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An assessment of the impacts of rising food prices on consumers: Implications for the welfare of the poor and vulnerable

TESIS DOCTORAL

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Summary

The recent developments in world agricultural commodities prices have given rise to serious concerns in relation to their potential impact on the welfare of the poor, not only from the perspective of developing countries but also from that of the most vulnerable in developed countries. Understanding the implications of changes in agricultural commodities prices is key for ensuring food security. This thesis aims at evaluating the potential consequences of rising food prices on the welfare of consumers and households from a global perspective. Specifically, the thesis focuses on the European Union and Tanzania as examples of the developed and the developing world respectively. Even though the impact of rising food prices on the welfare of European Union consumers may seem to be limited, given the inequalities existing between and within member states in terms of consumer food prices, household food budget and household income some segments of the population may find difficulties in their access to food under a scenario of higher food prices. However, the real threat of increased food prices to the welfare of the population lies in low-income countries, where the vast majority of the food insecure population live and the ability to cope with food price related shocks continues to be a challenge.

First, this thesis aims at assessing the effects of changes in world agricultural commodity prices on consumer welfare in the European Union in light of the recent agricultural commodities price crises occurred in 2007-2008 and 2011-2012. As a first step, it is necessary to evaluate price transmission between world agricultural commodity and consumer food prices. To evaluate the extent to and speed at which world agricultural commodity price movements affect consumer food prices in the European Union member states, error correction models are developed taking

into consideration three types of world agricultural commodity price indices and supply and demand shifters. The findings reveal a long-term equilibrium relationship between world market and consumer food prices in half of the member states irrespective of the world index used. Despite this, there are differences in both the integration between world and consumer food markets and the extent to and speed at which agricultural commodity price movements impact consumer food prices within integrated markets across member states. When member states are classified into different categories according to eurozone membership, price transmission across member states does not differ so widely. Even though a long-term equilibrium relationship exists for a majority of member states, the extent to and speed at which prices return to equilibrium is insubstantial. The results also suggest that supply and demand shifters play a key role in the process of price transmission between global and consumer prices. This chapter leads to the conclusion that increased food prices may affect the consumption and health of households that spend a large share of their income to food in the face of price shocks in world markets, even if the impact of higher price levels and volatility in global markets on consumer prices is limited and temporary.

Second, empirical analyses at the household level may offer depth in measuring the impact of rising food prices on the welfare of European Union consumers, once shown that global agricultural commodity prices are related to and may have an effect on consumer food prices and on the welfare of some of the most vulnerable European Union households. To this end, the European Union Statistics on Income and Living Conditions are used to test whether increasing food prices —and the deviation of food prices relative to general consumer prices— have an impact on food deprivation in European Union households, particularly on the access of households to an adequate protein intake. The analysis, which is undertaken from 2003 to 2011 and thus coincides with the surge in agricultural commodities prices of 2007-2008, uses population-averaged panel data models. The results show no clear evidence of an increase in food deprivation following the recent food price crisis. Nevertheless the results suggest that there is a significant and negative relationship between food deprivation and the consumer food price index

during the analyzed period, period in which the consumer food price index increased around the world following the 2007-2008 world food price increase. The most vulnerable households to food deprivation are those belonging to the lowest income quintile in the member states recently acceded to the European Union. These findings provide evidence to conclude that increased food prices do have an impact on food consumption in the poorest European Union households and may be useful for the evaluation of food assistance programmes that aim to compensate the negative effects of increasing food prices.

Third, Tanzania seems a particularly convenient example in which to assess the short-term consequences of increasing food prices on the welfare of the population in developing countries, as food energy deficiencies and malnutrition continue to be a widespread problem among its population. Furthermore, the rise in overweight and obesity in developing countries is becoming an increasingly severe problem. Considering the multidimensional nature of the welfare impacts of increased food prices, the thesis aims at broadening the focus followed so far and examine the consequences of a price surge on the adult population's actual nutritional status. By simulating the impact of the main staple's price increase on the population's weight outcomes and its incidence in the prevalence of underweight, overweight and obesity, the thesis explores the potential effects of price increases in two of the three dimensions of malnutrition —undernutrition and overnutrition. A food demand model that allows to later undertake a calorie-to-weight simulation is developed. The findings show that undernutrition increases in the face of the price increase, while the overweight and obese population actually improve their nutritional status. This is due to the scarce substitution possibilities which are restricted to other energy-dense foods with a low content in micronutrients. However, the results provide some evidence to support that consumption patterns could be evolving towards the typical patterns that characterize an early stage of the nutrition transition. The shifts in the diet and activity patterns due to economic growth and urbanization amongst others typical of the nutrition transition are driving an increase in obesity around the world. The findings suggest that there will be a need for programmes that

address simultaneously the undernutrition and overnutrition facets of malnutrition in the near future as the nutrition transition continues to develop.

The thesis concludes that even if the impact of higher agricultural commodity or food prices is limited and temporary, they may affect the welfare of the most vulnerable households that spend a large share of their income to food, either through their consumption or their food security and nutrition status. The impacts of increased food prices on consumers will depend not only on the country but also on the segment of the population within the country and the time frame studied. This is clearly illustrated by the findings of the European Union analyses in which member states with a large average share of household expenditure on food generally have larger price transmission elasticities from global market prices to consumer food prices and have a higher probability of being food deprived, while this probability increases more in the lowest income quintile in the face of the food price rise. Nonetheless, the effects are in general terms small, although relevant for the most vulnerable segments of society. In developing countries such as Tanzania where the share of household expenditure on food is significantly higher and food consumption is constrained by household income, the impact of a staple price increase can entail a large calorie intake fall. The increase in the price of maize decreases the available budget to substitute to other foods and substitution possibilities cannot be sufficiently used to avoid the calorie fall, with the resulting adverse effects on nutrition outcomes.

Resumen

La evolución de los precios mundiales de las materias primas agrarias en los últimos años ha generado cierta preocupación sobre su posible impacto en el bienestar de los pobres, no sólo desde la perspectiva de los países en desarrollo sino también desde la de la población más vulnerable en los países desarrollados. Comprender las implicaciones de los cambios de los precios de las materias primas agrarias es un elemento clave para garantizar la seguridad alimentaria. La tesis tiene como objetivo evaluar las posibles consecuencias del aumento de los precios de los alimentos en el bienestar de los consumidores y hogares desde una perspectiva global. En concreto, la tesis se centra en las posibles consecuencias sobre el bienestar de la población de la Unión Europea y de Tanzania como ejemplo de países desarrollados y en desarrollo, respectivamente. A pesar de que el impacto de la subida de los precios de los alimentos sobre el bienestar de los consumidores de la Unión Europea pueda parecer limitado, el acceso a los alimentos de determinados segmentos de la población puede verse perjudicado ante un escenario de subida de estos a la luz de las desigualdades existentes entre Estados Miembros y dentro de los Estados Miembros en términos de precios de los alimentos, presupuesto destinado a los alimentos e ingresos. Sin embargo, el verdadero desafío del aumento del precio de los alimentos reside en los países de bajos ingresos, donde vive la mayor parte de la población que padece inseguridad alimentaria y donde la capacidad de hacer frente a este tipo de adversidades sigue siendo todo un reto.

En primer lugar, uno de los objetivos de la tesis es evaluar el impacto del aumento repentino de los precios de las materias primas agrarias en el mercado mundial en el bienestar de los

consumidores de la Unión Europea, a la luz de las recientes crisis que han tenido lugar en 2007-2008 y 2011-2012. Como primer paso, es necesario evaluar la transmisión entre los precios mundiales de las materias primas agrarias y los precios de consumo de los alimentos. Para ello, se desarrollan modelos de corrección del error para cada Estado Miembro con el objeto de evaluar en qué medida y a qué velocidad los cambios de los precios mundiales de las materias primas agrarias afectan a los precios de consumo de los alimentos en los países de la Unión Europea, teniendo en cuenta para ello tres índices distintos de precios mundiales de materias primas agrarias y una serie de parámetros de cambio de oferta y demanda. Los resultados revelan una relación de equilibrio a largo plazo entre los precios en el mercado mundial y los precios de consumo de los alimentos en la mitad de los Estados Miembros con independencia del índice mundial utilizado. A pesar de esto, se encuentran diferencias entre los Estados Miembros tanto en el hecho de que el mercado mundial de materias primas agrarias y los precios de consumo estén o no integrados como en el grado y la velocidad a la que los precios mundiales de las materias primas agrarias afectan a los precios de consumo de los alimentos. Si los Estados Miembros se clasifican en diferentes categorías según su pertenencia a la eurozona, es evidente que el proceso de transmisión de precios se asemeja más dentro de cada grupo. A pesar de que existe una relación de equilibrio a largo plazo para la mayoría de los estados miembros, la medida y velocidad a la que los precios vuelven al equilibrio es bastante débil. Los resultados también sugieren que los parámetros de cambio de oferta y demanda juegan un papel clave en el proceso de transmisión de precios. Este capítulo concluye que ante una crisis de los precios mundiales de las materias primas agrarias, el aumento de precios de los alimentos puede afectar al consumo de aquellos hogares que emplean una gran parte de sus ingresos en alimentación y al estado de salud de sus integrantes, a pesar de que el impacto del aumento del nivel de los precios en los mercados mundiales en los precios de consumo de los alimentos sea limitado y temporal.

En segundo lugar y una vez demostrado que los precios mundiales de las materias primas agrarias y los precios de consumo de los alimentos están relacionados y que los primeros pueden tener un efecto sobre los segundos y sobre el bienestar de algunos de los hogares más vulnerables de la

Unión Europea, los análisis empíricos a nivel del hogar pueden ofrecer un análisis más detallado del impacto de la subida de los precios de los alimentos en el bienestar de los consumidores de la Unión Europea. Se utiliza la Encuesta de Condiciones de vida de la Unión Europea con el objeto de comprobar si el aumento del precio de consumo de los alimentos —y la desviación del precio de consumo de los alimentos sobre el índice general de precios al consumo— ha tenido un impacto en una medida de la privación de alimentos que mide el acceso a una ingesta adecuada de proteínas en los hogares de la Unión Europea. Para llevar a cabo el análisis se utilizan modelos marginales. El análisis se ha realizado en el periodo comprendido entre 2003-2011 y que coincide por tanto con el periodo en el que tuvo lugar la crisis de precios de las materias primas agrarias de 2007-2008. Los resultados no muestran una evidencia clara de un incremento de esta medida de privación de alimentos tras la reciente crisis de precios mundiales de las materias primas agrarias. Sin embargo, los resultados sugieren que existe una relación significativa y negativa entre la medida de privación de alimentos y el índice de precios de consumo de alimentos durante el período analizado, periodo en el que, tras la crisis de precios de las materias primas agrarias, el índice de precios al consumo de los alimentos aumentó en distintos lugares del mundo. Los hogares más vulnerables a la escasez de alimentos son aquellos que pertenecen al quintil más bajo de ingresos en los Estados Miembros que han accedido recientemente a la Unión Europea. Estos resultados proporcionan evidencia para concluir que el aumento de precios de los alimentos tienen un impacto en el consumo de alimentos en los hogares más pobres de la Unión Europea. Los resultados pueden ser útiles para la evaluación de los programas de asistencia alimentaria que tienen por objeto compensar los efectos negativos del aumento de precios de los alimentos.

En tercer lugar, Tanzania parece un ejemplo particularmente adecuado para evaluar las consecuencias a corto plazo del aumento del precio de los alimentos sobre el bienestar de la población en los países en desarrollo, ya que las carencias en el consumo calórico y la malnutrición continúan siendo un problema generalizado. Además, el aumento del sobrepeso y la obesidad se está convirtiendo en un problema cada vez más grave. Teniendo en cuenta la naturaleza multidimensional de los impactos de la subida de los precios de los alimentos sobre el

bienestar de la población, la tesis tiene como objetivo examinar las consecuencias de la subida del precio del maíz en el estado nutricional real de la población adulta, ampliando así el enfoque seguido hasta ahora. Se simula el impacto de una subida de los precios del maíz, que es el alimento básico en Tanzania, en el peso de la población y su incidencia en la prevalencia de peso por debajo de lo normal, la prevalencia de exceso de peso y la prevalencia de obesidad. De esta forma, la tesis explora los posibles efectos de las crisis de precios de alimentos en dos de las tres dimensiones de la malnutrición —la desnutrición y la sobrealimentación. Se desarrolla un modelo de demanda de alimentos que permite llevar a cabo más adelante una simulación que transforma los cambios en el consumo de calorías en cambios en el peso corporal de la población. Los resultados muestran que, ante un aumento del precio del maíz, la desnutrición aumenta mientras que la población con sobrepeso y obesidad mejora su estado nutricional. Esto se debe a que las escasas posibilidades de sustitución se limitan a otros alimentos ricos en energía con un bajo contenido en micronutrientes. Sin embargo, los resultados muestran indicios de que los patrones de consumo de la población con sobrepeso y obesidad podrían estar evolucionando hacia los patrones que caracterizan una etapa temprana de la transición nutricional. Los cambios en la dieta y en los patrones de actividad debido al crecimiento económico y a la urbanización entre otros típicos de la transición nutricional están impulsando el aumento de la obesidad a lo largo del mundo. El capítulo concluye que en un futuro próximo se necesitarán programas que aborden simultáneamente estas dos facetas de la malnutrición, la desnutrición y la sobrealimentación, según siga desarrollándose la transición nutricional.

