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Food price changes and food security in developing countries: a multidimensional analysis

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Table of Contents

List of figures and tables

List of abbreviations

CFS	Committee on food security
FAO	Food and Agriculture Organization of the United Nations
IFAD	International Fund for Agricultural Development
OECD	Organization for Economic Cooperation and Development
PCA	Principal component analysis
WFP	World Food Program
WFS	World food summit

Abstract

The thesis examines the impact of food price inflation and food price volatility on food security using a panel data set of 105 developing countries over 2001 to 2012 (taken on three-year averages). Recognizing the multidimensional nature of food security, we use different indicators of food security and employ principal component analysis to develop one overall composite indicator, and three indices that represent different dimensions of food security. Using these indices as dependent variables, we employ the fixed effects estimator to investigate the impacts of food price inflation and food price volatility. The results show that food price inflation and food price volatility have different impacts on the food security indices. In addition, the findings show that the effect of food price changes varies for different dimensions of food security. Finally, the study shows the adverse impact of food price changes in Africa compared to other developing countries.

Chapter one: Introduction

1.1 Background of the study

Since food security came to the agenda at the World Food Conference in 1974, its definitions and measures have been evolving from its simplest definition of ‘‘food supply’’ to the current multidimensional definition (Badolo & Kinda, 2014). Analytically, food insecurity has been taken as if it is synonymous to terms such as “hunger”, “undernourishment”, “undernutrition” or “food deprivation” (Aurino, 2014), and narrowly defined as the availability of enough food irrespective of the scale of analysis (household, community, national or global) (Pinstrup-Andersen, 2009). Yet, these terminologies represent different aspects of food insecurity, and it is misleading to use these terms interchangeability (CFS, 2011).

It is still in progress to design a comprehensive food security measure by capturing its different dimensions properly (FAO et al., 2014). The most popular and widely accepted definition of food security has been given by the Food and Agriculture Organization of the United Nations (FAO). According to FAO “*food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*” (WFS, 1996). The definition of FAO reflects the multidimensional nature of food security, and comprises four dimensions: availability, accessibility, utilization and stability of food (FAO et al., 2014; WFS, 1996). We mostly use different methods to ‘‘estimate’’ than to ‘‘measure’’ food security exactly due to its complex and multidimensional nature. Even though it is impossible to get a single direct measure of the state of food security, the estimation of food security should go beyond the availability of food to include elements like access and vulnerability (Cafiero, 2014; CFS, 2011; FAO, 2008; FAO et al., 2013).

Achieving food security has been among the key challenges of the world. Even though the world is struggling to achieve food security, a significant proportion of the world population has remained food insecure with the least progress in sub-Saharan Africa (FAO et al., 2013; Reig, 2012). According to a recent FAO report, about 842 million people in 2011–13, or around one in every eight people in the world were food insecure (FAO et al., 2014). Despite increasing food production from year to year, the estimated number of food insecure people has been also increasing. Population growth, increasing wealth, consumption diversification, climate change, biofuel demands and food accessibility are among the main factors behind the unbalanced food system (Godfray et al., 2010; Lee et al., 2013).

Food security cannot be achieved if food is not accessible to all people. The price of food is one of the basic determinants of food accessibility, and has recently been taking the blame for triggering poverty and food insecurity around the globe. Even though food price fluctuations are not a new phenomenon, the world has witnessed significant changes since 2000 (Headey, 2013). For example, in 2008 the food price index was three times higher compared to the 2000 index (Von Braun & Tadesse, 2012), and dropped 75-80 million people below the poverty line (FAO, 2008). Given this, it is not surprising that its impact, especially on the global population has been a concern at local, national and international stages (Headey, 2013).

In this study, we use the different dimensions of food security as devised by FAO and analyse them to get one composite indicator and individual indices for the components of food security, and estimate the impact of food price changes on these different food security aspects for a sample of developing countries.

1.2 Statement of the problem

Political, social and economic conditions determine the food security situation of a country. Income per capita, economic inequality, agricultural public investment, agricultural productivity, population growth, engagement in international trade, food prices and institutional quality are among these determinants (FAO et al., 2014; Reig, 2012). These variables affect the distribution, affordability and access of food in a country and determine status of food security (Wineman, 2014).

As we said above, one of the covariates that affect food security is the food price (Barrett, 2010; Wang, 2010). Despite the general agreement on the adverse impact of the food price on food security of the poor, this relationship has been contested on theoretical, conceptual and methodological grounds. Theoretically, a higher food price can contribute to food security by encouraging producers to produce more, increasing agricultural income, stimulating agricultural investment and increasing agricultural productivity (Von Braun & Tadesse, 2012). In a related argument, Headey (2011) and Headey & Fan (2008) claim that the effect of food price on food security depends on the occupation of the population under consideration, and on the depth of their poverty. If the increasing prices increase farm income, the overall impacts might be encouraging. But, increasing productivity may not necessarily lead to better access to food (FAO et al., 2014). In addition, if poor people spend a large share of their income on food, rising food prices may increase food insecurity and malnutrition (FAO et al., 2014; Lee et al., 2013). Expensive food baskets could decrease the quality and quantity of household food consumption, which, in turn, impedes the long-term human development of countries (Brinkman et al., 2010).

Studies that assess the food price and food security relationship mostly conceptualize food security as ‘‘food availability’’ which has not the capacity to capture the multidimensionality nature of food security (Díaz-Bonilla & Francisco Ron, 2010; Headey, 2011). Moreover, many studies on the relationship between food price and food security of countries mainly focus on the theoretical and conceptual explanations (FAO et al., 2013; Headey & Fan, 2008; Lee et al., 2013), and lack empirical investigations due to the lack of comprehensive data at country level. So, most empirical works that estimate the impact of food price on food security are simulation-based and do not contain representative countries (Headey, 2011).

The empirical literature on food price and food security is diverse. Most studies assess the impact of price changes on household food security (Akter & Basher, 2014; Cohen & Garrett, 2010; Kumar & Quisumbing, 2013; Mallick & Rafi, 2010; Wang, 2010). Some studies empirically investigate the impact of higher food price on nutrition and health outcomes of countries. Brinkman et al. (2010) investigated the impacts of higher food price on the nutrition and health using three sample countries. They used simulations and regression techniques and found that food prices affect the diversity and frequency of food consumption negatively. Christian (2010) assessed the effect of high food price on child mortality using different nutritional pathways, and showed how it could threaten the success of the Millennium Development Goals. Lee et al. (2013) also estimated the impact of food price change on population health using infant mortality, child mortality and undernourishment as health indicators.

Others also synthesized that the impact of rising food price on food security depends on the position of countries in the international market (buyers or sellers) (Ivanic & Martin, 2008). Another study by a panel of experts of FAO shows that the effect of the rising world food price on the food security of countries depends on the transmission of the world price to local markets (HLPE, 2011), since not all countries would absorb the increasing food price at the same rate.

Headey (2013) discusses how the impact of price levels on food security depends on the measurement of food security. Similarly, FAO et al. (2014) in their recent report cautioned that it is necessary to fully analyse the various dimensions of food security in order to get ‘‘a complete and more nuanced picture of the state of food security in a population’’ (FAO et al., 2014, p. 13). The report shows that we get different stories when we see the individual dimensions of food security. Food availability has shown significant improvement in the last two decades; whereas food utilization and food accessibility remain a challenge.

To our best of knowledge, studies that use and analyse different indicators of food security for the same dataset at national level are scarce. Therefore, it is worth examining the impact of food price changes and volatility on food security by using various indicators.

1.3 Objective and research questions

General objective

The general objective of this study is to investigate the causal relationship between food security and local food price inflation and food price volatility in developing countries by using different indicators of food security.

Specific research questions

- Does the impact of food price and food price volatility on food security differ for different indicators of food security?
- Do food prices have the same impact on food security for different regions of the developing world?

1.4 Organization of the thesis

The thesis has six chapters. In the second chapter, theoretical literature connected to food security and food prices, and related empirical work done on food security and food prices are reviewed. In addition, the conceptual framework of the study is presented in this section. The third and the fourth chapters explain data sources and the methodologies used to achieve the stated objectives. Empirical results and their interpretation are addressed in the fifth chapter. The last chapter gives conclusions and implications of the results.

Chapter two: Literature review

2.1 Defining food security (insecurity)

The definition and measures of food security have been changing since it was coined for the first time at the World Food Conference in 1976 (Badolo & Kinda, 2014; Headey, 2013). Initially, it was similar to food supply and it was taken simply as availability of food. But, later on, it was realized that the physical availability of food is a poor proxy for food security, and the definition of food security had to go beyond the physical availability of food and deal with other aspects such as accessibility and vulnerability (Aurino, 2014). The 1996 WFS definition of food security is the well-known definition that acknowledges the multidimensionality of food security. Food security is realized "*when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (WFS, 1996).

This definition of food security is based on four pillars: availability, accessibility, utilization and stability of food (FAO et al., 2013, 2014). The first dimension deals with the physical availability of food, and includes all kinds of food irrespective of their sources. It includes all food supply from domestic production, imports, stocks and food aid. This dimensions basically captures availability of food at regional or national level (Reig, 2012). Various studies by FAO have also been estimated this dimension of food security by ''dietary energy intake'' which represents the minimum amount of dietary energy (calorie) a person should consume daily (Cafiero, 2014). Nevertheless, it assumes food is distributed in the country for all who needs it, and does not address the issue of accessibility of food (Pinstrup-Andersen, 2009).

Access reflects the demand side of food security and represents the way that people can obtain the food available in the economy (Reig, 2012). This pillar ''*comprises indicators of physical access and infrastructure such as railway and road density; economic access, represented by the domestic food price index; and the prevalence of undernourishment*'' (FAO et al., 2014, p. 13). The physical accessibility aspect captures the degree to which available food can be delivered to all people who need it. The economic access evaluates the affordability of the food available. Sociocultural accessibility of food also determines food security of individuals. This may happen when physically available food is not accessible due to some cultural or social barriers like gender (FAO et al., 2014; Gilbert & Tabova 2011).

