FAO, 2009). World food prices rose sharply again at the end of 2010, hitting an all-time high in February 2011 (Barrett and Bellemare, 2011), resulting in a significant increase in food insecurity around the world.

The FAO has developed a food price index to monitor food commodity price trends at a global level, but it largely reflects supply and demand conditions in export markets in the developed world and the most advanced countries of the developing world. A component of the FAO Food Price Index, the Cereals Price Index is an indicator of price trends in globally-traded cereals but only poorly reflects variations in the least expensive food often consumed by the poor in food-insecure countries (Brown and Funk, 2008; Funk and Brown, 2009). Prices of staple cereals in food-insecure regions often do not immediately follow international export market price trends, due to imperfect market integration, prices for local products moving between the export and import parity price bounds, an absence of imported products, and/or policy barriers to trade (Tondel, 2011). These variations make the use of the FAO indices more difficult for monitoring changing food access and food security conditions for the poor in the developing world. As the global commodity market changes, monitoring the potential impacts it may have on food security by making food more expensive in food insecure areas of the world, becomes much more important.

Here we seek to develop alternative staple food price indices to the FAO global indices, by using price data from markets and commodities in food-insecure countries in order to better reflect how changing food prices are impacting the food security of the poor (Alem and Söderbom, 2011). Regional price indices that capture the movement of local cereal prices of staple commodities being consumed by the poor would provide new information that is currently lacking from the global price indices, and will enable a much improved measure of access to food by the poor (Garret and Ruel, 1999; Schmidhuber and Tubiello, 2007).

Materials and Methods

The new local, national and regional indices produced in this paper use information from a continuously updated price database comprised of food prices from 232 markets in 39 countries, sourced from both the FAO and the US Agency for International Development's Famine Early Warning Systems Network (FEWS NET) (Figure 1). There are 124 different commodities in the database, which were selected by local experts as appropriate to assess food security in the selected area. The database has retail price data in local currencies from 1997 to 2011, but the starting year of each series varies by market. Here we use the most complete information from 2004 through 2011 to form the price indices.

The data was combined into indices using information on the local production system and patterns of food consumption. We created the following indices:

- National Cereals Price Index for selected food insecure countries, constructed using prices of commodities that are important in the diet of food insecure communities (see Table 1);
- Regional, capital-city only cereal price indices, generally representing prices in the largest city in each country in a region;
- Agricultural production-based cereal price indices, based on the major surplus, minor deficit, and major deficit zones of selected food insecure countries.

FEWS NET Production and Market Flow Maps were used to classify markets into major surplus, minor deficit, and major deficit zones in each country. The trade flow maps can be found on the FEWS NET website (www.fews.net) under Markets and Trade.

While the FAO Food Price Index is more known globally, the FAO Cereal Price Index most closely approximates the food security-related indices we are building,

because the commodity baskets in our price databases and our analyses were selected based on staple cereals that dominate the diet of the poor. The FAO Cereal Price Index combines maize, wheat, and rice price indices (FAO, 2011b) and is composed of one maize export price quotation, a combination of nine wheat price quotations and the Rice Price Index that combines the prices of three varieties of rice (Japonica, Aromatic, and Indica) for a total of 16 price quotations (FAO, 2011a). The index is based upon weighted averages of cereal commodity prices in international export markets, expressed in terms of their value in a base period (2002-2004), and calculated on a monthly basis (Tondel, 2011).

The average price in the base year of 2006 was used to create a nominal FEWS NET price index for every market and commodity combination, in the same way that the FAO indices are constructed (Tondel, 2011). The number of data observations available from January 2004 to April 2011 was used as a weight for each market and commodity combination, reducing uncertainty due to missing information. The commodity price indices were then averaged to form a country price index for each country, and the country price indices were then averaged together to create the regional indices. The selected time period captures more than 75% of the price data from 18 of the 35 countries, between 50% and 75% of the price data from 10 of the countries, and between 25% and 50% of the price data from 6 countries.[1] The FEWS NET price indices reflect the average rate of price change for a bundle of key staple cereals that are consumed in each food insecure country(Tondel, 2011).