La tesis concluye que aunque el impacto de los precios más elevados de los productos agrarios o de los alimentos sea limitado y temporal, pueden afectar al bienestar de los hogares más vulnerables que destinan una mayor parte de sus presupuesto a la alimentación, ya sea a través del consumo o del nivel de seguridad alimentaria o de nutrición. El impacto del aumento de los precios de los alimentos en los consumidores no sólo dependen del país, sino también del segmento de la población considerado y del período de tiempo estudiado. Esto queda claramente patente en los resultados del estudio de la Unión Europea en el que los Estados Miembros en los

que el gasto de los hogares destinado a la alimentación es elevado tienen generalmente elasticidades de transmisión de precios entre los precios del mercado mundial y los precios de consumo más elevadas y cuyos hogares tienen una mayor probabilidad de carecer de alimentos, mientras que dicha probabilidad aumenta más en el quintil más bajo de renta como resultado del aumento de precios de los alimentos. Sin embargo, los efectos son en términos generales pequeños aunque sean relevantes para los segmentos más vulnerables de la sociedad. En los países en desarrollo, como Tanzania, donde el gasto de los hogares en alimentos es más elevado y el consumo de alimentos está limitado en gran medida por el nivel de renta, el impacto del aumento del precio de un alimento básico puede conllevar una pérdida considerable en el consumo de calorías. Esto se debe a la disminución del presupuesto disponible para adquirir productos sustitutivos a raíz de la subida del precio del alimento básico y a que las posibilidades de sustitución no pueden ser suficientemente utilizadas, con los consecuentes efectos adversos en los resultados nutricionales.

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Acronyms and Abbreviations

ADF	Augmented Dickey-Fuller
ADL	Autoregressive distributed lag
AIDS	Almost ideal demand system
BMI	Body mass index
CAP	Common Agricultural Policy
CEIGRAM	Research Centre for the Management of Agricultural and Environmental Risks
CGE	Computable general equilibrium
COICOP	Classification of individual consumption by purpose
CPI	Consumer price index
DSU	Denmark, Sweden and the U.K.
€	Euro
EAAE	European Association of Agricultural Economists
EC	European Commission
ECB	European Central Bank

ECM	Error correction model
ECT	Error correction term
EIU	Economist Intelligence Unit
Eq.	Equation
EU	European Union
EU-15	MSs that acceded to the EU before 2004 (throughout the document Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the U.K. are considered to be EU-15 MSs)
EU-12	MSs that acceded to the EU from 2004 onwards (throughout the document Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia (plus Croatia in some occasions which acceded to the EU in 2013) are considered to be EU-12 MSs)
EU-28	Includes all EU MSs including Croatia which acceded to the EU in 2013
EU-27	Includes all EU MSs except for Croatia which acceded to the EU in 2013
EU-SILC	European Union - Statistics on Income and Living Conditions
FAO	Food and Agriculture Organization of the United Nations
FSN	Food Security and Nutrition
GDP	Gross domestic product
GEE	Generalized estimating equations
GWP	Gallup World Poll
HAZ	Height for age

HH	Household
HICP	Harmonized index of consumer prices
IBRD	International Bank for Reconstruction and Development
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
JRC	Joint Research Centre
LDCs	Least developed countries
LOP	Law of one price
LSMS-ISA	Living Standards Measurement Study—Integrated Surveys in Agriculture
MAFAP	Monitoring and Analysing Food and Agricultural Policies
MS	Member state
NBB	National Bank of Belgium
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
PAL	Physical activity level
PIGLOG	Price-Independent Generalized Logarithmic
PP	Phillips-Perron
QUAIDS	Quadratic almost ideal demand system
SBS	Structural Business Statistics
SE	Standard error

SNAP	Supplemental Assistance Program
SSA	Sub-Saharan Africa
Std. Dev.	Standard deviation
TDHS	Tanzania Demographic and Health Survey
TNBS	Tanzanian National Bureau of Statistics
TZNPS	National Panel Survey for Tanzania
UK	United Kingdom
ULYSSES	Understanding and coping with food markets voLatilitY towards more Stable World and EU food SystEmS
UN	United Nations
UNU	United Nations University
UPM	Technical University of Madrid
URT	United Republic of Tanzania
US	United States
USD	U.S. Dollars
VAR	Vector autoregressive
VECM	Vector error correction model
WAZ	Weight for age
WB	World Bank
WFP	World Food Programme

WHO World Health Organization

WHZ Weight for height

Chapter 1

Introduction

1.1 Motivation

The recent developments in agricultural commodities prices in global markets have raised major concerns in relation to their impact on the poor from the perspective of both developed and middle- and low-income countries. The price spikes occurred in 2007-08 and 2011-12 and the large increase in agricultural commodities prices volatility took place after a long period of relative stability and raised much controversy among the international community. Thus the issue has received extensive attention in the literature. Even though it was predicted that these high agricultural commodities price trends were likely to continue in the future, this has not been exactly the case. Currently agricultural commodity price developments have somewhat slowed down. Yet, the consequences of rising food prices on consumers and households remain a matter of serious concern because of their obvious implications in the consumption of food and the nutritional status of the poor, which in turn are critical and necessary for human and economic development. This evidences the need to develop more robust and effective policies in order to cope with food-related price shocks. There is no doubt that the consequences are much more severe in middle- and especially in low-income countries —the vast majority of the undernourished live in developing countries (see EIU, 2015). However, the behaviour of domestic price movements has been diverse across countries, and these developments do not need to respond to changes in world agricultural commodity prices but depend on many other factors (Garrido et al., 2016). In addition, food security issues can be analyzed from many perspectives

and regional contexts because problems faced by each country are different and food systems differ across countries (EIU, 2014). Thus, considering the analysis of welfare from different perspectives —particularly from the perspective of developed and low-income countries— can provide different insights into a global problem and inform policies concerning the specificities that characterize each of them.

Following the food price spikes occurred in 2007-2008 and 2011-2012 and the increase in food price volatility, consumer food prices increased around the world including the EU. In addition, food inflation ran above general inflation in OECD countries (McCorriston, 2014). These facts lead to concerns about the potential impact these developments in global agricultural commodities prices could have on EU consumers, in particular when considered from the perspective of the poor and vulnerable populations (Beatty, 2010; McCorriston, 2012; Gregory and Coleman-Jensen, 2013). Evidence of more expensive food having an impact on consumers in developed countries exists in the literature and several potential effects have been identified—for example, changes in eating habits or purchasing strategies (Beatty, 2010; García-Verdú et al., 2012). Food and nutrition security has not been fully achieved in the EU, despite the sufficient food availability and the stable food security environment (Cockx et al., 2015). Key problems identified in the EU are malnutrition, especially overweight and obesity, and micronutrient deficiencies (Cockx et al., 2015). As a matter of fact, the analysis of the item used to determine the number of people materially deprived that concerns the affordability of food—the ability to afford a meal with meat, chicken or fish every second day— shows that up to 27.7 percent of the population in Hungary and nearly 40 percent of the population in Bulgaria acknowledge not being able to access an adequate protein intake in 2014 (measured as the capacity to afford a meal with meat, chicken, fish (or a vegetarian equivalent) every second day; EUROSTAT, 2015d). These figures clearly evidence the potential vulnerability of certain parts of the EU population to rises in food prices. Even if problems of availability may seem to be eradicated, this might not be the case of the access to affordable, healthy and nutritious food, at least for the most vulnerable segments of the population.

The impact of increased food prices on the welfare of EU consumers may appear to be limited because of several facts. First, the impact depends on the price transmission process from agricultural commodities to consumer food prices. This is a complex process that depends on a number of factors —among which are determinants of agricultural markets and the food value chain— and softens food price instability (Gilbert and Morgan, 2010). Within these factors, the fact that the final food item only comprises a small share of the raw agricultural product (McCorriston, 2012) largely influences the relationship. Second, food has typically a small share in overall consumer budgets in developed countries (around 10-15 percent on average; Gilbert and Morgan, 2010). Nevertheless, there are differences in the share of food in the household's total budget across MSs —from 7.8 percent in Luxembourg to nearly 30 percent in Romania in 2010— and across income segments within MSs, where the share of food in the total budget in households belonging to the lowest income quintile is much higher than the average share (see Figure 3.1). Thus the food consumption share in total budget is still significant in low-income households in new and even in traditional MSs. Additionally, there are also significant differences in average disposable income levels across EU member states (MSs), reflecting different income and welfare levels. Lower incomes may make the access to nutritious food more difficult. Differences across MSs are also reflected in the recent trends of food prices in the EU MSs (Bukeviciute et al., 2009; Lloyd et al., 2013). Besides, not only are the lower income segments of the population —especially of certain MSs— identified as vulnerable to food price rises but also women and children, ethnic minorities and the elderly (Cockx et al., 2015). Even though the evidence shows that more expensive food may have an impact on consumers in developed countries, practically no attempt has been made to assess the impact of the recent developments in food prices on the access to food among the most vulnerable in the EU. This can help evaluate food assistance programmes in compensating the negative effect of increasing food prices, especially considering the large disparities in social policies that aim to protect poorer households across MSs (Cockx et al., 2015).

While the impacts of food price increases in developed countries —particularly considering the poorer and most vulnerable— are worth the investigation, a source of bigger concern is the potential consequences among the poor in low-income countries, where poverty levels and food insecurity are much more severe. There is extensive evidence of the welfare effects of rising food prices in middle- and low-income countries, especially after the recent rise in agricultural commodities prices. These effects can be varied depending on the structure of the economy of the country considered, the particular commodity to which the price change affects and the relative number of net buyers —those who buy more than sell— and net sellers —those who sell more than buy (Ivanic and Martin, 2008; Anriquez et al., 2013). Similarly to developed countries, both the consumption of food —in quantity and in quality— and of other basic necessities may be reduced in the face of a price increase. But contrary to developed countries, the share of processed food consumed is lower (Dewbre et al., 2008) and food is typically a large share of household expenditure. Considering this, food price rises can substantially hurt the poor in developing countries. Nonetheless, high and volatile grain prices —cereals are usually the main staple in less developed countries— impact primarily on the poorer countries and among these, on the poor within the country (Gilbert and Morgan, 2010). These impacts are particularly severe in regions such as sub-Saharan Africa (SSA) which still is the poorest region of the world (EIU, 2014) and where limited progress in terms of lowering undernourishment has been made (FAO et al., 2015). The consequences not only depend on the budget devoted to food but also on the budget devoted to staple commodities, the substitution possibilities among foods and the relative position as net buyers or net sellers (Magrini et al., 2016). The latter can offset the negative consequences or even drive gains to the population in the face of a price increase.

It is particularly important to understand how the population responds to a price increase that affects the staple food (Anriquez et al., 2013). Staple foods not only are the bulk of consumption but also typically the main source of calorie intake. The population rely heavily on them. The impact of price rises ultimately affects the nutritional status of the population. At first households replace foods with less expensive sources of calories or lower-quality foods in the face of

increased food prices (IBRD and WB, 2012). When substitution possibilities become scarce, household calorie consumption decreases (IBRD and WB, 2012). Thus, changes in dietary intake patterns due to a price or income shock can be a potential cause of shifts in nutritional outcomes and therefore can increase the risks of malnutrition (Ecker and Qaim, 2011). In this sense, food security encompasses nutrition security, in such a way that food security is necessary but not sufficient for nutrition security (IBRD and WB, 2012). Malnutrition —referring to all departures from adequate nutrition, including undernutrition and overnutrition (Shetty, 2002)— can result in increased health problems, decreased labour productivity and problems related to poor cognitive function and deficits in schooling, and can ultimately erode economic growth and perpetuate poverty (WB, 2006). Therefore, food security and malnutrition policies are central to poverty reduction in developing countries (WB, 2006).