Improvement in availability and accessibility do not necessarily bring food security unless it is utilized properly. In the WFS definition the utilization dimension is explained as ‘‘*safe and nutritious food to meet...dietary needs*’’(FAO et al., 2013, p. 16). It shows the degree to which people use the available food, and captures factors that influence food utilization such as access to water and sanitation (Aurino, 2014; FAO et al., 2014). It also embraces the respective outcomes of poor utilization of food available such as wasting, stunting and underweight (FAO et al., 2014).

Stability of food is achieved when people get food at all times. It includes countries' vulnerability to shocks (FAO et al., 2013) that potentially affect smooth consumption. This dimension of food security ‘‘*emphasises the permanency and sustainability of the three dimensions over time*’’ (Aurino, 2014, p. 4; FAO et al., 2014).

Food security is ‘‘*experienced at a range of spatial scales from households to regions, as well as a range of time scales*’’ (Wineman, 2014, p. 3). Food security status at individual and household level is usually self-reported. Mostly, household food security measures capture in-depth information in the various dimensions of food security. But, to measure food security at country level usually needs to compromise the inclusion of all types of food security dimensions (Pinstrup-Andersen, 2009). Food security can also be examined based on duration of food security status. If the food security problem is persistent over time we call it chronic, cyclical if it re-emerges due to seasonality, and transitory if it exists only for a short period of time (WFP, 2009).

2.2 Measures of food security

Food security is a multidimensional and complex concept to measure due to its multiple causes (FAO et al., 2014). Given its multifaceted nature, it has been difficult to devise a single indicator to measure it despite the improvement in its theoretical understanding (CFS, 2011) . It is even impossible to measure food security exactly, rather we usually “estimate” it (Cafiero, 2014). Given this, different measures have been proposed to capture food security in the last couple of decades and it is still in progress to design a comprehensive food security measure by capturing its different dimensions properly (FAO et al., 2014). In this section, we review different methods that have been used in the food security literature.

Dietary energy intake

This method (also called FAO method) is mostly used to measure undernourishment and taken as a proxy for food security. It captures the percentage of people who do not meet minimum dietary energy requirements that a person should consume (De Haen et al., 2011). In other words, if the amount of the dietary energy consumed by a person is below some predetermined minimum level, then that person (household) is considered as undernourished (food insecure) (Shahla et al., 2009). When we analyze at country level, it measures the proportion of undernourished people to total population. But, this indicator has been criticized for capturing only part of food consumption and ignores, for example, importance of micronutrients such as iron, zinc and vitamins. In addition, it fails to address the issue of distribution and accessibility of food (Pinstrup-Andersen, 2009), which makes it difficult to inform policy makers to solve the problem of food security (De Haen et al., 2011).

Consumption and expenditure survey based approaches

National household surveys are also used to get information on food expenditure and food consumption to calculate food security (Demeke et al., 2010; Wang, 2010). Calorie intakes calculated from consumed commodities tell whether a household is food secure or not. A household is food secure if the calorie consumption is greater than the recommended daily calorie consumption (Korale-Gedara et al., 2012). Different scales have been developed to measure food security through household surveys. The United States household food security survey module, the household food insecurity access scale, the household hunger scale and the Latin American and Caribbean food security scale are among the scales used in different studies (Ballard et al., 2013).

If a national household survey is representative enough, it has the advantage to get detailed evidence on consumption patterns, which is often better than the macro estimation of undernourishment (De Haen et al., 2011). In addition, in household surveys it is convenient to divide households based on socioeconomic and demographic conditions which helps to get deeper insight into the food security problem. But, it is also difficult to recall all food items consumed and accurately converting them into a caloric equivalence. In addition, there are many countries who still cannot afford and realize representative household surveys and the few national household surveys conducted have been usually for a single round which makes it impossible to capture food security dynamics (De Haen et al., 2001; Pinstrup-Andersen, 2009).

Anthropometric measurements

The most commonly used anthropometric measures are wasting (low weight for height), underweight (low weight for age) and stunting (low height for age) of children under five years in a household (Lee et al., 2013; Shahla et al., 2009). These three measures indicate different aspects of the nutrition problem. "*Wasting is an indicator of acute undernutrition particularly relevant to monitor acute food shortages. Stunting is an indicator of chronic undernutrition, while underweight is a summary indicator combining both facets*'' (De Haen et al., 2011, p. 764). These indicators are usually calculated based on demographic and health surveys and household surveys (Bloss et al., 2004). However, these measurements do not address genetic differences which makes it challenging to make comparisons across time and space (De Haen et al., 2011).

Food gap

The food gap can be used to measure food security at household and country level. At household level, it measures the number of months that a household might face food shortage (Berhane et al., 2011; Headey, 2011). On the other hand, to measure food security at national level, the food gap estimates the amount of food needed to raise consumption in each income quintile to the nutritional requirement (Lee et al., 2013; Shahla et al., 2009).

Subjective (psychological) measures

Subjective measures are also used to capture the perception of people themselves towards their food security status (Greer & Thorbecke, 1986). Based on psychometric scales, this measure provides information on the actual experiences of people associated with food insecurity that cannot be captured by other measurements. Another advantage of this measure is that it can provide indicators at different levels of food insecurity (mild, moderate, severe). But, it may lead to biased results due to its subjective nature (Headey, 2013).

In conclusion, there is no perfect single indicator that can embrace all aspects of food security and devising a better food security measure is still undergoing (FAO et al., 2014). Due to the absence of a "gold standard'' measure of food security, it is generally conventional to include a suite of indicators to assess food security in a more comprehensive manner (Mallick & Rafi, 2010; Wineman, 2014).

2.3 Food price changes

2.3.1 Differentiating inflation and volatility

Food price change can be distinguished as food price trend, food price spike and food price volatility (Von Braun & Tadesse, 2012). A price trend represents the general movement of prices over a given period of time (FAO et al., 2011). A price spike ''*refers to a change in price levels over a shorter period of time, usually between two consecutive observations*'' (Von Braun & Tadesse, 2012. p. 3). It represents the extent of a food price change and it can take either a negative or positive value. It is referred to as inflation when it takes a postive value, and commonly measured using percentage changes. The third type of price change is food price volatility, which stands for variability of price (Gilbert & Tabova, 2011). It represents ''*the dispersion of a price series from the mean*'' (Von Braun & Tadesse, 2012. p. 3). Food price volatility is usually measured using the standard deviation of prices or the coefficient of variation and does not show the direction of the change (FAO et al., 2011; Von Braun & Tadesse, 2012).

Price spike and volatility are related concepts as both are mainly determined by demand and supply interactions. But, food price can be high and it may not necessarily lead to food price volatility (Gilbert & Tabova, 2011). In addition their costs and benefits are different (FAO et al., 2011). High food prices affect consumers, especially the poor, and food price volatility is a challenge for both consumers and producers. Food price inflation (rises) usually motivates producers to produce more, but it hits the poor who are net food buyers and spend a significant portion of their income on food. Food price volatility may have detrimental effect on both producers and consumers since it poses risks and affect production and consumption decision making due to its unpredictable nature (Balcombe, 2011; Von Braun & Tadesse, 2012). So, it is relevant to assess the impacts of both types of price changes on food security of countries.

2.3.2 Causes of food price change

Food price changes originate from demand and supply shocks. High population growth in the developing world, increasing GDP per capita and rising demand especially from India and China, changing consumption preference towards meat and costly crop products, and biofuel policies that bring new demands on farm output are factors that push food price up from the demand side (Mitchell, 2008; Reig, 2012; Von Braun & Tadesse, 2012).

The net impact of these demand factors on food prices has been controversial. Many governments have implemented subsidies, tax reliefs and mandates in their biofuel policies which have resulted in resource diversion from production of food and increased prices (FAO, 2008; Von Braun & Tadesse, 2012). Zilberman et al. (2012) assess the impact of biofuel production on food price and found that the effect differs across food items and regions. Ajanovic (2011) argues that the registered price volatility between 2000-2009 was not mainly attributed to biofuel production, but rather, oil price and speculation were the main drivers. In addition, Headey & Fan (2008) strongly argue that we should not conclude that all these factors, particularly high demand from Asia contribute to the recent surging food price. For example, India and China have been self-sufficient countries for long, and surprisingly, China imported a smaller amount of wheat between 2000-2007 relative to previous eight years.

On the supply side, low investment in the agricultural sector, low productivity, high costs of inputs, especially cost of energy, supply shocks due to weather, changing agricultural policies in the developing world, and low food stocks contribute towards high food price around the globe (FAO et al., 2011; Gardebroek & Hernandez, 2013; Von Braun & Tadesse, 2012). Agricultural productivity remains low in most developing countries, mainly due to small public expenditure on agricultural research activities. Apparently, the price of oil can affect agricultural production directly, e.g. for transport costs, or indirectly through the use of other inputs (fertilizer, for example) (FAO et al., 2011). Between 2001 and 2008, the prices for oil and fertilizers increased more than the prices of agricultural products in the world (FAO et al., 2013) and contributed to the food crises of 2007/2008 (Piesse & Thirtle, 2009). But, Gardebroek & Hernandez (2013) investigated the dynamics of volatility in the US oil, ethanol and corn markets and found no indication of the volatility effect of oil and ethanol prices to corn prices.

The change in policies, especially subsidy reduction has also contributed to the low level of food stock in low income countries (Gilbert & Tabova, 2011; Piesse & Thirtle, 2009) which drove food prices up. Since 1999/2000 world stock-to-use ratio has been declining and created high spikes (Von Braun & Tadesse, 2012). FAO et al. (2011) also found that low stock relative to food demand was among the driving forces of the 2007/2008 and 2010 price spikes. A bivariate regression indicates that 42 percent of the variation in food price change from 2006-2008 was explained by low stock to use ratios (Piesse & Thirtle, 2009).