We use the FAO Cereals Index to predict future changes in the FEWS NET national, regional and surplus/deficit area indices, as a way of providing early warning of price increases in food insecure areas. To account for the time-series nature of the data, we first test for stationarity using an augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979). Failure to account for the presence of unit-roots in the

[1] The database holds only few observations of food price data from the early 2000s and before. Because of missing values for some commodity-market pairs, the composition of country and regional price indices may differ from one period to another. However, in general, these differences are minor. Instead of inputting missing values, we chose to use an unbalanced panel data set.

indices may distort inference and our conclusions. All of the indices were found to have a unit root. Thus, all series were transformed into first-differences and retested using the ADF. All of the first-differenced series were found to be stationary in differences or integrated of order one.

We also use the FAO Cereals Index to predict future changes in the FEWS NET food price indices by country, to provide early warning of price increases in specific food insecure areas. We report the highest significant lagged correlation coefficient (r^2) after testing lags between 1 and 12 months for each country. The predictive capability of the FAO Cereals Index, alone, was compared to a polynomial linear regression with both the FAO Cereals Index and the vegetation index for the previous growing season as parameters. A one-tailed F-Test with an alpha of 0.05 was used to compare the two regressions and determine if the vegetation index significantly improved the model. After taking the first differences of the price data, we observed a normal distribution of the sample data with eighty-eight observations minus the lag shown in Table 1. Including the error term, the FAO Cereals Index regression model had two parameters while the FAO Cereals Index and vegetation index regression had three.

Satellite remote sensing of vegetation greenness was used in a cross correlogram analysis to assess growing conditions in the area around each market. We used an average of five MODIS Climate Model Grid (CMG) 0.05 degree (Brown et al., 2006a; Justice et al., 1998) monthly vegetation index pixels around each market to represent the growing conditions in the region around the market (Brown et al., 2006b). The data are used as a substitute indicator for rising and falling cereal supply in regions with late or unreliable production statistics for locally grown staple cereals (Fuller, 1998; Funk and Budde, 2009). Satellite remote sensing data has the advantage of being an early indicator of drought and weather-related production increases and declines across multiple agroecosystems, and is used operationally by both USAID and the FAO to assess food production (Brown, 2008).

Results and Discussion

Five regional price indices for East, Southern and West Africa, Central America and Central Asia are shown in Figure 2A. Changes in these price indices tend to lag behind the FAO Cereals Index during periods of food price increases.

If market integration in a region is strong, then prices in different markets will move together within a short period of time. If prices in different markets move at different paces, then this will be reflected in higher price dispersion across markets, especially during periods of significant price movements, until equilibrium is restored. The variability in price indices across country within East Africa increases after the 2008 food crisis, shown by the increasing size of blue deviation lines in Figure 2B. Other regional indices also display a similar increase in price dispersion across markets included in them as of 2008, the time period of the first global "food price crisis". The crisis thus appears to mark a fundamental shift in the dynamics of regional and global commodity markets (Moseley et al., 2010; Trostle, 2010). Variations in efficiency of transportation, ability to sell goods to the international markets and a variable need for importing food from international markets with higher prices all contribute to the marked variability of local prices after 2008 (Badiane and Shively, 1998; Deaton and Laroque, 1992; Wodon et al., 2008).

Figure 2C shows the relationship between isolated, non-capital city market cereal food prices, capital city cereal prices in each region, and internationally traded cereal prices. We found that of the capital cities used in FEWS NET regional indices, only 35% of them are able to capture 60% or more of the variability of food prices in secondary urban centers and rural areas, suggesting a need for more price data from remote areas that produce food. The correlation between the first differences of the regional capital city price index and an index developed from the remaining non-capital markets for each region is 0.38 for East Africa, 0.08 for Southern Africa, 0.26 for West Africa (Figure 2C), 0.54 for Central America and 0.37 for Central Asia

(Moseley, 2010). These diverse and relatively low correlations demonstrate the ongoing need for continuous monitoring of staple cereal prices in rural markets.