Within the sub-Saharan region, Tanzania looks like a particularly appropriate example in which to analyze the consequences of a staple price increase. At the national level, the energy supply does not meet the average energy requirements of the population and micronutrient deficiencies are widespread (URT, 2013). Although undernourishment continues to be the main nutritional problem among the population, overweight and obesity have increased in recent years (URT, 2013). The population relies on maize as the main staple and the major source of calorie intake. Economic and agricultural growth in Tanzania have outpaced poverty, food security and nutrition, which remain high (FAO et al., 2015). According to FAO et al. (2015), social policies that cope with hunger reduction and improve food and nutrition have to be strengthened in Tanzania because they suffer from limited coverage and are not sufficiently well targeted. For all these reasons, Tanzania provides an adequate background to evaluate food accessibility in light of a price increase and permits to move beyond accessibility and analyze nutritional outcomes. This can help design improved food security and nutritional security strategies and policies in order to cope with food price increases.

1.2 State of the art

This section reviews the literature particularly relevant for the development of the thesis —the literature on the recent developments of EU agricultural commodity prices and consumer food prices in relation to price developments in global markets, the price transmission from global agricultural commodity markets to consumer food prices, the welfare consequences of increasing food prices on consumers in developed countries and the welfare consequences of rising food prices on households in developing countries. Since Chapters 2, 3 and 4 are the main contributions of the thesis, they review in more detail the literature pertinent to each of them.

Recent developments of EU agricultural commodity prices and consumer food prices in relation to price developments in global markets

World agricultural commodity prices increased by 70 percent during 2007/2008, and then decreased sharply. In 2011/2012 world prices increased again by about 30 percent and agricultural commodity price volatility increased throughout the entire period. These developments in world agricultural commodity prices have affected producers and consumers in the EU (Swinnen et al., 2013). This subsection reviews the literature on the relation between global agricultural commodity prices and domestic agricultural commodity prices and consumer food prices in the EU, respectively, as well as the factors that possibly explain the differences in the development of consumer food prices across EU MSs. These factors may play a role in determining the relation between world and consumer food prices.

EU average agricultural commodities prices followed a similar trend to world agricultural commodity prices although their changes were proportionally smaller (Swinnen et al., 2013). Similarly, the relation between world and EU domestic agricultural commodity prices appeared to be stronger than the relation between global commodity prices and retail prices in the U.K. (Davidson et al., 2011). A similar finding holds for wheat and retail bread prices in the U.K., France and Poland (Lloyd et al., 2012).

On the other hand, the literature provides evidence to conclude that consumer food prices rose in many developed economies following this period of price instability in global agricultural commodity markets (Bukeviciute et al., 2009; Lloyd et al., 2013; McCorriston, 2014). However, consumer food prices evolved in a much more subtle way than global agricultural commodities prices —and domestic agricultural commodities prices. While world agricultural commodities prices experienced sharp increases (and decreases) during the 2007-2012 period, food price inflation increased slightly and its volatility was considerably smaller —Swinnen et al. (2013) document an average 5 percent increase in real food prices in the EU throughout the 2005-2012 period, whereas Lloyd et al. (2015) document a 27 percent increase in the OECD European countries in the 2005-2013 period. One of the main reasons for the different developments across agricultural commodities and consumer food prices and one to which all authors generally make reference to is that the cost of the raw agricultural commodity comprises only a small share of the total cost in the final food product's prices (Bukeviciute et al., 2009; Swinnen et al., 2013; Schnepf, 2013; Lloyd et al., 2015). Apart from the latter, other reasons such as competition related issues and asymmetry —consumer food prices increase more and/or more faster in the face of a price increase than their relative decrease when commodity prices decrease— along the food chain are usually also contemplated (Bukeviciute et al., 2009; McCorriston, 2014; Lloyd et al., 2015). The literature also documents that food price inflation is considerably more variable than non-food inflation in the majority of the EU MSs, especially in non-eurozone MSs (Lloyd et al., 2015).

The fact that consumer food prices have been less volatile when compared to international and domestic agricultural commodities prices does not mean that they have not been volatile. In fact, food inflation was higher and also more volatile during the recent commodities price surges in many EU-15 MSs (Lloyd et al., 2013). On the other hand, food price inflation has fallen both in level and variability in the EU-12 MSs due to the very high levels of inflation of the preceding period (Lloyd et al., 2013). Still, food inflation levels are higher and more variable in the EU-12 MSs than in the EU-15 MSs (Bukeviciute et al., 2009; Lloyd et al., 2013). These authors

recognize that these differences in the development of food price inflation across MSs give rise to a matter of concern in light of global price shocks. Specifically, Lloyd et al. (2015) stress this concern considering that the EU MSs share a single market and a set of common policies and a monetary and exchange rate framework common to the majority of the MSs.

Bukeviciute et al. 2009 identify the following features that characterize the EU-12 MSs as factors possibly explaining the differences in developments of consumer food prices between EU-15 and EU-12 MSs: their generally higher levels of wage and price inflation, their higher share of agricultural commodities in the cost of food, the greater contribution of food inflation to overall inflation and the functioning of downstream market conditions. Similarly, Lloyd et al. (2013) point out as potential reasons for the disparities across MSs the following: the difference in the share of food in total expenditure across MSs, the relative extent of import exposure, the degree of market integration, the exchange rate —whether a particular MS uses the euro or not—, the market structure within the food chain typical of each MS or the exercise of market power, amongst others.

Price transmission from global agricultural commodity markets to consumer food prices

The literature on price transmission in agricultural markets and along the food value chain is large. This strand of the literature also covers the analysis of the impact of changes in global agricultural commodities prices on food inflation in developed countries. It shows that this impact may be weak (IMF, 2008a; IMF, 2008b; Davidson et al., 2011; McCorriston 2012; Ferrucci et al., 2012). But at the same time the literature considers that the price transmission process is a fundamental factor in the determination of the relation between global and consumer food prices (Lloyd et al., 2015). The price transmission process in this particular case that links agricultural commodity and consumer food prices is determined by the characteristics of both international and domestic agricultural markets and the food sector (Davidson et al., 2011; Lloyd et al., 2013). In the specific case of the EU, the nature of price transmission along the food supply chain varies

largely across MSs and product category (McCorriston and von Cramon-Taubadel, 2016). This subsection reviews the literature on price transmission in developed countries with a special focus on price transmission between world agricultural commodities prices and consumer food prices in the EU.

Empirical studies of price transmission are in many occasions underpinned by the law of one price (LOP). The LOP states that markets linked by trade and arbitrage will have a same price after deducting transaction costs (Fackler and Goodwin, 2001). While many have questioned the validity of the LOP (Listorti and Esposti, 2012), others claim that even if there are many evaluations of price transmission in the empirical literature, most lack the underpinning theoretical framework (Lloyd et al., 2015; Garrido, 2016). Leaving this discussion for later, the price transmission process depends on both agricultural markets and the food value chain in the case of price transmission from global to consumer food prices. In other words, it depends on horizontal and vertical price transmission. This approach that includes both horizontal and vertical price transmission is reflected by Lloyd et al. (2011) and Ferrucci et al. (2012), who address the link between agricultural commodity and consumer food prices. In this way, horizontal price transmission is related to the extent to which world and domestic markets are integrated and vertical price transmission refers to the relation between both world and EU agricultural commodity prices and consumer food prices along the value chain (Lloyd et al., 2011).

Horizontal price transmission is in fact defined as the co-movement of prices between spatially differentiated markets at the same stage of the supply chain or across different agricultural or nonagricultural commodities markets (Listorti and Esposti, 2012). World to agricultural domestic prices will be completely transmitted only in the absence of active policy intervention in trade and in commodity or exchange markets (Dewbre et al., 2008).

Related to the role of policy intervention in trade and commodity markets, some authors believe that EU agricultural commodity prices should be used to evaluate price transmission in the EU instead of global agricultural commodities prices, as the Common Agricultural Policy (CAP) has

traditionally mitigated price transmission of world agricultural commodity shocks into the EU (see, for example, Ferrucci et al., 2012 and Kanutin, 2012). They claim EU commodity prices incorporate the impacts of the CAP measures and other schemes on agricultural prices. These impacts of CAP and other measures are no longer so relevant due to the recent developments in agricultural support and trade interventions towards less distorting schemes (Swinnen, 2013; Lloyd et al., 2015). As a result, global and EU domestic agricultural commodities prices have become somewhat more closely correlated in recent years (Lloyd et al., 2015).

Vertical price transmission refers to the price linkages along the food value chain (Vavra et al., 2005). Most authors identify two fundamental factors that affect vertical price transmission in the food sector: the low share of raw commodity in the final retail product and its structure and efficiency (Bukeviciute et al., 2009; Lloyd et al., 2013; Lloyd et al., 2015).

Related to the structure and efficiency of the food sector, Lloyd et al. (2014) suggest that for most countries they analyze —the bread and wheat commodity value chain across eleven EU MSs— the influence of developments in the food sector itself on bread prices could be larger than developments in wheat commodity prices. In regard to the structure and efficiency of the food sector, the literature generally identifies several issues that should be further investigated: the cost structure, competition, regulatory practices, public policy and macroeconomic factors, amongst others (Bukeviciute et al., 2009).

Focusing first on the cost structure, it should be noted that the cost structure of the food sector comprises a number of other cost factors, apart from the raw agricultural commodity. Among these, transport, energy and labour stand out (Bukeviciute et al., 2009). For example, Davidson et al. (2011) and Lloyd et al. (2014) incorporate into their analysis other factors, apart from world agricultural commodity prices, possibly affecting consumer food prices. Among these, manufacturing costs are considered. In this sense, crude oil prices have been used in the literature to proxy food industry production and retail costs (Leibtag, 2009; Davidson et al., 2011; Flachsbarth and Garrido, 2014).

The issue of competition is receiving increasing attention in the literature but still remains under investigated due to lack of data (Lloyd et al., 2015). Competition in the food industry and the retail market is usually contemplated as a factor influencing the price transmission process (Bukeviciute et al., 2009; Lloyd et al., 2014; Lloyd et al., 2015). The influence of competition in food prices is exerted through different factors, examples of which are the levels of concentration in the food sector, the penetration of private labels, the growth of discounters (Lloyd et al., 2015) or retailers' sophisticated and dynamic pricing strategies (Castellari et al., 2013). Despite the issue of the lack of comparable data, Lloyd et al. (2014) are able to correlate food inflation with two measures that proxy competition: barriers to competition in the retail sector and the market share of discounters. While both measures are correlated with food prices, only the first one shows the expected sign between the measure that proxies competition and food prices. They conclude that, even if research in this field has progressed recently, the impact of the characteristics of the food chain in food price inflation requires further research.

Recent research on the relation between agricultural commodity and consumer food prices in light of the recent developments in global markets focus on the EU (National Bank of Belgium (NBB), 2008; IMF, 2008a; IMF, 2008b; Davidson et al., 2011; Ferrucci et al., 2012). The general finding is similar —the magnitude of the impact of global commodity prices on consumer food prices is not strong. Research focused on the U.S. has been undertaken reaching similar conclusions (Leibtag, 2009; Richards and Pofahl, 2009; Berck et al., 2009) (see Section 2.2 for a more detailed review of some of this research).

Recent research on both horizontal and vertical price transmission usually focus on time series econometric techniques (Vavra and Goodwin, 2005; Hassounch et al., 2012; Lloyd et al., 2015). These techniques present a number of advantages such as that they correctly model the time-series properties of prices such as their usual nonstationary price behaviour, and that dynamic models, of which the vector autoregressive (VAR) model is the basic version, can take price endogeneity and deviations along time toward an equilibrium between prices into account (Listorti and Esposti, 2012). One drawback the approach may present as discussed earlier in this section is the lack in

many occasions of underpinning theoretical framework as acknowledged by Lloyd et al. (2015). These authors explain that while being able to capture price transmission, it is not easy to identify the exact explanatory variables driving the results.

Given the nature of the data used later in the analysis of price transmission, certain aspects of time series techniques pertinent to the research are reviewed. Error correction models (ECMs) and vector error correction models (VECMs) permit to adequately represent the co-integration between non-stationary time series—or how price series tend to move together (Hassouneh et al., 2012). These models are capable of measuring the long-run equilibrium relationship between price series and the short-run deviations from the long-run equilibrium. In other words, they are capable of measuring the extent to which prices are affected by a shock in the short term and their adjustment to their equilibrium in the long term (Baquedano et al., 2014). The first are conditioned to weak exogeneity between the cointegrating variables and to a single cointegrating relationship. The second, however, present the advantage of being able to model prices which are endogenously determined by each other (Baquedano et al., 2014) and permit to examine more than one cointegrating relationship.