In addition to demand and supply factors discussed above, financial speculation could also play a role in food price volatility (Balcombe, 2011; Von Braun & Tadesse). Speculation means "*taking large risks or gambling with the hope of making large, quick gains*" (Von Braun & Tadesse, 2012, p. 24). Speculators may physically buy quantities of the commodity and build up stocks, anticipating a future rise in prices to resell the commodity at profit. This speculative behaviour could affect trade volumes and prices in the short-run (Balcombe, 2011; Von Braun & Tadesse, 2012).

Gilbert (2010) argues that index based investments (long-term contracts) in futures markets served as a channel for macroeconomic factors such as high demand from China and devaluation of the dollar that resulted in high food price in 2007-2008. But, Irwin et al. (2009) argue that the usual economic fundamentals such as increasing demand (especially from China and India) and oil price as the factors behind the 2008 price surge, and we cannot confidently tell the impacts of speculation due to the lack of direct empirical works (Irwin & Sanders, 2011). Irwin & Sanders (2011) contend that Gilbert (2010) used a very short period of time to conclude about the effect of speculation on food price change. Chowdhury (2011) discusses the difficulty of dissecting the impact of demand, supply and financial speculation on food price change accurately, and adds that there were large amount of index funds held in 2008 compared to previous periods and this would signal the contribution of speculation to food price rises.

2.4 How do food price changes affect food security? Theoretical explanations

The conflicting impact of price levels on producers and consumers has been a major policy dilemma. A higher food price encourages producers to produce more which increases availability of food. On the other hand, high prices penalize net buyers by decreasing the access to food and eroding their living standards (Gilbert & Tabova, 2011; Headey, 2013). Rising food prices could benefit countries with a significant proportion of agricultural labor only if the rising food price attracts more production and demand more labor (Headey, 2011). But, this process may be accompanied by high inequality which will worsen the distribution of income and food security. Even though the overall impact of increasing food prices may be complex, the consequence is obviously adverse on food buyers and rural poor who are massive in low income countries (Cohen & Garrett, 2010; Gilbert & Tabova, 2011).

The impact of high food prices on the macroeconomic situation of a country can be seen from its consequences on trade. High food prices make the value of food import expensive, which leads to balance of payment deficits. (FAO, 2008; Gilbert & Tabova, 2011) and may worsen food security. At the same time, higher agricultural prices may stimulate production and reduce poverty if producers are competent enough (Headey, 2013). So, the net benefit from higher food prices depends on the position of countries in the international market (Ivanic & Martin, 2008).

Another dimension of the macroeconomic impact of higher food price is the amount of subsidy countries spend on domestic food consumption (FAO et al., 2011). The effect of higher food prices will be severe if countries spend a significant amount of their budget on food subsidies, especially when they continue to compensate for rising food prices. This process would make countries to use their financial resource to curb the effects of higher food price rather than investing in other productive sectors that would safeguard long-term food security.

2.5 Impact of food price on food security (food insecurity): empirical overview

In general, food availability showed improvements throughout the world over the past two decades, whereas stability showed the least progress showing the impacts of political unrest and global food price volatility. The trend in food security varies across the developing world. East Asia and Latin America have improved in all aspects of the food security dimensions over the past two decades. But, Sub-Saharan Africa and South Asia showed only little improvement in the availability dimension, and are lagging behind in the other three dimensions (FAO et al., 2014). From these two regions, the food security problem has been a deep concern in Sub-Saharan Africa. Low food utilization, low progress in access to food and political instability and civil strife remain the challenges of the region in achieving food security (Reig, 2012).

Despite the significant improvement in the availability of food in the world, food price changes put a challenge, particularly in developing countries by making the available food less affordable and less accessible (Reig, 2012). Agricultural prices have been volatile in the past decade (see figure 2.1) especially for wheat, maize and soybeans and have brought food security concerns at the front (Balcombe, 2011).

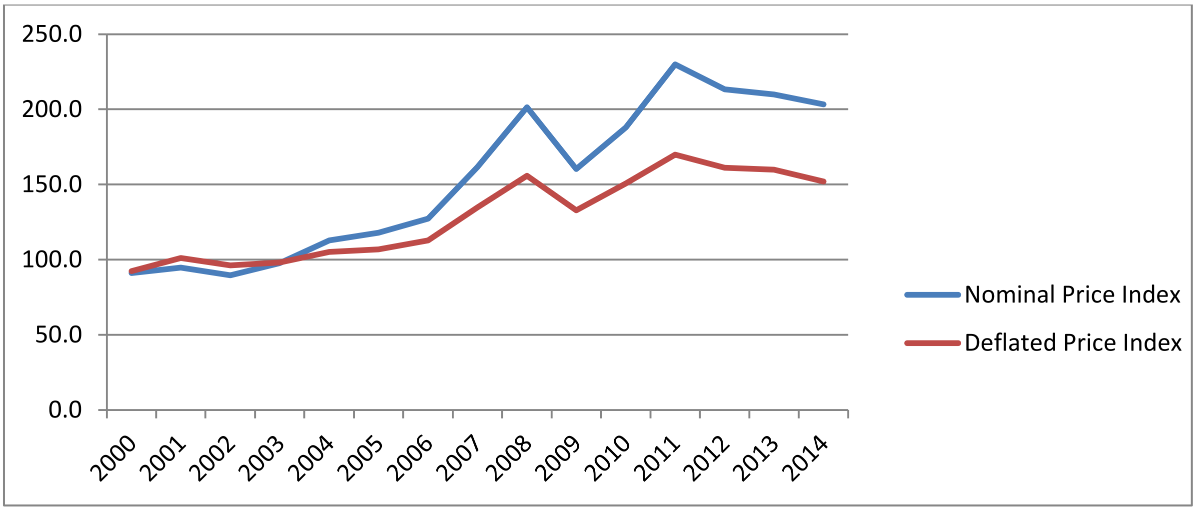

Figure 2.1 Nominal and real food price index (2002-2004=100)
(Source: http://www.fao.org/worldfoodsituation/foodpricesindex/en/)

Different studies researched the impact of rising food prices on food security especially in the last decade at different scales of analysis, viz. household and national. FAO et al. (2011) documents how the effect of 2006–08 price surge can be seen from three group of countries in the world. The first group contains countries who were highly dependent on food imports and responded to the price rise through trade restrictions, safety net programs and stock release. The trade restrictions decreased government revenues, and possible returns for farmers that would be benefited from a higer price. The restrictions even resulted in higher price in international markets and aggravate the problem. The second group of countries benefited from the surging price as they were food sellers even after paying for higher oil and fertilizer costs. Countries in this group, such as Thailand and Vietnam, have equal distribution of land in relative terms which gave their farmers the opportunity to produce and supply more. The third group of countries are mostly from Africa and were totally dependent on food import, and had to rely on external assistances due to insufficient stocks and lower domestic resources to safeguard its people. The burden of the higher food price was higher in this group countries compared to the previous two groups.

Brinkman et al. (2010) use different methods to assess the impact of rising food prices on food consumption, nutrition and health. They apply risk analysis, assessment surveys, simulation and regression analysis. They use food consumption scores to measure diet diversity and find a negative correlation between food price and the diversity measure. Their simulation also shows that the rising food price between 2006-2010 increased the number of people at risk of malnutrition in all the developing world though the rate differs. They also magnify the long term consequences of high food price on countries due to the undernutrition prevailed in young children and pregnant women. FAO et al. (2011) also underlines that the reduction of real income which leads to nutrition cuts may threaten future earning capacity of people in the developing world, and calls for reliable safety net programs for vulnerable groups.

Lee et al. (2013) investigate the impact of food price inflation on population health of a sample of developing countries. They measure population health using infant mortality rate, child mortality rate, and the prevalence of undernourishment. Their results show that a rising food price has adverse impact on these health outcomes, especially in the least developing countries with a lower share of agriculture in gross domestic product. Their health indicators are similar to the "utilization" dimension of food security of the FAO definition we use for this study.

Headey & Fan (2008) argue that most conclusions made on the impacts of the rising food price do not differentiate the macro and micro levels which led to superficial results. In addition Headey (2011) argues that the studies that identify causes of the higher food price are mainly simulations and do not use observed price levels. Applying a proxy for self-assessed food security from the World Gallup dataset, Headey (2013) found that the food security indicator did not change, and even improved in some cases, during price rises when sample countries from all regions of the world are used. But, the author confirmed that increasing prices worsen food security when we consider only low income countries, and points out the importance of incorporating subjective measures to get a full picture of food price and food security relationship.

A significant number of studies have been taken on the impact of food price on food security at household level. Korale-Gedara et al. (2012) investigate the impact of soaring prices on food security by taking Sri Lanka as a case study. They demonstrated that the percentage of undernourished population rises during the food price rise, especially without considering income change. But, the increase in undernourishment is found to be low when the impact of higher income is incorporated in the study. Kumar & Quisumbing (2013) discover the gender effect of the 2008 food price inflation in Ethiopia and how it affected the consumption patterns of households. Using panel data, they find that households experienced wider food gap due to the high food price in 2008/09 and female-headed households were more vulnerable to the food price change compared to their male-headed counterparts. Using access and utilization dimensions of food security, Torres (2013) shows how the increasing price affected food consumption of Mexican households though at different levels. But Wang (2010) finds no evidence of the impact of price on food security using dynamic panel data analysis on 27 provinces of China.