Our focus in this paper was to construct new food security-oriented price indices for selected food insecure countries and regions, using commodities most relevant to food access for the poor. Local, national and regional cereal prices often lag behind international cereal prices, but can be predicted using the FAO Cereals Index (Figure 2D and Table 1). Using a pragmatic approach, we show that the FAO Cereals Index explains more than half of the variance in the FEWS NET national price indices for half of the markets. When we include the vegetation index as a second predictor for each country; 51% of the countries showed an improvement in predictability (Table 1), indicating that the influence of weather-related local production variability is an important factor in determining price variability.

Figure 3 shows regional price indices for different types of agro-ecological zones in East, West, and Southern Africa defined as cereals surplus producing zones, minor cereals deficit zones, and major cereals deficit zones. Price indices were formed by averaging prices from markets in those zones. Price dispersion within each zone index is measured by the standard deviation of market-specific price indices. The plot shows significant differences between the index formed from each zone index and the regional index due to the impact of local food production, and differences in price propagation between the regions. In southern Africa, for example, markets in Mozambique make up 88% of the minor deficit price index for Southern Africa. In 2007, the Zambezi River basin experienced major flooding while southern Mozambique experienced a drought; this resulted in poor harvests and higher prices, which explains the high peak and large standard deviation in the minor deficit price index (FEWSNET, 2007).

Conclusions

Here we used a continuously updated food price database containing 232 markets in 39 countries to derive new food security-related price indices that enable quantification of food access conditions in local, national, and regional marketsheds that experience food insecurity. We found that it was possible to use the FAO Cereals Index as a predictor of future movements of cereal price dynamics in the majority of the areas examined.

Previous research has highlighted the negative impact of increasing food prices for the food security of the poor (25-27). As international cereal prices continue to respond to increasing global demand and tight supply, improving our understanding of if and how completely these prices are transmitted to food insecure regions is critical for safeguarding the food security of the poor (FAO, 2008). When localized droughts reduce food supplies, chronic reductions in food access can occur due to elevated prices that can persist over a period of years. This analysis shows that including information about local food growing conditions can help identify markets in which food prices may greatly affect conditions of food access for the poor.

This work shows the value of local, national and regional food price indices that can inform authorities and decision makers in the humanitarian community of the potential for food price-related food insecurity, even before the increases occur. This information is of increasing value as a globalization of the food market begins to increase the transmission of price signals from developed countries into less developed countries, and periodic imbalances between global demand and supply of food is becoming more frequent.