These econometric techniques are capable of accounting for non-linear price behaviour such as threshold effects, policy interventions or asymmetries (see for example Hassouneh et al. (2012) for a discussion of non-linear VECMs including their theoretical background and estimating issues).

Welfare consequences of rising food prices on consumers in developed countries

The literature agrees on the fact that the impact of changes in food prices on consumer welfare in developed countries is limited because it depends on the share of food in total household income, which is on average relatively low (EC, 2008; Dewbre et al., 2008; Gilbert and Morgan, 2010; Huang and Wu Huang, 2012; Lloyd et al., 2015; Swinnen et al., 2013). However, it also points out that low-income households may be especially affected. For this reason, the literature evaluating the impact of increased food prices on consumers in developed countries usually pays

particular attention to the distributional effects and the impact on vulnerable segments of the population (see for example Huang and Wu Huang, 2012; Gregory and Coleman-Jensen, 2013; Grethe et al., 2012). The recent developments in agricultural commodity prices have coincided in time with other factors that have also affected consumer incomes and purchasing power across Europe and other developed countries, such as the rise in energy prices and the economic and financial crisis (Swinnen et al., 2013). The conjunction of all these factors and their relation to food demand and consumption, coupled with the rise in the number of the food insecure population reported by several European countries in recent years (Loopstra et al., 2015), have given rise to the acknowledgement that food insecurity might be increasing in the EU (Loopstra et al., 2015). Finally, changes in food prices may lead to shifts in consumption patterns to relatively cheaper and worse quality foods. This may affect the health of the population, as well as social policy responses (Lock et al., 2009). This subsection reviews the literature on the impacts of increased food prices on consumers in developed countries, with a particular focus on EU consumers, as well as the literature on the state of food and nutrition security in the EU.

Theoretically, increased food prices have two simultaneous effects on food consumption: the substitution effect and the income effect. The substitution effect implies that consumers respond to increased food prices by spending relatively less on the foods whose price has increased, while buying relatively cheaper goods. The income effect implies that as food prices rise, the expenditure devoted to other necessities such as health or education falls. While wealthier consumers respond to increased prices by spending more to buy what they would have purchased anyway (Dewbre et al., 2008), poorer consumers who spend a larger part of their income to food face increasing difficulty in finding substitutes to food. In this way, the share of food in households' total budget can be considered as an indicator of vulnerability to unexpected price changes (Ligon, 2008; Dorward, 2011; Schnepf, 2013; García-Verdú et al., 2012; Cockx et al., 2015).

The limited effects of changes in food prices on consumers in developed economies and their distributional effects are reflected in some papers. For example, Huang and Wu Huang (2012)

find that an increase in food and energy prices in the U.S. would give rise to substantial consumer welfare loss, especially for low-income households. Gregory and Coleman-Jensen (2013) find that the household participants of the Supplemental Assistance Program (SNAP, formerly Food Stamps) in the U.S. are more sensitive to food prices, while the effect on the food security status of nonparticipants is zero. Analogous results are obtained by Grethe et al. (2012), who assess the distributional effects of world price shocks on household income in Israel. As a result of increased world food prices, total household income falls. Income effects are progressive as higher income households experience larger income declines because they receive a lower share of transfer income from the government. However, the regressive effect on the expenditure resulting from high expenditure share in low-income households overcompensates the income effect. Thus, low-income households are more affected and the increase of food price skews the income distribution.

The EU is no exception when considering the limited effects of changes in food prices on consumers and the vulnerability of certain segments of the population. This view is supported by the fact that policy changes in response to the price surges of 2007/2011 in the EU have been relatively limited because effects have been limited (Swinnen et al., 2013). However, food and nutrition security in Europe has yet to be totally fulfilled and micronutrient deficiencies are still widespread (Cockx et al., 2015). The issue of vulnerability of certain countries and segments of the population to food security deserves particular attention especially when discussing the EU. Cockx et al. (2015) emphasize once more the difference existing between and within MSs and stress the special vulnerability of the new MSs, which generally have larger shares of food expenditure in household budgets. They identify lower socioeconomic groups, women and children, ethnic minorities and the elderly as populations in greater risk of being food insecure and acknowledge the large heterogeneity in social protection policies across MSs. Loopstra et al. (2015) ask themselves to what extent is food insecurity really increasing in the EU, while supporting the idea that it has increased in recent years. They identify the following factors following the economic recession as possibly driving the rise in food insecurity in Europe:

unemployment and debt and housing arrears, but recognise that they may affect differently different countries.

Because consumers respond to changes in relative food prices or income by shifting to relatively cheaper food products which may or may not result in worse quality diets (Ligon 2008; Lock et al., 2009), health and nutritional effects are an important cause of concern. The literature provides conflicting evidence as to whether more expensive food may result in worse diets or eating habits. On the one hand, it has been documented that the price of less healthy foods have risen less than the price of more healthy foods in the U.S and the U.K., making less healthy food more affordable and potentially leading to increased health inequalities (Monsivais and Drewnowski, 2007; Lock et al., 2009; Jones et al., 2014). Similarly, higher diet costs are related to nutrients associated with a lower risk of chronic disease (Aggarwal et al., 2012). On the other hand, Antentas and Vivas (2014) document significant changes in the composition of diets of Spanish consumers in response to the economic crisis, with a notable increase of legumes, fruits and vegetables and food consumed at home but also of low-quality foods.

Cockx et al. (2015) identify the prevalence of undernutrition and overnutrition as the main food and nutrition security problems that the EU currently faces. For the purpose of dealing with the increasing rates of overweight and obesity around the world, there is a growing body of literature that evaluates the effects of changes in relative food prices due to taxing in order to promote healthy diets (see for example Finkelstein et al., 2010; Lin et al., 2011; Briggs et al., 2013a,b; Manyema et al., 2014; Zhen et al., 2013; Ruff and Zhen, 2015).

Welfare consequences of rising food prices on households in developing countries

The literature focusing on the welfare effects of changes in food prices on households in developing countries is quite extensive. There are many studies that examine the short-term consequences of food price changes on welfare, and specifically on poverty and food and nutrition security all over the developing world. Even though the impacts on poverty can be diverse, a large part of this literature agrees on the fact that food price increases raise poverty in

most developing countries (Martin and Ivanic, 2016). D'Souza and Jolliffe (2012) identify the degree of price transmission, the dependence on food imports, whether staple foods are traded internationally, overall levels of productivity and whether households are net buyers or sellers of food amongst others as factors influencing these diversity of results. Impacts on food security and nutrition can be very diverse too. Estimates of food insecurity for the same country and period can vary greatly depending on the indicator used (see de Haen et al., 2011; Harttgen et al., 2016). This subsection reviews the literature on the welfare effects of increased food prices on households in developing countries.

The literature on the welfare effects of increased food prices in developing countries covers a broad range of impacts—including impacts on poverty and income distribution, food security and malnutrition. The conventional approach followed to measure the welfare impacts of increased food prices on poverty usually focuses on assessing these by means of a series of measures of the monetary value of food consumption or total expenditure (see for example Ivanic and Martin, 2008; De Janvry and Sadoulet, 2009; De Hoyos and Medvedev, 2011; Vu and Gleewe, 2011; Minot and Dewina, 2013). For example, Ivanic and Martin (2008) report that higher staple food prices impacts on poverty differ considerably by commodity and by country in 9 countries from different regions: Bolivia, Cambodia, Madagascar, Malawi, Nicaragua, Pakistan, Peru, Vietnam, and Zambia. Authors show that even if higher food prices can improve the situation of households that sell more than buy (net sellers), poverty increases more and more frequently than it falls—only households in Vietnam and Peru improve their situation. Vu and Gleewe (2011) show that higher food prices improve average household welfare in Vietnam but worsen the situation of most households. Average household welfare improves because welfare loss in households that experience welfare losses are smaller than the average welfare gain in households where there is a welfare gain.

The impact of increased price shocks on nutrition outcomes has been less investigated due largely to lack of data (Torlesse et al., 2003; Arndt et al., 2016). This literature that evaluates increased food price impacts on FSN measures uses different approaches. Some papers use calorie

consumption based indicators such as the prevalence of undernourishment to measure inadequate household food consumption as a proxy of poor nutritional status (see for example Jensen and Miller, 2008; D'Souza and Jolliffe, 2012; Anriquez et al., 2013). Jensen and Miller (2008) find a small decrease in calorie intake in response to food price increases in one of the provinces of China included in their study, while no decline in another province. D'Souza and Jolliffe (2012) find that food insecurity measured as per capita daily calorie intake worsens in Afghanistan during the 2007/2008 food crisis.

Other studies use anthropometric indicators to assess the actual nutritional status at the individual level in the face of price shocks. Anthropometric measures usually relate to the individuals' height or weight and are more commonly used to assess nutritional outcomes in children aged 0 to 5 (de Haen et al., 2011). The literature shows that the nutritional status of children is generally affected by changes in food prices. De Brauw (2011) shows that children's height for age (HAZ) in El Salvador declined in the face of the 2007/2008 food price increases and that this decrease in HAZ was lower in children from households with access to international migrants. For Mozambique, Arndt et al. (2016) find that children's weight for age (WAZ) and weight for height (WHZ) improve when food inflation is low, while the measures deteriorate when food inflation increases.

Some other authors use subjective self-reported food insecurity indicators to evaluate the impact of the 2007-2008 global food crises. These studies show contrasting results. Headey (2013) uses a self-reported food insecurity indicator from the Gallup World Poll (GWP) measured from 2005 to 2008 for 69 low- and middle-income countries. This study concludes that the food insecurity indicator remained the same or even improved for all the countries as a whole after the food price crises due to economic growth and limited food inflation in some large developing countries. This overall result conceals differences across and within countries because self-reported food security substantially decreases in some countries. Verpoorten et al. (2013) find that self-reported food security improves in 8 countries in SSA, while it worsens in 10 other SSA countries from 2005 to 2008. On average, rural households worsen their self-reported food security status while urban households improve theirs.

The welfare consequences of changes in food prices have been widely studied in SSA countries. For example, Abdulai and Aubert (2004a) examine the relationship between calorie demand and income in Tanzania. Abdulai and Aubert (2004b) analyze the relationship between food demand patterns, food prices and expenditures in Tanzania, including calories and other nutrients in the analysis. Ecker and Qaim (2011) focus on the prevalence of particular macro- and micronutrient deficiencies in Malawi as a result of income and price changes. Anríquez et al. (2013) evaluate undernourishment in selected countries, while Harttgen et al. (2016) simulate the impact of income and price shocks on Malawi's calorie availability and some poverty measures —poverty headcount, poverty gap and severity index (see Section 4.2 for a more exhaustive review of these studies on the impacts of changes in food prices on different measures of welfare in SSA).

Methodological approaches for the assessment of the welfare consequences of increased food prices

Some of the studies reviewed in the previous two subsections use food demand models to estimate price elasticities in order to later undertake a simulation based approach to evaluate the impact of increased food prices on different indicators of the welfare of consumers. For example, Huang and Wu Huang (2012) estimate a differential-form demand system, Lin et al. (2011) and Briggs et al. (2013a) estimate AIDS models, Abdulai and Aubert (2004a) use a QUAIDS model and Ecker and Qaim (2011) estimate a three-stage budgeting process that combines a Working-Leser model and QUAIDS models. However, Finkelstein et al. (2010) use a two-step marginal effect model where the resulting estimates are weighted means of the association between changes in price with changes in consumption. Other authors use previously estimated elasticities (for example Vu and Glewe, 2011; Anríquez et al., 2013; Briggs et al., 2013a; Manyema et al., 2014; Ruff and Zhen, 2015), while Harttgen et al. (2016) use a simple OLS regression to find the relationship between household calorie availability and income. Based on the estimated elasticities, different simulations are undertaken. Huang and Wu Huang, for example, estimate the compensating variation —the amount of money that has to be transferred to consumers after a price change to make them as well-off as it was before— while Lin et al. (2011) or Ruff and Zhen

(2015) simulate counterfactual weight outcomes after a price increase due to taxation (in addition to the simulated indicators already indicated in the review of the literature of developing countries).