2.6 Conceptual framework

The definitions and dimensions of food security we discussed so far are general in terms of duration, level of analysis and evaluation. Therefore, it is worthwhile to operationalize food security in the context of our study. As we discussed in section 2.1, the 1996 WFS definition of food security is the well-known definition that has acknowledged the multidimensionality of food security. The definition conceptualizes food security in four dimensions: availability, access, utilization and stability. Food security requires that all four dimensions must be simultaneously fulfilled (FAO et al., 2014; Torres, 2013) due to their hierarchical and complementary nature (Aurino, 2014; Wineman, 2014). Given the objectives of this thesis, we measure food security by incorporating selected indicators of availability, accessibility, utilization and stability dimensions to get a comprehensive representation. The indicators for each dimension are selected considering the objective of the study and data availability.

Moreover, we discussed in section 2.3.2 that food price is determined by factors that affect food demand and supply. Natural disaster, conflict, food stocks and the balance of payments are among the factors that lead to sudden shocks in food supply and demand, and to price shocks. On the other hand, agricultural production, research and technology, economic growth, natural resources, climate change, population growth and urbanization affect long term food demand and supply and lead to price change. The food price changes, in turn, affect the food security of countries by making available food less accessible which hinders the proper utilization of food. Figure 2.2 presents the summary of these relationships.

Based on the above discussion and Kalkuhl et al. (2013), we use the following general conceptual model to empirically investigate the impact of price changes on food security:

$$FS_{kt} = f(\Delta FP_t \ or \ FPvol_t, X_t)$$

Where FS_{kt} represents food security index k at time t, ΔP_t and $FPvol_t$ denote food price change and food price volatility respectively at time t, and X_t comprises other explanatory variables.

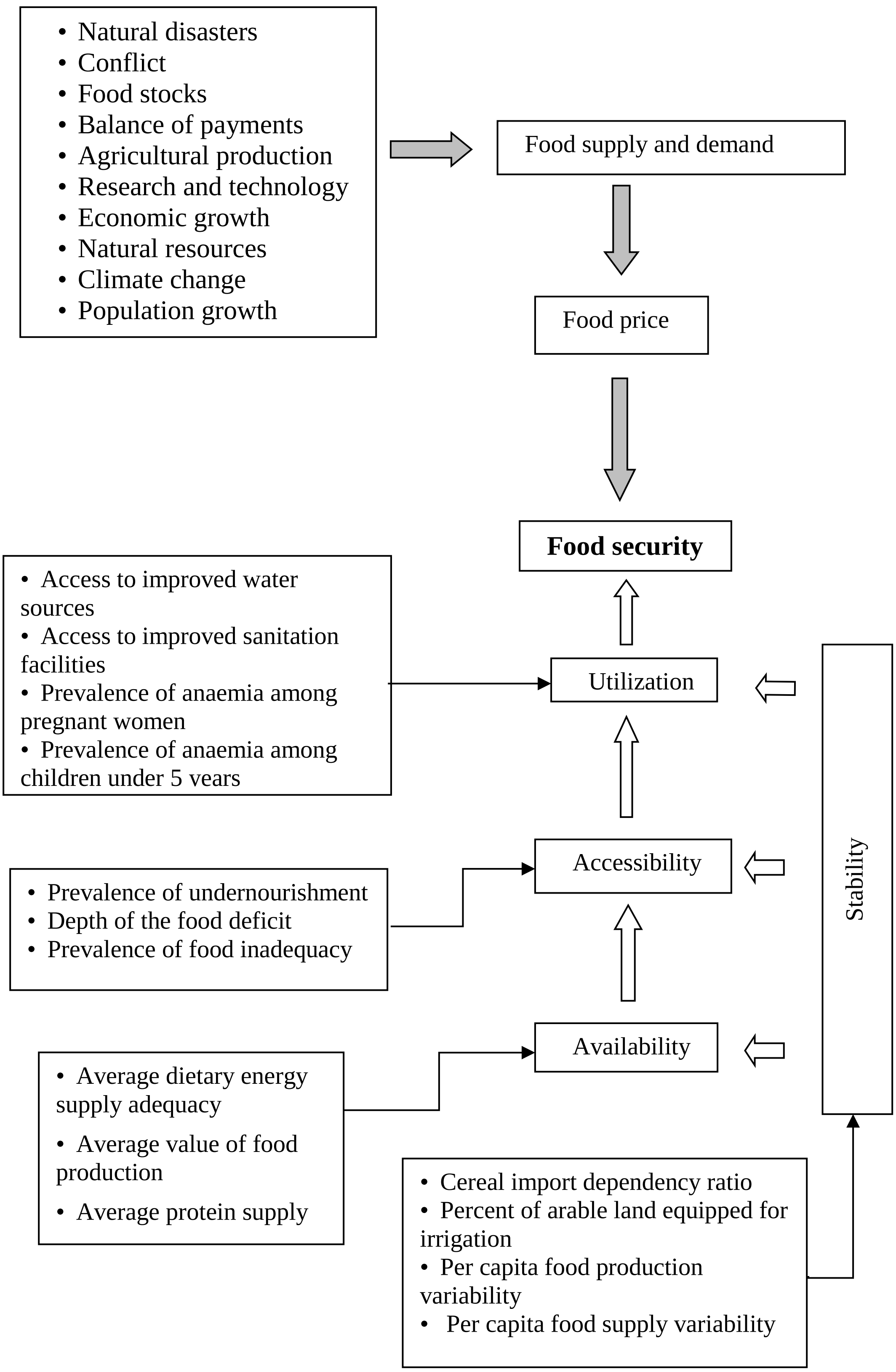

Figure 2.2 The conceptual relationship between food security and food price changes

Chapter three: Building the food (in)security index: principal component analysis

The multidimensional nature of food security makes it difficult to capture it by a single indicator (FAO et al., 2014). To measure food security at country level one usually needs to compromise the inclusion of all types of food security dimensions (CFS, 2011; Pinstrup-Andersen, 2009). We use indicators of availability, utilization, access and stability dimensions based on the well-known definition of food security devised by FAO in 1996 (WFS, 1996), and develop one overall food security indicator and separate indices for each of the dimensions of food security using principal component analysis. In the subsequent sub-sections, we explain the rationale for PCA, the data sources and the variables used to develop the composite food security indicator and the individual indices..

3.1 Why principal component analysis?

A composite indicator helps to capture a multidimensional concept when it is impossible to capture it in one indicator (OECD, 2008). One of the multivariate techniques that helps to reduce multi-dimensional data to a composite index is principal component analysis (PCA). PCA is a type of factor analysis that takes linear combinations of a correlated set of indicators, and reduces them into factors (components) by extracting the largest variance of the original variables (Field, 2009, p. 660). In other words, the main purpose of PCA is to reduce a large set of data and create a smaller set of variables (called factors or components) that can preserve the information in the original large set of variables (Reig, 2012). The specific effects of variables on the components are called loadings and they capture the correlation between variables and components (Field, 2009, p.631).

PCA is appropriate when there are sufficient number of cases compared to variables. Even though it is problematic to define the sufficiency of cases accurately, as a rule of thumb PCA needs a minimum ratio of cases to variables to be 5. In addition, since the first rationale of PCA is to reduce many correlated factors to fewer components, it requires a fair amount of correlation between the variables. In general, PCA requires a minimum correlation size of 0.3 between variables (Field, 2009, p. 657).

The number of factors to be extracted depends on standard criteria and the objective of the extraction. The well-known standard criteria are to retain all factors whose eigenvalues (squared factor loadings that load on a factor taken together) exceed one, and the inflexion point of a scree plot (graph of each eigenvalue against the respective factors) (Field, 2009, p. 639). Theoretically, the first factor in PCA captures the maximum variation between the factors and the subsequent components capture new but lower variation (Field, 2009, p. 660).

Generally, we can represent the factor model mathematically as follows:

$$Y_i = b_1X_{1i} + b_2X_{2i} + \cdots + b_nX_{ni}$$

Where Y_i represent factors or a linear combination of variables (in our case it is either overall food security indicator or an index for one of the four main dimensions of food security), X_{ni} represent variables (indicators) from *1* to *n* for factor *i*, and *b* denote factor loadings.

3.2 Indicators of food security included in the PCA

As we discussed in chapter two, there are four dimensions of food security. Different indicators have been proposed to capture these dimensions. We selected 14 indicators of food security from FAO (2014) based on the aim of the study and the availability of data. Most of the indicators are available only as three years averages. Due to this, we also use three years average for other variables to make it consistent. We considered the data from 2001 to 2012 for 105 countries given our objective to assess the impact of food price on food security from 2000. That means, we have a panel of four rounds on three years average: 2001-2003, 2004-2006, 2007-2009 and 2010-2012.

We included three indicators for the availability and utilization dimension, and four indicators for the stability and accessibility dimensions on three years average. Table 3.1 presents the descriptive statistics of the variables for the total 105 countries considered. For ‘protein_sup’, ‘anaemia_preg’, ‘import_dep’ and ‘fsupply_var’ we took only the average of 2010 and 2011 due to missing values for 2012.

Table 3.1 Descriptive statistics of food security indicators

	N	Minimum	Maximum	Mean	Std. Deviation
dietary_sup	420	84.00	155.00	113.09	13.59
food_value	420	29.00	985.00	219.76	133.65
protein_sup	420	34.00	105.00	67.15	14.76
undernoursh	420	5.00	58.10	18.53	12.56
food_deficit	420	2.00	592.00	131.66	104.66
food_inadeq	420	5.00	64.40	25.79	14.72
import_dep	400	0.00	303.70	42.85	35.80
irrigation	396	0.10	100.00	27.66	30.62
fprod_var	420	0.70	73.30	9.73	8.74
fsupply_var	416	3.50	150.30	33.50	21.99
water_access	420	0.00	100.00	78.87	16.66
san_access	416	6.90	100.00	55.82	29.04
anaemia_preg	416	19.70	68.80	39.38	11.88
anaemia_5yrs	416	17.90	88.90	47.61	17.81

In the next section, we explain these variables as defined and measured in FAO (2014).

i) Availability

This dimension captures the physical availability of food, and includes all kinds of food irrespective of their sources. It includes all food supply from domestic production, imports, stocks and food aid (Reig, 2012). The three indicators included to capture this dimension also reflect supply of food in terms of calories, per capita value and protein supply.