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Captions

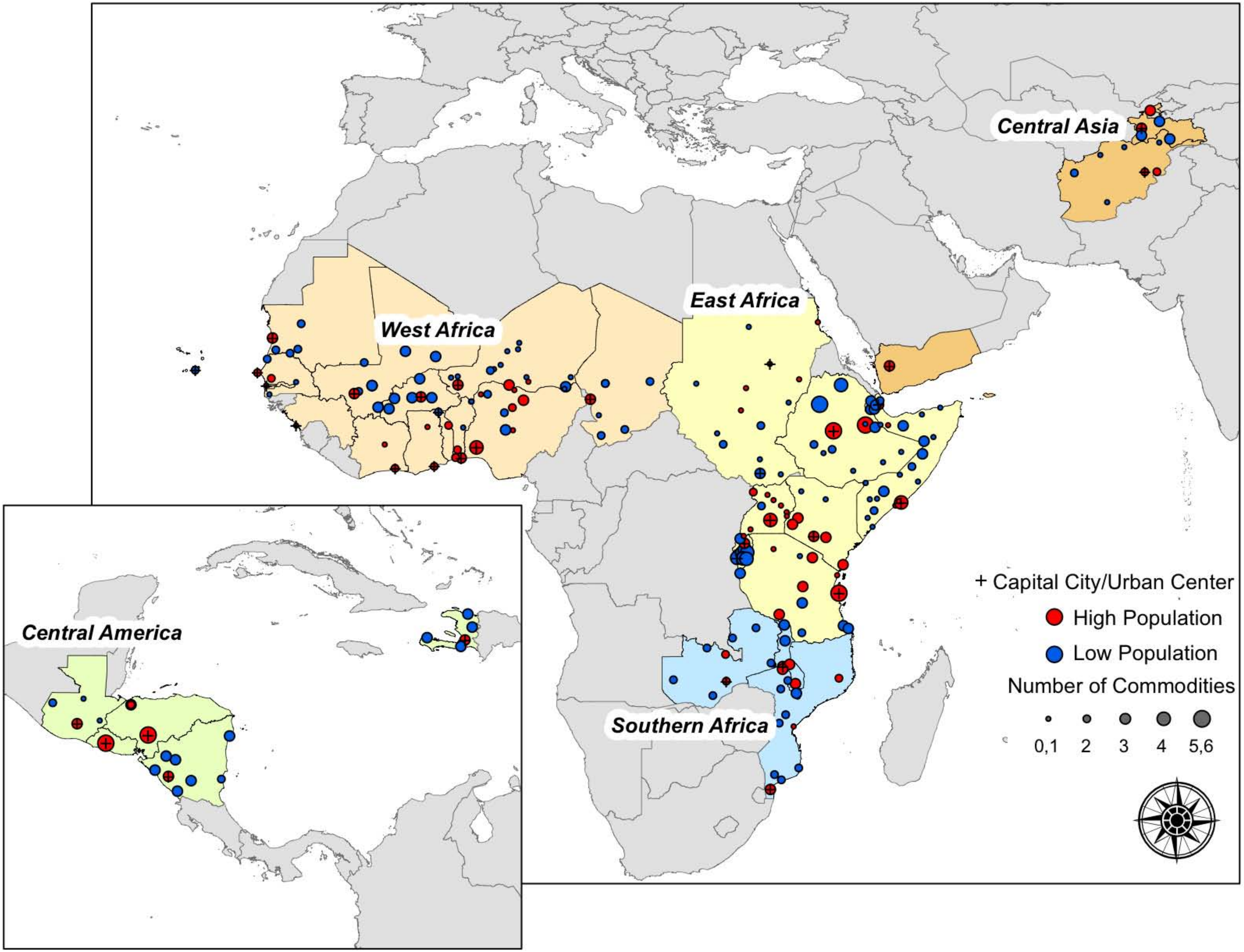
Figure 1. Map of markets with commodity prices used in FEWS NET indices.