While food demand models appropriately represent demand theory, they make several assumptions and are conditioned to the availability of detailed data on consumption or expenditure. One problem faced by food demand models is that they do not permit to include a large number of goods due to estimation limitations. Generally, several related assumptions are made to overcome this problem: a multi-stage decision process which is underpinned in weak separability of consumer preferences is assumed (Edgerton, 1997; Ecker and Qaim, 2011). Under a multi stage decision process and weakly separable preferences, expenditure is allocated within groups based on price indices and independently and the demand of certain goods is assumed to be independent of the demand of other goods respectively (Ecker and Qaim, 2011).

When specific data is not available, or the focus of the study is set on evaluating the impact of food price rises on self-reported food insecurity indicators, the approach followed is different. For example, Headey (2013) and Verpoorten et al. (2013) use survey-based ex-post analysis rather than simulations. Headey (2013) conducts econometric tests to determine whether trends in aggregated self-assessed food security are explained by changes in GDP and various food price indices. Verpoorten, however, use data at the individual level and conducts a multivariate probit analysis appropriate for the binary nature of the independent variable studied.

1.3 Objectives

The general objective of this thesis is to shed some light on the impacts of higher global or domestic food prices on welfare, both in the developed and the developing world. Specifically, the thesis focuses on the EU and Tanzania, as examples of the developed and the developing world.

The specific objectives of this thesis are the following: (i) evaluate how EU consumer food prices respond to changes in world agricultural commodity prices; (ii) investigate whether food prices

influence the prevalence of EU households that are unable to afford an adequate protein intake, and (iii) examine how an increase in the price of maize affects the nutritional status of the adult population of Tanzania in terms of the body weight and the BMI at the individual level and of the prevalence of underweight, the prevalence of overweight and the prevalence of obesity at the national level.

Section 1.2 reveals that there are still gaps in the literature related to the price transmission process in the EU and related to its determinants. It also reveals that to date no study covers all the EU MSs. The research aims to address the following questions as regards specific objective (i): do consumer food prices in the EU MSs respond to changes in world agricultural commodity prices; if they do, to what extent do food consumer prices respond to world agricultural commodity prices, and which are the potential implications of rising consumer food prices for the welfare of the EU, with a special focus on the vulnerable segments of the population. This part of the research will be dealt with in Chapter 2.

Section 1.2 reveals that food insecurity has risen in recent years in the EU. As of yet, it is unclear to what extent food insecurity has risen in the EU and there is some uncertainty about the factors that may drive it. The research aims to address the following question as regards specific objective (ii): do consumer food prices have an impact on the percentage of households suffering food deprivation. This part of the research will be dealt with in Chapter 3.

Section 1.2 reveals that the impact of increasing food prices on anthropometric outcomes in developing countries has been less investigated than on other indicators, especially on adults. Broadening the focus to cover the adult population can give critical insights into the population's nutritional status. The research aims to address the following questions as regards specific objective (iii): to what extent do changes in prices affect household food, and therefore calorie demand patterns; how do food consumption patterns and calorie intake at the household and at the individual level respond to a 20 percent shock to its main staple food —maize— basic to the country's food security; to what extent does the predicted change in calorie intake after the maize

price shock impact weight outcomes and the BMI at the individual level in the short- or medium-term; and how does the price shock impact the indicators of nutritional outcomes —the prevalence of underweight, the prevalence of overweight and the prevalence of obesity at the population level. This part of the research will be dealt with in Chapter 4.

1.4 Structure of the thesis

The thesis is structured in 5 independent chapters—including this one. Chapters 2, 3 and 4 are the main contributions of the thesis. Because each of them is an independent chapter, chapters 2, 3 and 4 are organized as independent documents. Figure 1.1 summarizes the structure of the thesis.

Chapter 1. Introduction

This section focuses on the motivation and context that has led to undertaking this research. It provides an overview of the general and specific objectives of the thesis and its main research questions and outlines each of the chapters comprising the research.

Chapter 2. Evaluating price transmission between global agricultural markets and consumer food price indices in the European Union

This section evaluates whether and to what extent food prices in the 28 EU MSs respond to changes in agricultural commodity prices in world markets, with a special focus on the consequences on welfare and poverty among the EU population. To do so, ECMs are developed using three different indices of world agricultural commodity prices, each defined by different commodities and weighting criteria—in order to capture possible differences in the process of price transmission across them—and a comprehensive set of shifters of supply and demand. The 28 MSs are analyzed from 2000 to 2012. The ECMs developed are country specific. The models permit to examine whether world agricultural commodity prices and consumer food prices have a long-term equilibrium relationship, the magnitude of this relationship and the speed at which consumer food prices adjust once again to equilibrium after a world agricultural commodity price

shock. Finally, possible similarities or differences across the EU MSs are evaluated in order to identify potential implications for the welfare of the EU population.

Chapter 3. Do increasing prices affect food deprivation in the European Union?

Once seen in the previous chapter that world agricultural commodity prices are related to consumer food prices at least for a number of EU MSs, this section explores whether increasing consumer food prices and the deviation of food prices relative to general consumer prices had an impact on EU households' food consumption, specifically on their access to an adequate protein intake. The period of analysis covers 2003-2011 which includes the food crisis of 2007-2008. The access to an adequate protein intake is defined by an indicator that measures whether households are able to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day. The indicator is measured in the EU-level survey, the EU Statistics on Income and Living Conditions (EU-SILC) provided by EUROSTAT. It has a binary outcome and it is examined using population-averaged panel data models estimated by the method of generalized estimating equations (GEE).

Chapter 4. The impact of food price shocks on weight loss: Evidence from the adult population of Tanzania

This section examines the potential impact of an increase in the prices of maize on the nutritional status of the adult population of Tanzania. The analysis focuses specifically on the impact of the price shock on body weight and the BMI at the individual level. The analysis exploits the 2010/2011 National Panel Survey for Tanzania (TZNPS) implemented by the National Bureau of Statistics of Tanzania (TNBS) and which is part of the Living Standards Measurement Study-Integrated Surveys in Agriculture (LSMS-ISA) project of the World Bank. This chapter goes beyond the previous two chapters and estimates in the first place a food demand model—a quadratic almost ideal demand model (QUAIDS)—that permits the analysis of substitution and complementary relationships within food items. Second, a 20 percent increase in the price of maize is simulated on the total household calorie intake. Third, as food consumption is collected

in the survey only at the household level and the aim of this section is to assess the impact of the price shock on anthropometric indicators at the individual level, the aggregate household change in calorie consumption is allocated across household members. Fourth, the change in calorie consumption at the individual level is converted into the corresponding change in body weight. To do so, a static and a dynamic calorie-to-weight models are used. The dynamic model has been developed recently by Hall et al. (2011) and applied by Lin et al. (2011) to assess the impact of taxing sugar-sweetened beverages on weight loss in the US. The change in body weight is applied to the initial body weight to predict the counterfactual weight after the shock. Finally, the last step allows to predict the counterfactual BMI and the prevalence of underweight, overweight and obesity at the national level after the price shock.

Chapter 5. Conclusions

This section concludes the thesis. It includes the main conclusions and findings of the thesis, identifies the limitations faced by the research, and addresses issues for further research.

Figure 1.1. Structure of the thesis

1.5 Research context

A part of this thesis is based upon research conducted from 2012 to 2015 at the Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM), of the Technical University of Madrid (UPM), within the framework of the EU ULYSSES project (Understanding and coping with food markets volatility towards more Stable World and EU food Systems). The project, which was funded by the European Commission (EC) under the 7th Framework Programme, was partnered with 6 institutions, Technical University of Madrid (Spain; UPM), Georg-August-University Göttingen (Germany), Wageningen University (The Netherlands), University of National and World Economy (Bulgaria), the Joint Research Centre (European Commission; JRC) and the United Nations Food and Agriculture Organization (FAO).

The ULYSSES project aimed at addressing the issue of food and agricultural markets instability from different perspectives: (a) volatility measures and drivers and market spillovers; (b) long term impacts: climate change, biofuels, macro effects and supply shocks; (c) value chain perspectives in both the EU and low income countries; (d) impacts on consumers in the EU, middle- and low- income countries, and (e) policy conclusions and recommendations. This thesis is framed specifically within the objective (d) of the project, impacts on consumers in the EU, and middle- and low-income countries.

In addition to the involvement in the ULYSSES project, two stays were carried out at the Food and Agriculture Organization (FAO) of the United Nations (UN), which contributed to the development and completion of the work conducted at the CEIGRAM. The first stay took place from February 2015 to May 2015 and the second one from November 2015 to November 2016. During the stays, work on the thesis research was conducted with the support of the method team of the MAFAP programme. They provided support in specific thematic and methodological areas. In addition to contribute to the completion of the work conducted at the CEIGRAM, the research conducted at FAO results in chapter 4 of the thesis. During the second stay, the completion of the thesis has been combined with the involvement in different projects which have contributed to

further increase my expertise mainly in household food and nutrition security analysis in different geographical contexts, and deepening my knowledge in household survey and QUAIDS analysis.

Table 1.1 lists the publications and presentations derived from the thesis.

Table 1.1. List of publications and presentations

Publications and presentations
Articles
García-Germán, S., Bardají, I., Garrido, A., 2016. Evaluating price transmission between global agricultural markets and consumer food price indices in the European Union. <i>Agricultural Economics</i> 47, 59-70.
García-Germán, S., Bardají, I., Garrido, A., 2016. Do increasing prices affect food deprivation in the European Union? Submitted.
García-Germán, S., Romeo, A., Magrini, E., Balié, J., 2016. The impact of food price shocks on weight loss: Evidence from the adult population of Tanzania. Submitted.
Book chapters
García-Germán, S., Morales-Opazo, C., Garrido, A., Magrini, E., Balié, J., Bardají, I., 2016. Impacts of increased food prices and volatility on households' welfare. In: Garrido et al. (Eds.), <i>Agricultural Markets Instability: revisiting the recent food crises</i> (pp. 98-114). London and New York: Routledge.
ULYSSES project deliverables
García-Germán, S., Morales-Opazo, C., Garrido, A., Demeke, M., Bardaji, I., 2013. Literature review of impacts of food price volatility on consumers in developed and developing countries. Working Paper 5.17, ULYSSES project, EU 7th Framework Programme, Project 312182 KBBE.2012.1.4-05, http://www.fp7-ulysses.eu/ , 51 pp.
García-Germán, S., Garrido, A., Bardají, I., 2014. Evaluating Transmission Prices Between Global Agricultural Markets and Consumers' Food Price Indices in the EU, Scientific paper 7A, ULYSSES project, EU 7th Framework Programme, Project 312182 KBBE.2012.1.4-05, http://www.fp7-ulysses.eu/ , 29pp.
García-Germán, S., Bardají, I., Garrido, A., 2015. Analysis of food deprivation in the EU under food prices volatility and rise. Scientific paper 10, ULYSSES project, EU 7th Framework Programme, Project 312182 KBBE.2012.1.4-05, http://www.fp7-ulysses.eu/ , 29 pp.

Conference proceedings and other conferences

García-Germán, S., Garrido, A., Bardají, I. Evaluating transmission prices between global agricultural markets and consumers' food price indices in the EU. Poster presentation. 14th Congress of the European Association of Agricultural Economists (EAAE), Ljubljana, Slovenia. August 26th-29th 2014.

García-Germán, S., Garrido, A., Bardají, I. Transmission of world agricultural prices to consumer prices in the EU. Presentation. Pre-congress workshop. Workshop 2: New developments in understanding price dynamics. 14th Congress of the EAAE, Ljubljana, Slovenia. August 26th-29th 2014.

Working papers

García-Germán, S., Romeo, A., Magrini, E., Balié, J., 2016. The impact of food price shocks on weight loss: Evidence from the adult population of Tanzania. DARE Discussion Paper 1611. University of Göttingen.

Chapter 2

Evaluating price transmission between global agricultural markets and consumer food price indices in the European Union

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Abstract. This paper uses error correction models to evaluate the extent to and speed at which world agricultural commodity price movements affect consumer food prices in the 28 European Union member states. We consider three types of world commodity price indices, each containing different commodities and weighting criteria. Results reveal a long-run relationship between world agricultural commodity and consumer food prices in over half of the member states. Consumer prices in different member states and categories of member states respond differently to specific world price indices, suggesting that there are disparities in the structure and the efficiency of their food markets. The eurozone founders generally have lower transmission elasticities. This should be taken into account when predicting the impacts of extreme world price volatility and consumer food price rises, prompting governments to pay attention to the most vulnerable households.