Average dietary supply adequacy (dietary_supply)

This indicator measures the dietary energy supply (in terms of calories) as a percentage of the average dietary energy requirement of each country (since the average dietary energy requirement of countries depends on the social and demographic structure of their population. In other words, it expresses the average supply of calories for consumption to the proportion of average dietary energy requirement estimation.

Per capita value of food production (food_value)

This indicator is calculated by dividing the total value of annual food production by the total population of each country.

Average protein supply (protein_supply)

Expressed in grams per capita, this indicator tells us the amount of national average protein supply.

ii) Accessibility

Accessibility deals with the social, physical and economic access of people to the available food. It represents the demand side of food security, and includes the physical and the economic endowment of people to access the food available in the economy (Reig, 2012). We used three indicators to capture this dimension of food security. The indicators reflect the outcomes of poor food accessibility.

Prevalence of undernourishment (undernourish)

This indicator is calculated based on the probability that a random chosen person from a given population consumes insufficient calories to attain his/her energy requirement for a healthy life. According to FAO (2014) this measure is not based on the real counting of undernourished people in a country, but based on the probability of a person being undernourished. It is expressed in terms of the proportion (using this probability) of undernourished people from the total population.

Depth of the food deficit (food_deficit)

The depth of the food deficit estimates the amount of calories that would be required to raise the undernourished to the nutritional requirement. First, the average intensity of food deprivation (the difference between the average energy requirement and average dietary energy consumption of undernourished) is calculated for all undernourished people. Then, the total food deficit in the country is divided by the total population to get it in terms of kilocalorie per capita per day.

Prevalence of food inadequacy (food_inadequacy)

This access indicator measures the proportion of the total population that is at risk of not attaining the minimum energy requirement for healthy life. It captures not only those who are considered as chronically undernourished but also at the risk of undernourishment.

iii) Utilization

The third dimension is food utilization, and captures the right use of available food in terms of nutritional value, hygiene, and food safety (FAO et al., 2014; Reig, 2012). We included four indicators which show both the process and outcome of food security. The access to better water and sanitation services directly support the proper utilization of food. The other two indicators reflect the outcome of shortage of micro-nutrients.

Access to clean water (water_access)

This indicator captures the proportion of the total population who get reasonable access to clean water.

Accessed to improved sanitation facilities (san_access)

Access to improved sanitation facilities indicates the proportion of the population with at least adequate access to basic human waste disposal facilities.

Prevalence of anaemia among pregnant women (anaemia_preg)

This indicator captures the prevalence of anaemia during pregnancy periods. It captures the proportion of pregnant women whose hemoglobin level is less than the minimum requirement (110 grams per liter at sea level). Iron deficiency is mostly considered as the basic cause of anaemia.

Prevalence of anaemia among children under 5 years of age (anaemia_5yrs)

This indicator measures the percentage of children under 5 years of age who are anaemic or whose hemoglobin level is less than the minimum requirement.

iv) Stability

Stability of food is achieved when people get food at all times. It includes countries' vulnerability to shocks that potentially affect food consumption smoothing (FAO et al., 2013). It stresses the sustainability of the other three dimensions of food security (availability, accessibility and utilization).

Per capita food production variability (fprod_var)

This indicator of stability characterizes the variability of the value of net food production in 2004-2006 US dollar. The variability corresponds to the standard deviation of the deviation from a trend over a 5 years period.

Cereal import dependency ratio (import_dep)

This variable captures the dependency of countries on cereal import compared to domestic consumption. It is calculated as the ratio of cereal import to total cereal production plus cereal import minus cereal export.

Per capita food supply variability (supply_var)

This variable corresponds to the standard deviation of per capita food supply in Kilo calorie per person over 5 years of the deviation from the trend.

Percentage of arable land equipped for irrigation (irrigation)

This is calculated as the ratio of land equipped for irrigation to total arable land. Irrigation schemes help to smooth food production all year round and improve productivity and income which directly contribute to food security.

3.3 Appropriateness of PCA

The overall PCA is performed on the pooled data (using software SPSS version 20) which covers four rounds of three-year averages from 2001-2012. The pooling helps to devise a food security index that can be compared over time (Cavatassi et al., 2004).

The first requirement to conduct PCA is an adequate sample size and correlation between the variables. As stated in section 3.1, PCA requires a minimum ratio of cases to variables to be 5. In our case this ratio is almost 26.5 (371 total cases considered by the PCA divided by 14 variables) which is much higher than the minimum requirement. Next, we inspect the correlation between the variables if they are correlated enough to perform PCA. Initially, we included 14 variables and checked the correlation structure of the variables. Table 3.2 presents the correlation matrix of the variables. A closer look at the correlation matrix shows that the variables import dependency ratio, percentage of arable land equipped for irrigation, per capita food production variability, per capita food supply variability and anaemia among pregnant women have many cells (more than 40%) with correlation sizes less than the required minimum size of 0.3 to run PCA (highlighted in grey in table 3.2). The first four variables are all indicators for the stability dimension of food security. Therefore, we excluded this dimension from the final PCA for the overall composite indicator, and we proceed by including the indicators of the other three dimensions (availability, accessibility and utilization) of food security that show sufficient correlation as displayed in table 3.3.

Furthermore, the relationship between the variables is checked using Bartlett's test of sphericity which tests the null hypothesis that the correlation matrix is an identity matrix (absence of correlation). The P-value of the test is 0.000 which tells us to reject the null hypothesis confirming the appropriateness of PCA.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy also tests if the partial correlations among the variables are large enough to undertake PCA. The statistic is between 0 and 1. In general, values greater than 0.5 are acceptable, values between 0.7 and 0.8 are good and values between 0.8 and 0.9 are considered superb. The KMO statistic in our case is 0.823 which reflects adequacy of the overall sample for PCA.

To evaluate the sample adequacy of each individual variable, we should inspect the diagonal cells of the correlation part of the anti-image matrix (KMO for individual variables). The anti-image correlation matrix encloses the negatives of the partial correlation coefficients. As table 3.4 shows all the variables have greater correlations than the required threshold of 0.5.

Table 3.2 Correlation Matrix of all variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
dietary_sup (1)	1.000													
food_value (2)	0.424 (0.000)	1.000												
protein_sup (3)	0.786 (0.000)	0.479 (0.000)	1.000											
Undernoursh (4)	-0.829 (0.000)	-0.476 (0.000)	-0.711 (0.000)	1.000										
food_deficit (5)	-0.809 (0.000)	-0.467 (0.000)	-0.683 (0.000)	0.986 (0.000)	1.000									
food_inadeq (6)	-0.870 (0.000)	-0.489 (0.000)	-0.733 (0.000)	0.987 (0.001)	0.968 (0.000)	1.000								
import_dep (7)	0.080 (0.060)	-0.153 (0.001)	0.107 (0.019)	-0.157 (0.001)	-0.132 (0.005)	-0.144 (0.003)	1.000							
Irrigation (8)	0.105 (0.021)	0.047 (0.181)	0.179 (0.000)	-0.157 (0.000)	-0.133 (0.005)	-0.124 (0.008)	0.040 (0.220)	1.000						
fprod_var (9)	0.283 (0.000)	0.585 (0.000)	0.403 (0.000)	-0.318 (0.000)	-0.312 (0.000)	-0.339 (0.000)	-0.005 (0.460)	-0.083 (0.054)	1.000					
fsupply_var (10)	-0.023 (0.329)	0.033 (0.264)	0.070 (0.087)	-0.025 (0.312)	-0.028 (0.294)	-0.027 (0.300)	0.104 (0.022)	0.094 (0.035)	0.163 (0.001)	1.000				
water_access (11)	0.517 (0.000)	0.428 (0.000)	0.553 (0.000)	-0.581 (0.000)	-0.531 (0.000)	-0.555 (0.000)	0.268 (0.000)	0.339 (0.000)	0.280 (0.000)	0.055 (0.142)	1.000			
san_access (12)	0.442 (0.000)	0.479 (0.000)	0.585 (0.000)	-0.514 (0.000)	-0.474 (0.000)	-0.500 (0.000)	0.230 (0.000)	0.519 (0.000)	0.338 (0.000)	0.146 (0.002)	0.745 (0.000)	1.000		
anaemia_preg (13)	-0.190 (0.000)	-0.348 (0.000)	-0.428 (0.000)	0.197 (0.000)	0.174 (0.000)	0.188 (0.000)	-0.160 (0.001)	-0.383 (0.000)	-0.255 (0.000)	-0.057 (0.134)	-0.512 (0.000)	-0.728 (0.000)	1.000	
anaemia_5yrs (14)	-0.267 (0.000)	-0.431 (0.000)	-0.469 (0.000)	0.308 (0.000)	0.281 (0.000)	0.295 (0.000)	-0.153 (0.002)	-0.391 (0.000)	-0.309 (0.000)	-0.117 (0.012)	-0.580 (0.000)	-0.774 (0.000)	0.860 (0.000)	1.000

Table 3.3 Correlation Matrix of variables included in the final PCA*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
dietary_sup (1)	1.000								
food_value (2)	0.423	1.000							
protein_sup (3)	0.755	0.446	1.000						
Undernoursh (4)	-0.832	-0.469	-0.697	1.000					
food_deficit (5)	-0.813	-0.460	-0.670	0.986	1.000				
food_inadeq (6)	-0.874	-0.482	-0.715	0.987	0.969	1.000			
water_access (7)	0.495	0.397	0.542	-0.574	-0.528	-0.544	1.000		
san_access (8)	0.422	0.456	0.610	-0.505	-0.466	-0.489	0.730	1.000	
anaemia_5yrs (9)	-0.288	-0.426	-0.481	0.338	0.310	0.324	-0.572	-0.764	1.000
*All correlations have a P-value of 0.000									