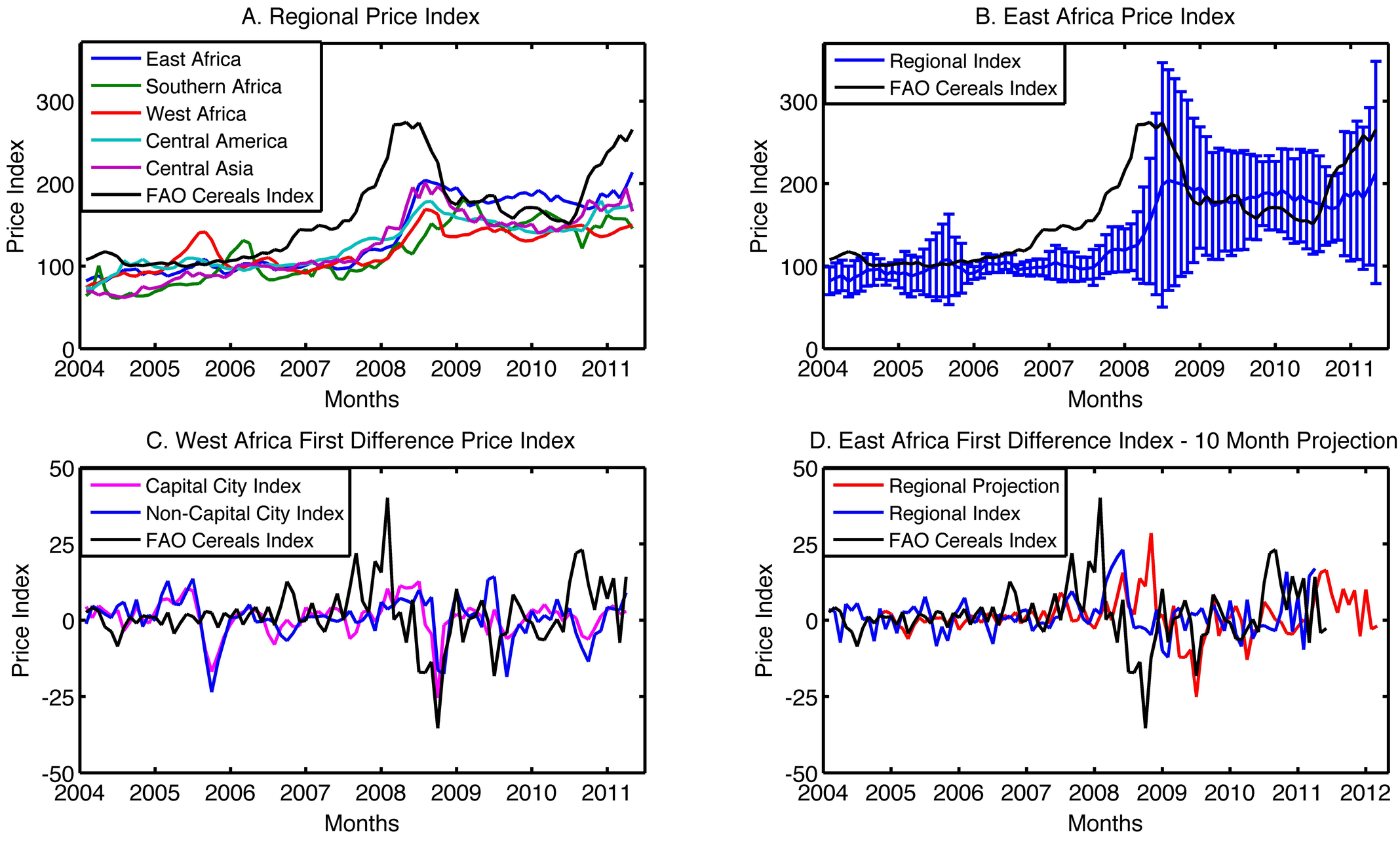
Figure 2. A. Regional price indices for each of the five food insecure regions. B. East Africa regional price index, based on capital city markets. Blue error bars show the standard deviation of country indices included in the regional index. C. West Africa regional index of capital city markets versus a West Africa index of non-capital city markets. D. The FAO Cereals Index is used to create a six-month projection of the East Africa regional index of capital city markets.