JEL classifications: E31, Q02, Q11, Q17

Keywords: Commodity prices; Consumer food prices; Error correction models; Price transmission; European Union

2.1 Introduction

The recent price surges and the increased volatility of agricultural commodity prices have resulted in a greater variability of consumer food prices around the world. Not only did EU food price variability increase but food prices also rose more than general consumer prices in OECD countries in recent years (McCorrison, 2014). The rise in consumer food prices has raised concerns about their potential effect on the welfare of the most vulnerable households (Beatty, 2010; Gregory and Coleman-Jensen, 2013; McCorrison, 2012) and on changes to less healthier eating habits (Antentas and Vivas, 2014; Jones et al., 2014).

To evaluate how movements in global agricultural commodity markets affect consumer welfare, we first have to assess the extent and speed of price transmission between world commodity and consumer food prices. The literature suggests that this relationship may not be overly strong (McCorrison, 2012) because the linkage is indirect passing through the EU agricultural markets and the food value chain. This price transmission is, on several grounds, usually incomplete, which moderates consumer food price instability (Gilbert and Morgan, 2010) (see Figure 2.1). The structure and efficiency of the food sector, an example of which are retailers' sophisticated and dynamic pricing strategies (Castellari et al., 2013), also affect the extent and speed of price transmission.

However, because EU agricultural market fundamentals are not identified as the major drivers or causes of world agricultural market instability (Brümmer et al., 2013; Chavas et al., 2014), the transmission of world prices to consumer prices in the EU warrants investigation. Besides, even though the impact on EU consumers will very much depend on the extent to which consumer food prices respond to agricultural commodity prices, the response is largely determined by the

relationship between world and domestic prices because of the limited use of trade policy in the EU in response to large swings of agricultural import or export prices.

The impact of increased food prices on the welfare of EU consumers may appear to be limited because food and raw commodity expenditure have a small share in overall consumer budgets and in the final retail product typical of these countries, respectively. Despite this, food's share in overall consumer expenditure is still considerable in low-income households in new and even in founding member states (MSs). In 2007, food expenditure's share in total household expenditure in the EU-27 as a whole stood at about the same level as in 2000 (14%). But among households in the lowest income quintile, food expenditure's share was above 20% in 2010 in Greece, the Czech Republic, Cyprus, Hungary, Slovakia, Poland, Estonia, Malta, Croatia, Latvia, Lithuania, Bulgaria, and Romania (García-Germán et al., 2015). There are also large differences in average per capita disposable income, ranging from €7,924 in Latvia to €29,847 in Luxembourg in 2012 (the EU-28 average is €20,085; Eurostat, 2014). Therefore, despite different eating habits and consumption patterns particular to each MS, the rise in consumer food prices could potentially aggravate the conditions of the poorest households.

To assess the effects of surges in and the volatility of world agricultural prices on consumer welfare, it is necessary to evaluate price transmission between agricultural and consumer food prices. The goal of this paper is to evaluate the extent to and speed at which world agricultural commodity price movements affect consumer food prices in the 28 EU MSs. We use Engle–Granger error correction models (ECMs) for each of the MSs, estimated using OLS Newey–West standard errors. This paper makes several contributions to the literature. First, all EU MSs are analyzed taking into account not only world agricultural commodity prices but also supply and demand shifters. Second, three different world commodity price indices are used to capture different impacts on the price transmission due to the coverage of commodities and the weighting structure used in their compilation. We do not focus on the price transmission of a particular agricultural commodity to a single food category along a specific supply chain but instead on an aggregate index of consumer food prices. Finally, we examine whether national currencies might

play a role in explaining the differences in both the consumer food price trends and the price transmission among EU MSs, as some are eurozone founding members since 2002, others joined later and nine still use national currency.

Figure 2.1. Evolution of the IMF's world agricultural price index and the EU's unprocessed food HICP.

Note: Author's elaboration based on EUROSTAT (unprocessed food) and author's calculations based on IMF (world agricultural commodity price).

The remainder of the paper is organized as follows. After reviewing the literature in Section 2.2, Sections 2.3 and 2.4 describe the methods and the data used to evaluate price transmission between changes in world market prices and consumer food prices in the different EU MSs, respectively. Section 2.5 reports and Section 2.6 discusses the results.

2.2 Literature review

Some papers have reviewed the recent evolution of food price inflation in the EU MSs¹. They point out the different food price inflation trends across MSs recently (Bukeviciute et al., 2009; Lloyd et al., 2013). Bukeviciute et al. (2009) suggested that the higher food price increases in the new MSs may be due to macroeconomic factors or differences in the functioning of the food chain. They considered that the appreciation of their national currencies could have debilitated the increase in consumer food prices in some new MSs: Czech Republic, Poland, Romania, and Slovakia. Lloyd et al. (2013) explained that these differences occur not only between EU-15 and EU-12 MSs but also within MSs belonging to EU-15. They concluded that, although price inflation levels and volatility have increased in EU-15 since 2007, they have decreased in EU-12. They identified the new MS transition process, the composition of consumer food expenditure, the importance of imports, the degree of market integration, exchange rates, agricultural policy, and market structure and market power as factors possibly explaining these differences.

¹ Throughout the chapter we consider Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the U.K. to be EU-15 MSs, whereas the EU-12 or new MSs are Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia (plus Croatia which acceded to the EU in 2013). MSs belonging to the eurozone are Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain (Latvia and Lithuania are considered as non-eurozone MSs rather than eurozone MSs here because they acceded to the eurozone in 2014 and 2015, respectively, which are not covered in the study period).

Some other papers evaluate price transmission from international or domestic agricultural commodity prices to consumer food prices in the EU. Bukeviciute et al. (2009) emphasized the differences in price transmission among EU MSs first between domestic agricultural commodity and producer food prices, and second between producer and consumer food prices. They found that the pass-through elasticities from domestic agricultural commodity to producer food prices range from 0.01 (Portugal) to 0.22 (Poland), whereas the long-term elasticities from producer to consumer food prices lie between 0.10 and 0.30. They suggested that several factors might have a bearing on the higher pass-through between producer and consumer food prices in the new MSs, such as the potential impact of indirect tax rises and higher energy prices on food prices, a larger share of agricultural input prices in final retail prices or price arbitrage, which could have pushed food prices upward in MSs with the lowest price levels. Besides, Ferrucci et al. (2012) using EU's agricultural commodity prices for those commodities produced in the EU instead of international prices found that there is a significant and long-lasting transmission of agricultural commodity prices to consumer prices in the eurozone. Using VAR models, they found that the cumulative elasticity of consumer food prices to domestic agricultural commodity prices lie between 0.33 and 0.38 after a year depending on the specification. Furthermore, Davidson et al. (2011) used a cointegrated VAR model to incorporate other factors, apart from world agricultural commodity prices, possibly affecting consumer food prices in the U.K. In this case, they found that there is a link between world agricultural commodity prices and retail prices that has a long-run transmission elasticity of 0.63. They claimed that retail food prices increase by 0.28% in the wake of a month-long 10% shock in world agricultural prices. If the shock lasts 18 months, retail food prices increase by 2.42%.

Finally, some studies of price transmission between world agricultural commodity prices and consumer food prices have been undertaken in the U.S. Leibtag (2009) concluded that the pass-through from commodity to consumer prices takes from four to 27 months at a rate of from less than 0.50% to nearly 7% depending on the respective food category. Kim and Ward (2013) found strong, though slightly decreasing overtime, price linkages and some evidence of asymmetries.

Rising prices are passed through more intensely than falling prices. Richards and Pofahl (2009) suggested that retail prices are influenced directly by changes in wholesale prices and indirectly as commodity inflation influences retailers' or wholesalers' pricing power. Finally, Berck et al. (2009) estimated the transmission of corn, wheat, and gasoline prices to retail cereals and chicken. They found a relatively high elasticity of cereal to flour of over one and of feed to chicken of 0.30. They attribute the rather high elasticities either to imperfect competition or data length inadequacy.

2.3 Modeling framework

The law of one price (LOP) states that markets linked by trade and arbitrage will have a same price after deducting transaction costs (Fackler and Goodwin, 2001). However, the transmission of movements in world agricultural commodity prices to consumer prices depends on both agricultural markets and the food value chain (Lloyd et al., 2013). The price transmission from world agricultural commodity prices (wp) to consumer food prices (cp) is augmented by exchange rates (e). Because we are evaluating price transmission from world agricultural commodity prices directly to consumer food prices, there are several additional costs apart from the linkages between agricultural commodity prices in different markets that should be considered so as not to overlook pass-through mechanisms. These costs include processing and retail costs², such as labor costs. Price transmission to consumer prices depends on the share of agricultural

² See Baquedano and Liefert (2014) for an explanation of this possible bias in price transmission between world and consumer food prices.

commodity costs in the total food product expenditure and the structure and efficiency of the food supply chain. Costs of processing and retail factors are proxied by a world crude oil price index (o) and by wages (w). Crude oil prices have been used in the literature to proxy food industry production and retail costs (Leibtag, 2009; Davidson et al., 2011).

Further, movements in food prices will to some extent affect demand, at least in MSs where food products have a large share in household expenditure. The unemployment rate (u) and economic growth (g) proxy demand. The unemployment rate has been used in the literature as a demand shifter (Davidson et al., 2011).

In order to evaluate the level of integration and the price transmission between world agricultural commodity prices and consumer unprocessed food prices in the EU MSs, we formulate ECMs between both price series for each EU MS. These models are augmented with several exogenous variables: the unemployment rate, the exchange rate, the world crude oil price index, wages and economic growth. The unemployment rate and economic growth are introduced in the models as demand shifters, whereas the exchange rate, the world oil price index and wages are introduced as supply shifters. The selection of shifters was somewhat conditioned by data availability, and other potentially important shifters such as changes in retail market concentration are not considered in the analysis.

Therefore, consumer prices in country i and period t are defined as follows:

$$cp_{it} = f(wp_t, e_{it}, u_{it}, o_t, w_{it}, g_{it}), \quad (2.1)$$

As discussed in Section 2.2, some authors consider that EU agricultural commodity prices should be used to evaluate price transmission in the EU (see, for example, Ferrucci et al., 2012 and Kanutin, 2012). They acknowledge that EU commodity prices incorporate the impacts of CAP measures and other schemes on agricultural prices and are therefore better for assessing price transmission within the EU. However, Davidson et al. (2011) use world commodity prices to

evaluate price transmission from world to retail prices in the U.K. in order to show the extent to which world markets influence retail prices. Our paper considers world prices too, since we want to assess the impact of the potential link between the volatility of world markets and consumer food prices on the most vulnerable consumers in the EU.

A parsimonious single equation ECM is derived from an autoregressive distributed lag (ADL) model. Using this type of price transmission models we can describe both the long-run equilibrium relationships and the short-run dynamics between world and consumer prices. They can estimate both the extent to which movements in agricultural commodity prices affect consumer prices and the time it takes for a shock in commodity prices to pass through to consumer prices (Baquedano et al., 2011).

It is hypothesized that causality runs from world agricultural commodity prices to consumer unprocessed food prices. Under the assumptions of weak exogeneity between the cointegrating variables and a single cointegrating relationship, the Engle–Granger single equation ECM promises to be a good approach for undertaking the analysis. It consists of a two-step estimation procedure.

An initial regression specifies the error correction term (ECT), which forms the vector of the stationary residuals of a linear combination of two or more integrated variables. The fact that the residuals of the first regression are stationary shows that there is cointegration between both price series. According to Engle and Granger (1987), if there is evidence of two or more series being cointegrated, then there should also be a valid error correction specification between the variables. The ECT is added to the second regression as a lagged regressor, thus defining a restricted form of the general ADL model (Baquedano and Liefert, 2014).

Therefore the approach is restricted to nonstationary and cointegrated price series of the same order of integration. To test for nonstationarity and the order of integration, augmented Dickey–Fuller (ADF) and Phillips-Perron (PP) stationarity tests are conducted on all analyzed series. After testing the data for nonstationarity, we check whether the disequilibrium errors or residuals of the

first regression are stationary in order to test for cointegration using the Engle–Granger method. The data nonstationarity issue will be dealt with later on by differencing the data. Tests results for stationarity and cointegration are included in Appendix A2 (Tables A2.1 and A2.2, respectively).