Table 3.4 Anti-image correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
dietary_sup (1)	0.832[a]	0.067	-0.409	-0.333	0.095	0.569	-0.204	0.157	-0.014
food_value (2)	0.067	0.939[a]	-0.041	-0.146	0.094	0.181	-0.045	-0.062	0.169
protein_sup (3)	-0.409	-0.041	0.923[a]	0.056	-0.049	-0.026	0.073	-0.266	0.097
Undernoursh (4)	-0.333	-0.146	0.056	0.734[a]	-0.764	-0.787	0.355	0.024	0.007
food_deficit (5)	0.095	0.094	-0.049	-0.764	0.841[a]	0.241	-0.241	-0.054	-0.021
food_inadeq (6)	0.569	0.181	-0.026	-0.787	0.241	0.785[a]	-0.275	0.042	0.038
water_access (7)	-0.204	-0.045	0.073	0.355	-0.241	-0.275	0.834[a]	-0.418	0.064
san_access (8)	0.157	-0.062	-0.266	0.024	-0.054	0.042	-0.418	0.817[a]	0.549
anaemia_5yrs (9)	-0.014	0.169	0.097	0.007	-0.021	0.038	0.064	0.549	0.833[a]
a. Measures of Sampling Adequacy (MSA)									

3.4 Factor extraction of the overall food security index

Once we checked the appropriateness of PCA, the next procedure is to extract the factors. We use the correlation matrix in PCA as it takes a standardized form of the matrix when we have variables measured using different scales (Field, 2009, p. 652). The first step in the factor extraction is to inspect the size of communalities which represent the sum of the squared values of factor loadings of a variable taken together. Communalities show the proportion of the variance in the original variables that is taken by the factor solution. PCA requires that the size of communalities should be over 0.5. In other words, the factor solution should capture at least half of each of the original variable's variance. We included 9 variables in the factor extraction and table 3.5 presents the communalities of these variables. All the variables except 'food_value' satisfy the requirement of 0.5. So, we eliminated this variable from the final factor extraction.

We checked both Kaiser's criterion and scree plot to check how many factors normally we should retain. Both methods showed that we should retain 2 factors. But, since our objective is to reduce the multiple dimensions of food security to a single index, we take the first component from the factor extraction.

Table 3.5 Communalities of variables included for the overall index

Variables	Initial	Extraction
dietary_sup	1.000	0.840
food_value	1.000	0.411
protein_sup	1.000	0.696
undernoursh	1.000	0.955
food_deficit	1.000	0.933
food_inadeq	1.000	0.972
water_access	1.000	0.683
san_access	1.000	0.864
anaemia_5yrs	1.000	0.823

In our factor model, the first component explains 67.5% of the total variance in the variables (see table 3.6). This proportion is much higher than Demeke et al. (2011) who got 32.5% in studying the impact of climate change on food security in Ethiopia, Reig (2012) studying food security in African and Arabic countries and got 56.2%, and Cavatassi et al. (2004) extracted 63.0% in their investigation of poverty in Costa Rica.

Table 3.6 Total variance explained (overall composite indicator)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.403	67.541	67.541	5.403	67.541	67.541
2	1.421	17.766	85.307	1.421	17.766	85.307
3	.442	5.529	90.836			
4	.349	4.366	95.202			
5	.205	2.559	97.762			
6	.151	1.883	99.645			
7	.023	.291	99.936			
8	.005	.064	100.000			

Our main interest in the PCA is to get weights of the variables on the first component to use them in the food security index construction. The component matrix shows the direction and weight of each variable on the component. The loadings of each variable show the correlations between the variable and each of the factors. In our case, the association between the variables and the first component shows a meaningful pattern. As the second column of table 3.7 shows ‘dietary_sup’, ‘protein_sup’, ‘water_access’ and ‘san_access’ load negatively to the first component, whereas ‘undernoursh’, ‘food_deficit’, ‘food_inadeq’ and ‘anaemia_5yrs’ are related positively. From these relationships, we can infer that the first component reflects ‘food insecurity’ status of the countries. Therefore, we use this component as our composite food insecurity index.

Table 3.7 Loadings on the first component of the overall composite index

Variables	***Loadings***
dietary_sup	-0.862
protein_sup	-0.838
undernoursh	0.931
food_deficit	0.906
food_inadeq	0.930
water_access	-0.740
san_access	-0.727
anaemia_5yrs	0.574

3.5 Factor extraction of individual components of food security

In this section we present the factor model solution for the three dimensions (availability, accessibility and utilization) of food security. The 'stability' dimension did not satisfy the correlation size requirement and we excluded it from the analysis.

Table 3.8 Correlation between the indicators of food security dimensions*****

Food availability				
	dietary_sup	food_value	protein_sup	
dietary_sup	1.000			
food_value	0.425	1.000		
protein_sup	0.755	0.448	1.000	
Food accessibility				
	undernoursh	food_deficit	food_inadeq	
undernoursh	1.000			
food_deficit	0.984	1.000		
Food_inadeq	0.987	0.967	1.000	
Food utilization				
	water_access	san_access	anaemia_preg	anaemia_5yrs
water_access	1.000			
san_access	0.730	1.000		
anaemia_preg	-0.489	-0.706	1.000	
anaemia_5yrs	-0.572	-0.764	0.855	1.000

*All the correlations are significant at 0.01.

We included the indicators of the three dimensions of food security and checked the correlation between the variables. As table 3.8 shows, all the correlations are sufficient (over 0.3) for PCA.

The KMO test also confirms that the partial correlation among the variables is enough to run PCA. Moreover, the Bartlett's test confirms that the correlation matrices are different from the identity matrix (see table 3.9).

Table 3.9 KMO and Bartlett's test for the three food security dimensions

		Availability	Accessibility	Utilization
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.632	0.706	0.755
Bartlett's Test of Sphericity	Approx. Chi-Square	451.1	2996.6	1220.9
	df	3	3	6
	Sig.	0.000	0.000	0.000

All the variables considered for the individual dimensions of food security satisfy the communality size requirement for 0.5 to run PCA (see table 3.10).

Table 3.10 Communalities of variables included for each food security dimension

Avalability		
	Initial	Extraction
dietary_sup	1.000	0.791
food_value	1.000	0.503
protein_sup	1.000	0.807
Accessibiliy		
Undernoursh	1.000	0.995
food_deficit	1.000	0.981
food_inadeq	1.000	0.983
Utilization		
water_access	1.000	0.616
san_access	1.000	0.839
anaemia_preg	1.000	0.770
anaemia_5yrs	1.000	0.843

Once we checked the size of the communalities, we extracted components for each of the dimensions of food security. We also considered the first component of the factor solution for the same reason explained in section 3.4. Table 3.11 shows the amount of the variance captured by the first component of the three factor models.

Table 3.11 Variance explained by the first components of the food security dimensions

Dimension	% of Variance
Availability	70.03
Accessibility	98.63
Utilization	76.74

We use the loadings of the first components as weights to develop the individual dimension indices. As we may see from table 3.12, all the indicators of the availability dimension (dietary_sup, food_value and protein_sup) load positively on the first component. This positive relationship shows that improvement in these indicators also improves the availability dimension of food security. So, we refer to it as 'availability index'.

The indicators of accessibility (undernoursh, food_deficit and food_inadeq) also load positively on the first component. But, we know that increase in these variables reflects poor accessibility of food. Based on this we label this index as 'food inaccessibility'.

We expect that water_access and san_access improves the proper utilization of the available food, where as anaemia_preg and anaemia_5yrs are outcomes of poor utilization of food. When we look at the loadings of these variables on the first component, water_access and san_access are related negatively, whereas anaemia_preg and anaemia_5yrs load positively. Based on this, we refer this component 'under_utilization' because water_access and san_access improves it, and anaemia_preg and anaemia_5yrs are outcomes of poor food utilization.

Table 3.12 Loadings on the first component of the three food security dimensions

Availability	***Loadings***
dietary_sup	0.889
food_value	0.709
protein_sup	0.898
Access	
undernoursh	0.997
food_deficit	0.991
food_inadeq	0.991
Utilization	
water_access	-0.785
san_access	-0.916
anaemia_preg	0.878
anaemia_5yrs	0.918

In a nutshell, we have extracted four different indices using four different PCAs. The first is the overall food insecurity index; the second is food availability index; we refer to the third as the food inaccessibility index following the signs of the loadings, and the final is the component that represents the food utilization dimension of food security and we refer to it as under-utilization index due to the signs of the loadings in the PCA. In the next section, we present the procedure we use to develop the food security indices by applying the loadings we get in the previous PCAs.

3.6 Developing the food (in)security indices

After getting the factor loadings from the factor extraction, our final target is to develop the food security score of countries by applying the loadings to the values of the variables for the four rounds (averages of 3 years) of the panel data. To do so, we multiply the loadings of the variables by the standardized scores of the variables of the countries and sum them up (Cavatassi et al., 2004; Demeke et al., 2011).

Mathematically,

$$\mathrm{FS}_{ik} = \sum_{1}^{n} w_j \left[\left(V_{ji} - V_i\right)/(S_i)\right]$$

Where FS_{ik} is the normalized food (in)security index *k* (the overall index or index of each of the components) of country *i*, w_j represents the weight (loading) of variable *j*, V_{ji} is the value of variable *j* for country *i*, V_j and S_j denote the mean and the standard deviation of variable *j* respectively.

Chapter four: Model specification and estimation strategy

In this chapter, we present the general framework, variables, data sources and specific estimation technique used to investigate the relationship between local food price changes (food price inflation and food price volatility) and food security.