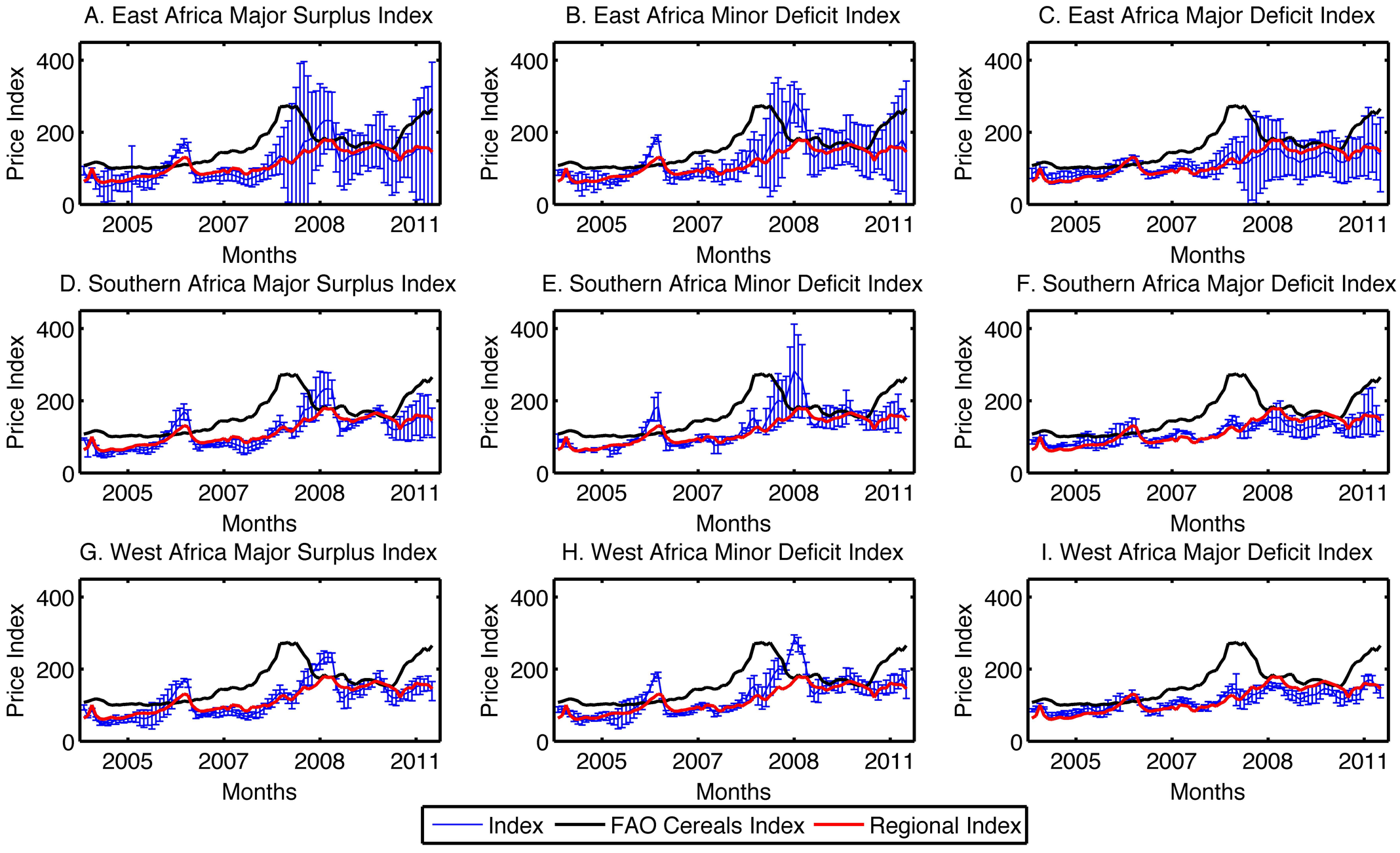
Figure 3. Surplus and deficit zone price indices for Africa. Error bars show standard deviation of the country indices within the regional index. The regional price index of capital city markets and FAO cereals index are also shown for comparison. A-C. East Africa; D-F. Southern Africa; G-I. West Africa major surplus, minor deficit, and major deficit indices and standard deviations. Markets were grouped into agricultural production zones determined from the FEWS NET market production maps for each region.

Table 1. Regression results by country. The results of two regression models are presented, one predicting the FEWS NET Regional cereal price index with a lagged FAO cereals index, and the second with both a lagged FAO cereals index and the previous growing season's maximum NDVI, used to estimate each country's price index of all the markets. The lag values reported were the maximum correlations between the FAO Cereals Price index and the country index. The corresponding r^2 values are reported. The p-value, which measures the significance of adding NDVI to the regression, was derived from a one-tailed F-Test, and is also given for each country.

Figure 1


Central Asia
East Africa
West Africa
Southern Africa
Central America
+ Capital City/Urban Center
High Population
Low Population
Number of Commodities
0,1
2
3
4
5,6


A. Regional Price Index
East Africa
Southern Africa
West Africa
Central America
Central Asia
FAO Cereals Index
Price Index
Months
B. East Africa Price Index
Regional Index
FAO Cereals Index
Price Index
Months
C. West Africa First Difference Price Index
Capital City Index
Non-Capital City Index
FAO Cereals Index
Price Index
Months
D. East Africa First Difference Index - 10 Month Projection
Regional Projection
Regional Index
FAO Cereals Index
Price Index
Months


A. East Africa Major Surplus Index
B. East Africa Minor Deficit Index
C. East Africa Major Deficit Index
D. Southern Africa Major Surplus Index
E. Southern Africa Minor Deficit Index
F. Southern Africa Major Deficit Index
G. West Africa Major Surplus Index
H. West Africa Minor Deficit Index
I. West Africa Major Deficit Index
Price Index
0
200
400
2005
2007
2008
2011
Months
Index
FAO Cereals Index
Regional Index