According to De Boef and Keele (2008), an exogenous variable may have both short- and long-run or only short-term effects on the endogenous variable in time series analysis. When the effects are short-term only, the consequences do not persist into the future. However, long-run effects are distributed across future time periods (De Boef and Keele, 2008). They claim that, in the long run, the behavior of the endogenous variable depends on the exogenous variable, and short-run changes in the outcome variable respond to deviations from the long-run equilibrium relationship. The lagged regressor of the ECT measures the speed at which the model returns to the long-run equilibrium following an exogenous shock. The first-stage regression, which defines the ECT or the long-run equilibrium relationship between both price series, is specified by the following equation, which in simple notation is country specific:

$$cp_t = \alpha + \varphi wp_t + \varepsilon_t, \quad (2.2)$$

where cp_t and wp_t are the natural logs of the consumer unprocessed food price index and the world agricultural commodity price index in time t , respectively, φ is the long-run price transmission elasticity of a change of consumer unprocessed food prices with respect to world agricultural commodity prices and ε_t are the residuals or the disequilibrium errors of the equation. To derive the ECM or second-stage regression, we start with the ADL model, which is defined as follows:

$$cp_t = \alpha_0 + \sum_i \alpha_1 cp_{t-i} + \sum_i \alpha_2 wp_{t-i} + \sum_i \alpha_3 e_{t-i} + \sum_i \alpha_4 u_{t-i} + \sum_i \alpha_5 o_{t-i} + \sum_i \alpha_6 w_{t-i} + \sum_i \alpha_7 g_{t-i} + \varepsilon_t, \quad (2.3)$$

where e_{t-i} , u_{t-i} , o_{t-i} , w_{t-i} and g_{t-i} are the natural logs of the exchange rate, the unemployment rate, the oil price index, wages and economic growth for the contemporaneous and lagged terms, respectively, and ε_t is the error term. We can derive an unrestricted single equation ECM by adding and subtracting lags of the variables in Eq. (2.3). The unrestricted model is defined by Eq. (2.4). Insignificant lags are eliminated to specify a more parsimonious model:

$$\begin{aligned} \Delta cp_t = & \beta_0 + \sum_i \beta_1 \Delta cp_{t-i} + \sum_i \beta_2 \Delta wp_{t-i} + \sum_i \beta_3 \Delta e_{t-i} + \sum_i \beta_4 \Delta u_{t-i} + \\ & \sum_i \beta_5 \Delta o_{t-i} + \sum_i \beta_6 \Delta w_{t-i} + \sum_i \beta_7 \Delta g_{t-i} + \varepsilon_t, \end{aligned} \quad (2.4)$$

where Δcp_{t-i} , Δwp_{t-i} , Δe_{t-i} , Δu_{t-i} , Δo_{t-i} , Δw_{t-i} and Δg_{t-i} are the first differences of the natural logs of the consumer unprocessed food index, the world agricultural commodity price index, the exchange rate, the unemployment rate, the world crude oil price index, wages, and economic growth for the contemporaneous and lagged terms, respectively. Equation (2.4) can be rewritten to incorporate the long-run relationship in Eq. (2.2). Thus the single equation ECM is specified as follows:

$$\begin{aligned} \Delta cp_t = & \delta_0 + \gamma(cp_{t-1} - \hat{\phi}wp_{t-1} - \hat{\alpha}) + \sum_i \delta_1 \Delta cp_{t-i} + \sum_i \delta_2 \Delta wp_{t-i} + \\ & \sum_i \delta_3 \Delta e_{t-i} + \sum_i \delta_4 \Delta u_{t-i} + \sum_i \delta_5 \Delta o_{t-i} + \sum_i \delta_6 \Delta w_{t-i} + \sum_i \delta_7 \Delta g_{t-i} + \varepsilon_t, \end{aligned} \quad (2.5)$$

where the expression $(cp_{t-1} - \hat{\phi}wp_{t-1} - \hat{\alpha})$ is the lagged ECT or the stationary residuals of Eq. (2.2) and γ is the speed of adjustment to equilibrium of the consumer unprocessed food index after a world commodity price shock. The speed of adjustment to equilibrium is the rate at which consumer unprocessed food prices return to equilibrium after a shock in agricultural commodity prices. According to Baquedano and Liefert (2014), cointegration is based not only on the residuals of Eq. (2.2) being stationary, but also on the adjustment parameter being different from zero.

The ECMs are estimated with Newey–West heteroskedastic standard errors in order to correct for autocorrelation and heteroskedasticity.

2.4 Data

Monthly price data spanning for most MSs the period from January 2000 to December 2012 are used in the price transmission models. In other cases, data intervals are shorter due to data unavailability, but they all cover the recent world agricultural commodity rises from 2007 to 2008, 2011 and 2012. The exceptions are Croatia (from December 2004 onwards) and Hungary and Romania (from December 2000 onwards).

Data for the unprocessed food harmonized index of consumer prices (HICP) were sourced from EUROSTAT (EUROSTAT, 2013)³. The unprocessed food HICP includes some subindices of the aggregate food index, namely, meat, fish, fruit, and vegetables. The monthly unprocessed food HICP is used instead of a more aggregate food HICP in order to minimize the underestimation of price transmission due to potential processing and retail costs not being taken into account.

As discussed previously, the literature suggests that different agricultural commodity indices may have different impacts on consumer food prices. Therefore we use three different monthly indices in order to capture differences in the integration and transmission of prices depending on the

³ See Table A1.1 of Appendix A1 for information on the agricultural commodities and the weighting scheme used to compile each index.

index used. Our study thus contributes to the literature by indicating which price indices are more appropriate for forecasting rises of consumer food prices in the MSs.

The three indices of world agricultural commodity prices used include one put together by the International Monetary Fund (IMF; IMF, 2013) and two compiled by the European Central Bank (ECB; ECB, 2013a)⁴. The two ECB indices⁴ differ in that one is weighted according to the eurozone import values and the other one is weighted according to the eurozone domestic demand or use. The world price index compiled by the IMF is a weighted average of individual commodity price indices, and weights depend on the relative trade volumes of each commodity compared to total world trade. Both ECB price indices cover the same range of 18 food commodities and their prices are world market prices. Both ECB indices, which are euro denominated, have been converted to U.S. dollars.

Figure 2.2 shows the evolution of the three world agricultural commodity price indices considered in the study. Note that the only change in the order of the three indices is in 2011 with the ECB's use-weighted index running above the IMF's index. The ECB's import-weighted index runs above the other two as of 2007.

⁴ See ECB (2008) for information on the ECB world price indices.

Figure 2.2. Evolution of the world agricultural commodity price indices used in the study (2005=100). (ECB indices have been converted into USD).

Note: Author's elaboration based on IMF and ECB.

Using the import-weighted index we can forecast price developments of imported commodities in order to single out how world imports affect price transmission toward consumer markets. Further, as we are evaluating price transmission at the consumer level, the use of a weighting scheme that is more comparable to consumption patterns in EU MSs could yield information on how EU consumer-level markets are integrated with international markets, taking into account that domestic prices should, to some extent at least, move in parallel with international prices. Finally, the analysis should also include an index weighted according to relative trade values in world markets.

The monthly unemployment rate was sourced from the ECB (ECB, 2013b) and the monthly world crude oil price was sourced from the IMF. Monthly exchange rates for each currency were sourced from OANDA (OANDA, 2015), considering the dollar to euro exchange rate or dollar

against national currencies for MSs not belonging to the eurozone. Wages were taken from different sources and were, in some cases, proxied by average hourly earnings, giving priority to monthly data. Monthly average hourly earnings were sourced from the OECD (OECD, 2015) and monthly wages or hourly earnings were sourced from different statistical offices (Croatian Bureau of Statistics, 2015; Republic of Bulgaria National Statistics, 2015; Statistics Estonia, 2015). Whenever monthly data were not available, quarterly data on wages or hourly earnings were sourced from EUROSTAT (EUROSTAT, 2015b) or the OECD. Economic growth was measured by the quarterly GDP at market prices and was sourced from EUROSTAT (EUROSTAT, 2015a). All variables are expressed in terms of natural logs, so the estimated coefficients are elasticities.

Figure 2.3 compares the evolution of the unprocessed food HICP for selected groups of MSs — France and Spain, Poland and Romania, Finland and Sweden, and Germany and the Netherlands— with the IMF world food price index trends. Because of the differences in both the evolution of food prices and the transmission of prices among MSs discussed in Section 2.2, the graphs grouped MSs geographically in order to reveal their similarities or differences.

Figure 2.3. Evolution of the unprocessed food HICP for groups of selected MSs: France, Portugal and Spain, Czech Republic, Poland and Romania, Denmark, Finland and Sweden and Belgium, Germany and the Netherlands (2005=100).

Note: Author's elaboration based on EUROSTAT (unprocessed food HICP) and IMF (world agricultural commodity price index).

As the first panel in Figure 2.3 shows, the trends in the unprocessed food HICP differ in France and Spain. Spain's unprocessed food HICP shows a sharp upward trend in the early part of the period, which slows down later on. From 2004 onwards, the trends for both countries become more alike. Consumer prices in the other Mediterranean countries that are not included in the graphs —Greece, Italy, and Portugal— appear to develop along similar lines to France, although the comparable trend in the Greek index is more variable, and Portugal's slows down slightly at the end of the period. As for the Mediterranean MSs that recently acceded to the EU, the consumer indices for Cyprus, Malta, and Slovenia appear to pick up slightly after 2007, whereas of the trends of Croatia appear to be similar to France's or Italy's. The second panel in Figure 2.3,

covering selected Eastern European countries, shows that food prices in Poland and Romania also evolve according to different patterns. Note that the trend for the two indices are rather different until 2004. As for the other Eastern European MSs, the trend in Slovakia's index is similar to France's or Italy's, although it is slightly more volatile, Estonia's index is similar to Cyprus's, Malta's, and Slovenia's. The trend in Bulgaria's index is very like Poland's, whereas, compared to Poland's index, Hungary's, Latvia's, and Lithuania's indices appear to pick up as of around 2006. Finally, the trend in the Czech Republic's index appears to be more variable than Poland's.

Finally, the third and fourth panels of Figure 2.3 show selected MSs in Northern Europe and Western Europe, respectively. In this case, the trends for the Northern European MSs —Finland and Sweden— are more alike (the same applies to Denmark, which was not included in the graphs), although Finland's index appears to rise faster than the other two toward the end of the period. As for the Western European MSs, the consumer indices appear to behave quite similarly in both the MSs that are illustrated —France, Germany, and the Netherlands— and not illustrated —Austria, Belgium, and Luxembourg— in the graphs. The trends for Ireland and the U.K. differ somewhat from the other Western European MSs. The consumer price index for Ireland slows down from 2008 onwards, whereas the index for U.K. speeds up.

2.5 Results

The unit root tests were estimated for all series used in the analysis both in levels and first differences of natural logs in order to test for the order of integration (see results in Table A2.1 of Appendix A2). The three world agricultural commodity price indices and the crude oil price index are nonstationary in levels and integrated of order one. Country exceptions are Ireland and Romania for the unprocessed food HICP, which are stationary in levels, Romania for the exchange rate, which is stationary in levels, Finland and Germany for the unemployment rate, which are nonstationary in first differences, and Austria, Belgium, Greece, Luxembourg, Portugal, and Romania for wages, which are stationary in levels.

The Engle–Granger cointegration tests between each of the three world agricultural commodity price indices and the unprocessed food HICP show that world commodity markets are cointegrated with consumer unprocessed food prices in some MSs (see results in Table A2.2 of Appendix A2). The cointegration tests performed with the IMF world index yield a higher number of MSs whose consumer prices are cointegrated with world prices. However, fewer MSs have consumer prices that are cointegrated with world markets when the cointegration tests are performed using the ECB price indices.

Table 2.1 shows the price transmission elasticities of the first and second-stage regressions with each of the world agricultural price indices. For the sake of brevity, we merely report parameters wp_t and ECT_{t-1} and whether or not the estimated short-term coefficients of parameter Δwp_t are significant. Parameter wp_t is the long-run price transmission elasticity of world agricultural commodity prices to consumer unprocessed food prices yielded by the first-stage regression. The other two parameters included in Table 2.1 were output in the second-stage regression. Note that Tables A2.3, A2.4, and A2.5 which also include whether or not the estimated short-term coefficients for supply and demand shifters are significant and the median lag lengths are available in Appendix A2⁵.

⁵ For brevity's sake, we merely report these results but all the results are available upon request.

Table 2.1. Price transmission elasticities for each MS with the three world price indices.