4.1 Data source and description of variables

We use panel data of three-year averages of 105 developing countries over 2001-2012. The time period is picked due to the high food price volatility in many low income countries during this period, and also because of data availability. We also take the three-year averages to make the data consistent as the food security data is available only on three-year averages (see section 3.1). Therefore, in total, our panel has four rounds: 2001-2003, 2004-2006, 2007-2009 and 2010-2012.

We use the following general conceptual model to empirically investigate the impact of price changes on food security (see also section 2.6). It specifies food security as a function of food price inflation or food price volatility and other covariates that can potentially affect food security.

$$FS_{kt} = f(\Delta P_t \; or \; Pvol_t, X_t)$$

Where FS_{kt} represents food (in)security index k at time t, ΔP_t and $Pvol_t$ denote price change and price volatility respectively at time t, and X_t comprises other explanatory variables.

Dependent variable

Our dependent variables are the indices we developed in the third chapter using PCA. The indices are standardized values with mean of zero and standard deviation of one. The first is the composite food insecurity indicator that we computed using eight indicators of the three dimensions of food security (availability, accessibility and utilization). In addition, we consider the individual indices devised from the three components separately, i.e availability index, inaccessibility index and and under_utilization index (see table 4.1).

Table 4.1 Descriptive statistics of standardized food security indices

	N	Minimum	Maximum
food insecurity index	412	-10.50	14.63
availability index	420	-4.09	7.23
inaccessibility index	420	-3.70	10.1
under_utilization	412	-4.48	6.71

Explanatory variables

i) Food price inflation and food price volatility

We are interested in the effect of food price inflation and food price volatility on food security. We estimated both the impact of food price inflation and food price volatility since these have different impacts on food production and consumption decisions (Von Braun & Tadesse, 2012). We take price changes between three years averages to match it with the food security data, and we use FAO (2014) for observed domestic food price data which is calculated using 2005 as base year. We also used the food price volatility data from FAO (2014) which is calculated as the average of the standard deviation of growth rates of monthly price indices to develop an annual volatility indicator. To minimize missing data bias, we use regional averages (using World Bank classification of countries based on income levels) of the food price changes. We expect that these variables increase food insecurity, decrease food availability, increase inaccessibility and result in lower food utilization.

ii) Gross domestic product (GDP) per capita

GDP per capita is included to control for the impact of economic growth on food security. The contribution of growth towards food security of countries is not clear. It might improve the availability of food, but its impact on the other dimensions of food security depends on the growth redistribution (FAO et al., 2013). This variable is calculated as the ratio of GDP (2005 US$) to mid-year population number of the countries. We accessed this data from the World Bank database (World Bank, 2015).

iii) Stability and absence of violence

Food security can be achieved if the institutional setting of countries ensures security and stability. Instability and violence can trigger a problem to food security by disturbing the production, consumption and commercialization of food (Jeanty & Hitzhusen, 2006). It can also decrease the incentive to invest in long term private and public sectors due to the risk and uncertainty that the violence may pose. Moreover, unrest can shift the time and energy of productive labor from agriculture to the resettlement and reconstruction of victims and damages (Bora et al., 2010). To capture this aspect, we included an ‘stability and absence of violence’ index, which measures the perceptions of the probability that a government will be overthrown by violent process. The index ranges from -2.5 (weak stability) to 2.5 (very stable) (World Bank, 2014). We expect that the more stabble, the lower the overall food insecurity, the higher the availability, accessibility and utilization of food.

iv) Population growth

The demand for food increases as the number of people increases. Increasing population puts pressure on available but limited resources like land, water, and energy, especially in regions where land distribution is already unequal (Godfray et al., 2010). This has been one of the major challenges in achieving food security, especially in Sub-Saharan Africa (FAO et al., 2011). To take this effect into account, we use the annual population growth rate (World Bank, 2015). We hypothesize that higher population growth will result in low food security.

Table 4.2 Summary statistics of explanatory variables

variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita	407	2007.65	1922.71	138.42	8308.22
population growth	420	1.77	0.94	-0.68	4.38
stability	414	-0.48	0.87	-2.91	1.4
food price volatility	414	10.01	7.26	0.53	82.03
food price inflation	410	1.87	6.87	-100	31.07

4.2 Estimation strategy

Panel data has the advantage over cross-section data that it gives more efficient estimates by incorporating many observations. Estimation proceeds by using specific panel estimation techniques that allow for unobserved heterogeneity.

The general equation of our model is specified as follows:

$$FS_{k,i,t} = \alpha_i + \beta_1 FP_{i,t} + X'_{i,t}\beta + \varepsilon_{i,t}$$

Where $FS_{k,i,t}$ is food security indicator k of country i in time t, α_i is the country specific intercept if the model is estimated by fixed effects model and it is part of the error term if it is estimated by random effects, $FP_{i,t}$ is annual food price inflation or food price volatility, $X'_{i,t}$ is a vector of control variables that affect food security and $\varepsilon_{i,t}$ is the error term.

The common estimation technique for static panel data estimation is either the random effect (RE) or fixed effect (FE). Which methods is best used depends on the outcome of the Hausman specification test. FE allows for time-invariant correlation between countries' error term and predictor variables, and we need to control time invariant unobservables that can bias or impact dependent or predictor variables. The FE estimator cancels out such time-invariant characteristics to capture the effect of the predictor on the dependent variable (Verbeek, 2012, p.384). FE helps to address the problem of unobservable heterogeneity or cross-country effects, and handles possible endogeneity of variables in the model that may arise from time-invariant omitted variable bias (Verbeek, 2012; Wooldridge, 2002). On the other hand, the RE model assumes sample entities as a random draw from a given population.

Chapter five: Result and discussion

In this chapter, we present and discuss the results of the econometric analysis. Our model uses the overall food insecurity index, and the three sub-indices of availability, accessibility and utilization dimensions of food security as dependent variables. GDP per capita, population growth, stability, food price inflation and food price volatility are used as explanatory variables. Initially, we tried to include other covariates, like inequality measures and public expenditure in agriculture sector, but we decided to exclude them due to many missing values.

To decide between the fixed effects and random effects models, we run the Hausman specification test which tests the null hypothesis of exogeneity of the unobserved error component (unobserved characteristics are not correlated with explanatory variables), and assumes the random effects model is more efficient. The test rejected the null hypothesis (p-value = 0.000) in all our specifications. Hence, we conclude that the random effects model is inconsistent, and the FE model is preferred (Verbeek, 2012, p. 386). Based on that, we use the fixed effects or within estimator to estimate the impact of food price inflation and food price volatility on food security indices using separate regressions.

We also checked heteroskedasticity using a modified Wald test for group-wise heteroskedasticity where the null hypothesis is homoskedasticity (constant variance) of error terms, and find a p-value of 0.000. Therefore, we reject the null hypothesis and use heteroskedasticity robust standard errors to get correct standard errors.

Given that our dependent variables are normalized indices derived from the specific data we used, it might not be appropriate to interpret the size of coefficients from the results of the estimations (Demeke et al., 2011; Wineman, 2014). So, it is proper to interpret the sign and the significance of the coefficients than their absolute magnitudes. We aslo perform one sided t-test for stability, food price inflation and food price volatility in all the specifications following our expectations mentioned in section 4.1.

Table 5.1 presents the impact of food price inflation on the different food security indices as shown by regressions (1) - (4). Column (1) shows that the food price inflation does not show a statistically significant impact on the overall food insecurity and the under-utilization index, but it has a statistically significant effect on the availability and the inaccessibility as we anticipated. Keeping all other things constant, an increment in food price inflation decreases the food availability index and increases the inaccessibility index (see columns (2) and (3) in table 5.1).

Even though, it is difficult to derive an absolute meaning from the magnitudes of the coefficients, we can tell from the results that food price inflation has a negative impact on the availability index, and it makes food less accessible. These results are as we expected. One explanation for this is that a higher price might make food imports expensive and decrease food availability (Gilbert & Tobova, 2011). In addition, with constant income, a higher food price decreases the accessibility of food by decreasing purchasing power of consumers, and this may lead them to cut down both food quantity and quality. But, higher food price could also encourage producers to supply more. To capture the direction of the effect more accurately, it would be better to control for countries' engagement in international trade, which we could not do due to data scarcity.

Table 5.1 Impact of food price inflation on food security indices

	Dependent variables			
	Food insecurity index (FISI) (1)	Availability index (2)	Inaccessibility index (3)	Under- utilization index (4)
Food price inflation rate	0.013	-0.005*	0.01*	0.001
	(0.013)	(0.004)	(0.008)	(0.004)
Log of GDP per capita	-6.12***	2.231***	-3.24***	-2.217***
	(0.556)	(0.217)	(0.407)	(0.261)
Stability	-0.035	0.020	-0.18*	0.052
	(0.293)	(0.111)	(0.202)	(0.115)
Population growth	0.246	0.040	0.115	0.059
	(0.269)	(0.141)	(0.180)	(0.088)
Constant	43.072***	-15.980***	22.734***	15.758***
	(3.932)	(1.563)	(2.861)	(1.898)
within R^2	0.51	0.45	0.39	0.39
F-statistic	31.13***	26.28 ***	16.07 ***	19.85***

***, ** and * denote significance at 1%, 5%, and 10%, respectively.

GDP per capita has a statistically significant effect on all the four food security indices. All things equal, when GDP per capita increases, food insecurity decreases, food availability increases, as well as food accessibility and food utilization improve. This tells us that economic growth contributes to the overall indicator and to the three different components of food security. This supports the claim that economic growth has the potential to boost food production and make food more available. But, there is a strong argument that questions the power of economic growth towards improving other dimensions of food security apart from the availability side if it is not supported by effective growth redistribution policies (FAO et al., 2013). Our thesis does not control for economic inequality of countries due to data shortage. Further investigation might shed light on the impact of economic growth by controlling for economic inequality.

Stability, which is included to capture the impact of democracy and violence, has a statistically significant effect only on the inaccessibility index. The result indicates that a higher score in the stability score decreases the food inaccessibility index, holding all other variables constant. This is as we anticipated and in line with Jeanty & Hitzhusen (2006) who find a devastating impact of instability on food security, though measured as per capita calorie supply. But the impact of stability on the other three indices is not statistically significant which needs additional investigation. Surprisingly, population growth does not seem to affect all the four food security indices which also needs further investigation.

Table 5.2 Impact of food price volatility on food security indices

	Dependent variables			
	food insecurity index (FISI)	Availability index	Inaccessibility index	Under-utilization index
Food price volatility	0.015**	-0.006**	0.009*	0.002
	(0.008)	(0.003)	(0.006)	(0.003)
Log of GDP per capita	-6.126***	2.273***	-3.23***	-2.186***
	(0.561)	(0.212)	(0.415)	(0.264)
Stability	-0.021	0.028	-0.163	0.055
	(0.290)	(0.108)	(0.200)	(0.117)
Population growth	0.175	0.069	0.078	0.049
	(0.266)	(0.135)	(0.178)	(0.089)
Constant	43.136 ***	-16.29***	22.619 ***	15.558***
	(3.973)	(1.520)	(2.915)	(1.931)
R^2 within	0.50	0.45	0.38	0.38
F-statistic	30.50 ***	29.10***	44.23***	19.39***

*** and ** denote significance at 1% and 5% respectively.

Table 5.2 shows the impact of food price volatility on food security indices. The regression results show that food price volatility has a statistically significant impact on all indices except the under-utilization index. Keeping all other things constant, food price volatility is associated with a higher food insecurity index and lower availability index, and it also worsens food inaccessibility. These results are as expected since food price volatility may increase risk and affect production and consumption decision (Balcombe, 2011). Compared to the impact of food inflation, food price volatility has a significant impact on the overall composite indicator but food price inflation does not. Population growth and stability do not have a statistically significant impact on food security in all specifications.

We included a dummy variable for Africa[1] to further see if the impacts of food price changes on food security differ from what we get considering all developing countries. Table 5.3 and table 5.4 report the impact of food price inflation and food price volatility interacted with the dummy *Africa*. The effect of food price inflation rate differs from what we get in table 5.1 above. Now, food price inflation has a statistically significant effect on the food insecurity, food availability and under-utilization indices only when it is interacted with Africa (see table 5.3).

Table 5.3 Effect of food price inflation on food security indices: Africa dummy included

	Dependent variables			
	food insecurity index (FISI) (1)	Availability index (2)	Inaccessibility index (3)	under-utilization index (4)
Food price inflation rate	-0.011 (0.013)	0.003 (0.006)	0.0001 (0.008)	-0.006 (0.005)
Africa dummy*food price inflation	0.034** (0.016)	-0.012** (0.007	0.015 (0.011)	0.010** (0.006)
Log of GDP per capita	-6.073*** (0.558)	2.212*** (0.221)	-3.222*** (0.410)	-2.203*** (0.261)
Stability	-0.048 (0.296)	0.025 (0.112)	-0.186 (0.203)	0.048 (0.115)
Population growth	0.246 (0.269)	0.041 (0.142)	0.114 (0.181)	0.059 (0.088)
Constant	42.739*** (3.940)	-15.856*** (1.563)	22.579*** (2.882)	15.657*** (1.895)
within R^2	0.51	0.45	0.39	0.39
F-statistic	28.67***	24.18 ***	13.90 ***	19.79***

*** and ** denote significance at 1% and 5% respectively.

The result shows that when food price inflation increases, the food insecurity index increases, availability of food decreases and utilization of food deteriorates. This is consistent with our expectation that food price inflation could affect subsistence farmers living in Africa compared to surplus farmers mostly in Latin America and Asia. This is not surprising since the poor spent a significant amount of their income on food consumption. In addition, these results are in line with the literature that claim the vulnerability of African consumers to high food prices (FAO et al., 2011). Using a self-assessed food security indicator, Headey (2013) also found significant effect of rising food prices on food security when only low income countries were considered.

[1] We have 41 African countries from the total 105 sample developing countries included in the study

But, when we interact the Africa dummy with food price volatility we get a different result from the case above. The impact of the interaction term is not statistically significant, but the food price volatility is still significant except for the low-utilization index.

Table 5.4 Effect of food price volatility on food security indices: Africa dummy included

	Dependent variables			
	food insecurity index (FISI) (1)	Availability index (2)	Inaccessibility index (3)	under-utilization index (4)
Food price volatility	0.014** (0.004)	-0.006** (0.002)	0.007** (0.003)	0.004 (0.003)
Africa dummy*food price volatility	0.001 (0.023)	-0.0002 (0.008)	0.007 (0.017)	0.005 (0.008)
Log of GDP per capita	-6.12*** (0.556)	2.274*** (0.212)	-3.222*** (0.411)	-2.119*** (0.261)
Stability	-0.020 (0.290)	0.028 (0.108)	-0.158 (0.198)	0.053 (0.117)
Population growth	0.174 (0.266)	0.068 (0.136)	0.070 (0.178)	0.057 (0.090)
Constant	43.130*** (3.957)	-16.29*** (1.521)	22.577*** (2.898)	15.594*** (1.941)
within R^2	0.50	0.45	0.38	0.37
statistic	25.74***	26.28 ***	13.27***	15.31***

*** and ** denote significance at 1% and 5% respectively.

This implies that food price inflation impacts food security dimensions differently for Africa compared to other developing countries, but this difference is absent for food price volatility. One explanation for this result might be the risk that food price volatility can pose to both producers and consumers all over the developing world (Balcombe, 2011). In other words, the rist associated with food price volatility may affect the short and long term decision of food producers compared to food price inflation.

Chapter six: Conclusion, implication and critical reflection

6.1 Conclusion and implication

Following the well-known definition of FAO (WFS, 1996), this study considers three components of food security (availability, accessibility and utilization). We use a cross-country panel data set of 105 countries from 2001 to 2012 (containing three-year averages) to develop food security indices using PCA. The indices are one overall composite indicator and indices of the three components of food security. The main objective of this study is to investigate the impact of food price inflation and food price volatility on these food security indices. The results indicate that food price inflation has a statistically significant impact on food availability and inaccessibility indices, whereas food price volatility impacts the overall food insecurity indicator in addition to food availability and inaccessibility disclosing the different impacts of the two price changes. The under-utilization component was not found to be responsive to both food price inflation and food price volatility in the specifications that consider all sample developing countries.

These mixed results indicate that the impacts of food price inflation and food volatility on food security depend on how we approach food security. Their impact on the overall indicator is not the same as their impact on the different food security dimensions. The disaggregation of food security into its components gives the room to evaluate the effect of the same predictor on the different dimensions. This reflects the necessary attention that should be given to the operationalization and measures of food security before embarking on policy actions to mitigate food security problems.

In addition, we use a dummy variable for Africa and interact with food price inflation and food price volatility to examine if the impact of food price and food price volatility differs when we consider Africa alone compared to the rest of the developing world. The results show that the impacts of the food price changes are adverse in Africa. In terms of development interventions, this illustrates the consequences that could arise from monitoring global food security and subscribing the same policy to all developing countries in trying to mitigate food security problems.

GDP per capita has a statistically significant impact on all indices of food security. This consistent result shows that a higher GDP per capita growth has a positive impact on food security which calls for efforts to enhance GDP per capita. In addition, this can be indirectly interpreted in terms of the effect of population growth in the sense that lower population growth helps to increase the GDP per capita figure. But, population growth does not show a statistically significant effect towards any of the food security indices which needs further investigation.

6.2 Critical reflection

Despite its four decades of age in the development agenda, food security as a term is still surrounded by widespread confusions. The confusions are related to both its very definition and measurement which are still fuzzy due to its multifaceted nature. One cannot measure a term if it is not defined properly. We observed that there is still a lack of comprehensive and objective definition and measure of food security which makes the evaluation and mitigation of food security problems more challenging.

FAO (WFS, 1996) puts a broad and general definition of food security which has been picked up by many studies, including this thesis, in the food security literature. But the definition does not put a clear reference on the scale (individual, household, national) and state (chronic, temporary or persistent) of food security. Obviously, this gives the way for all sorts of manipulations in studying the food security problem. In addition, the scarcity of data hinders from making the necessary analysis and comparisons across different regions of the world.

As we may guess, the best possible data source of food security, especially at country level, is FAO. But, the FAO food security dataset (FAO, 2014), which is believed to include most of the food indicators suffers from various shortcomings. First, the data does not cover a long period of time to investigate the persistent and dynamic nature of food security. Moreover, the data are available only as an aggregate of three years, which decreases variations over the years. These hindered us from using a dynamic panel estimation technique which has the advantages to investigate the persistent and dynamic nature of food security. We also believe that the insignificant results of the explanatory variables, like population growth and stability, could turn out differently if we use longer and yearly data.

Some of the definitions or operationalization of indicators of food security are questionable. In addition, the methods used to calculate them and their sources are not very clear to check their reliability. Sometimes, it was not convincing to use them as they are, but we used them due to the absence of a better alternative.

The PCA has given the chance to reduce the different indicators into a single index. But, this could also deter from targeting a specific individual element of food security while monitoring global food security and designing a sound food security development policy. In addition, the index may cover differences between countries by giving them the same food security scores. So, the interpretation and the implication of the indices should be made keeping its downsides in mind.

Further research might help to get more insight in the food price food security nexus. Another investigation including high income countries might contribute to validate the PCA methodology, and the result found on the impact of food price changes on food security. This might increase the number of observations, and help to cross-check the replicability of the PCA to employ it for related researches. Moreover, using additional explanatory variables and alternative indicators of food security might help to get a more nuanced representation of the food price and food security dynamics. Instrumental variable approach may also improve the investigation by mitigating possible endogeneity problem, which we couldnot implement due to lack of strong and valid instruments.

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