MS	IMF's index			Import-weighted ECB's index			Use-weighted ECB's index		
	ECT _{t-1}	WP _t	Δwp _t	ECT _{t-1}	WP _t	Δwp _t	ECT _{t-1}	WP _t	Δwp _t
Austria	-0.154*** (0.045)	0.252*** (0.018)	+	-0.153*** (0.036)	0.207*** (0.012)	+	-0.168** (0.027)	0.236** (0.012)	+
Belgium	-0.131*** (0.032)	0.259*** (0.020)	+	-0.224*** (0.040)	0.222*** (0.012)	+	-0.092** (0.029)	0.238** (0.018)	+
Bulgaria	-0.081** (0.033)	0.560*** (0.051)	+	-0.097*** (0.023)	0.457*** (0.046)	+	-0.102*** (0.016)	0.471** (0.039)	+
Croatia	-0.107*** (0.031)	0.254*** (0.030)	+						
Cyprus	-0.228*** (0.046)	0.609*** (0.027)	+	-0.159*** (0.046)	0.496*** (0.022)	+	-0.079*** (0.026)	0.506** (0.033)	+
Denmark	-0.153*** (0.024)	0.195*** (0.015)	+	-0.122*** (0.019)	0.161*** (0.015)	+			
Estonia	-0.037** (0.018)	0.467*** (0.037)	+	-0.064*** (0.020)	0.389*** (0.030)	+	-0.047** (0.018)	0.434** (0.033)	+
Finland	-0.079* (0.045)	0.239*** (0.027)	+						
France	-0.134*** (0.027)	0.231*** (0.015)	+	-0.098*** (0.025)	0.187*** (0.010)	+	-0.094*** (0.021)	0.217** (0.016)	+
Germany	-0.080*** (0.029)	0.174*** (0.023)	+	-0.095*** (0.025)	0.142*** (0.018)	+	-0.072*** (0.023)	0.162** (0.019)	+
Greece	-0.094** (0.041)	0.257*** (0.038)	+	-0.049 (0.036)	0.200*** (0.025)	+	-0.101* (0.057)	0.223** (0.030)	+
Hungary	-0.037* (0.021)	0.777*** (0.041)	+	0.010 (0.024)	0.625*** (0.033)	+	-0.000 (0.012)	0.710** (0.036)	+
Italy	-0.046*** (0.013)	0.256*** (0.024)	+	-0.05*** (0.014)	0.207*** (0.019)	+	-0.047*** (0.008)	0.234** (0.022)	+
Latvia	-0.049***	0.782***	+						

	(0.016)	(0.044)							
Luxembourg	-0.041***	0.263***	+	-0.027*	0.219***	+	-0.063***	0.248**	+
	(0.010)	(0.021)		(0.015)	(0.019)		(0.013)	(0.023)	
Malta	-0.105***	0.440***	+	-0.124***	0.356***	+	-0.134***	0.407**	
	(0.019)	(0.046)		(0.019)	(0.036)		(0.027)	(0.037)	
Netherlands	-0.113***	0.169***	+	-0.123***	0.139***	+	-0.153***	0.157**	
	(0.025)	(0.023)		(0.023)	(0.016)		(0.026)	(0.018)	
Poland	-0.101***	0.367***	+	0.003**	0.286***	+	-0.081**	0.344**	+
	(0.037)	(0.034)		(0.015)	(0.026)		(0.040)	(0.028)	
Portugal	-0.117***	0.113***	+	-0.098***	0.102***	+	-0.111***	0.101**	+
	(0.020)	(0.015)		(0.022)	(0.018)		(0.019)	(0.013)	
Slovakia	-0.124***	0.186***	+	-0.141**	0.168***	+	-0.227***	0.196**	+
	(0.027)	(0.021)		(0.034)	(0.019)		(0.030)	(0.020)	
Slovenia	-0.139***	0.348***	+	-0.139**	0.284***	+	-0.118***	0.322**	+
	(0.025)	(0.029)		(0.002)	(0.021)		(0.024)	(0.024)	
Spain	-0.033***	0.357***	+	-0.026**	0.293***	+			
	(0.008)	(0.035)		(0.008)	(0.034)				
Sweden	-0.119***	0.227***	+	-0.093**	0.185***	+			
	(0.027)	(0.023)		(0.023)	(0.018)				

Note: WP stands for world agricultural commodity price index, u for unemployment rate, e for exchange rate, o for world oil price index, w for wages and g for economic growth. Newey-West standard errors in parentheses. The table only includes MSs in which the consumer price index is I(1) and the residuals of Equation (2) are stationary. + means that, at the 5% level at least, the null hypothesis can be rejected in at least one lag (insignificant lags have been eliminated to specify a more parsimonious model). *** p<0.01, ** p<0.05, * p<0.1

The parameters of the long-term price elasticities are positive, as expected and fall within the expected interval of 0 to 1. The parameters of the ECT_{t-1} are in most cases significantly different from zero and negative, as expected. A value of 0 would imply that there is no long-run relationship, while a value of 1 would imply that consumer prices adjust immediately to their long-run equilibrium following a shock in world prices.

As stated in Section 2.3, the cointegration of two series is dependent not only on the residuals of Eq. (2.2) being stationary but also on the adjustment parameter being different from zero (Baquedano and Liefert, 2014). Table 2.2 shows the MSs for which the residuals in the first-stage regression are stationary and the adjustment parameter yielded in the second-stage regression is significant. These are the MSs for which there is a causal long-run relationship between world agricultural commodity prices and consumer food prices. Table 2.2 divides the MSs for which there is a causal long-run relationship between price series into four categories: (a) MSs which are founding eurozone members; (b) MSs that have recently acceded to the eurozone; (c) MSs which do not belong to the eurozone (other non-eurozone MSs), and (d) a separate category for Denmark, Sweden, and the U.K. (these MSs are classified separately on account of being EU-15 MSs but not belonging to the eurozone). In most of the MSs where the residuals of the first-stage regression are stationary, the adjustment parameters are significantly different from zero, the exceptions being Finland and Hungary for the IMF index; Greece, Hungary, and Luxembourg for the ECB's import-weighted index; and Greece and Hungary for the ECB's use-weighted index.

When considering price transmission between the IMF's index and the unprocessed food HICP, there is a long-run relationship between both price series in 21 out of the 28 MSs. When considering the ECB's import-weighted index, 18 MSs show a long-term relationship between both price series. Finally, when considering the ECB's use-weighted index, 15 MSs exhibit a long-term relationship between both price series.

Regardless of the world agricultural commodity price index used, the consumer prices of seven eurozone founding MSs (Austria, Belgium, France, Germany, Italy, the Netherlands, and Portugal), five MSs that recently acceded to the eurozone (Cyprus, Estonia, Malta, Slovakia, and Slovenia) and two MSs that do not belong to the eurozone (Bulgaria and Poland) are always integrated with world markets.

Table 2.2. Summary of MSs which, according to the Engle-Granger cointegration test results and the ECMs, are cointegrated (numbers in parenthesis show the number of MSs that are cointegrated or non-cointegrated over the number of MSs belonging to the group)

		Alternative world price index		
		IMF's WP	ECB's import-weighted WP	ECB's use-weighted WP
Eurozone (12)*	Cointegrated	Austria, Belgium, France, Germany, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain (10/12)	Austria, Belgium, France, Germany, Italy, Netherlands, Portugal, Spain (8/12)	Austria, Belgium, France, Germany, Italy, Luxembourg, Netherlands, Portugal (8/12)
	Non-cointegrated	Finland (1/12)	Finland, Greece, Luxembourg (3/12)	Finland, Greece, Spain (3/12)
Recently acceded to eurozone (5)	Cointegrated	Cyprus, Estonia, Malta, Slovakia, Slovenia (5/5)	Cyprus, Estonia, Malta, Slovakia, Slovenia (5/5)	Cyprus, Estonia, Malta, Slovakia, Slovenia (5/5)
	Non-cointegrated	-	-	-
Non-eurozone (8)*	Cointegrated	Bulgaria, Croatia, Latvia, Poland (4/8)	Bulgaria, Poland (2/8)	Bulgaria, Poland (2/8)
	Non-cointegrated	Czech R., Hungary, Lithuania, (3/8)	Croatia, Czech R., Hungary, Latvia, Lithuania (5/8)	Croatia, Czech R., Hungary, Latvia, Lithuania (5/8)
Denmark, Sweden, UK (3)	Cointegrated	Denmark, Sweden (2/3)	Denmark, Sweden (2/3)	-
	Non-cointegrated	UK (1/3)	UK (1/3)	Denmark, Sweden, UK (3/3)

Note: WP stands for world agricultural commodity price index. CP stands for unprocessed food HICP. The table only includes MSs with non-stationary unprocessed food HICP. The eurozone heading refers to founding MSs (plus Greece which acceded in 2001). The recently acceded to eurozone heading refers to Slovenia, Cyprus Malta, Slovakia and Estonia. The non-eurozone heading refers to Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Lithuania, Poland, and Romania. *Ireland and Romania are not included because the unprocessed food HICP series are stationary.

The magnitude of the long-run price transmission elasticities reported in Table 2.1 are slightly higher for models estimated using the IMF's world price index, followed by models estimated using the ECB's use-weighted index. The slightly greater magnitudes of the elasticities when using the IMF's world price index than when using the other two indices may be a consequence of the index commodity coverage: the commodity index compiled by the IMF accounts for seafood as separate from other commodities, whereas the unprocessed food HICP comprises the

fish category. Elasticities should therefore be higher when considering the IMF's index. Differences in commodity coverage may bring to light different commodity-specific transmission channels.

The slightly higher magnitudes of the elasticities yielded by the use-weighted index than the import-weighted index maybe a consequence of it using a weighting structure that is better adapted to the HICP. The use-weighted index is defined as an indicator of the demand for commodities in the eurozone, and it therefore fits the HICP better. For this reason, the use-weighted index may be more consistent with consumer consumption patterns than the import-weighted index.

The magnitude of the long-term elasticities depends on the MS in question. The magnitudes of the long-run price transmission elasticities of the eurozone founding members are quite similar and smaller than those of the new MSs (as shown in Table 2.1). These long-term elasticities show a small magnitude for price transmissions in traditional eurozone MSs. Of the non-eurozone MSs, Denmark and Sweden have long-term elasticities which lie within the ranges of the eurozone founding members referred to above. Our results are consistent with Bukeviciute et al.'s findings (2009) in that long-term price transmission elasticities vary across MSs and are generally greater in the new MSs than in eurozone MSs.

The average size of retail firms selling food, beverages, and tobacco in nonspecialized and specialized stores in the traditional eurozone MSs is generally bigger than in the new MSs⁶, suggesting that firms in traditional eurozone MSs may be more concentrated than in the new MSs (as suggested by Bukeviciute et al., 2009), leading to a less competitive market. Besides, commodity costs in the traditional eurozone MSs account for a smaller proportion of the final product (Bukeviciute et al., 2009), which is consistent with having smaller magnitudes of elasticities.

Of the five MSs which have recently acceded to the eurozone (Cyprus, Estonia, Malta, Slovakia, and Slovenia), only the long term price transmission elasticities of Slovakia and Slovenia lie within the previously stated ranges regardless of the world index used. The others have higher long-term price transmission elasticities. As for the non-eurozone MSs, they all, with the exception of Croatia, have higher long-term equilibrium relationships than reported for the traditional EU MSs (as shown in Table 2.1).

According to Davidson et al. (2011), an appreciation (depreciation) in the value of the currency against the dollar is associated with a fall (rise) in retail food prices. Eurozone MSs have mainly negative, although some positive, exchange rate transmission parameters when considering the IMF's index. On the other hand, other non-euro MSs, except Poland, generally have positive exchange rate transmission parameters (according to Bukeviciute et al., 2009, currency

⁶ Source: Own calculations based on Structural Business Statistics (SBS) data from EUROSTAT (EUROSTAT, 2015c) (see Appendix A3)

appreciation might have debilitated the increase of food prices in Poland). An appreciation of the currency would immediately reduce the impact of higher international agricultural commodity prices on domestic food prices (Lustig, 2012). Further, the short-term impact of the contemporaneous and lagged variables is ambiguous because they have opposite signs and similar magnitudes. Despite this, supply and demand shifters are significant for most MSs, showing that they are relevant in the price transmission process (as shown in Tables A2.3, A2.4, and A2.5 of Appendix A2).

In evaluating the estimated adjustment parameters, the results show that consumer unprocessed food prices run back to equilibrium very slowly after a shock in world commodity markets. This means that it takes months for consumer prices to take up world agricultural commodity price movements. The median lag length, which indicates how long it takes consumer food prices to reach the mid-point of their adjustment to their long-run equilibrium relationship with world agricultural commodity prices, also shows varying effects depending on the MS (see Tables A2.3, A2.4, and A2.5 of Appendix A2). Within MSs in which there is a long-term relationship, the lowest median lag lengths are, depending on the world index used, for Belgium, Cyprus, and Slovakia and the highest for Spain. It has again been observed in the literature that it takes consumer prices, even for perishable products as is this case, several months to respond to agricultural commodity prices.

2.6 Conclusions

This paper evaluates the extent of price transmission between world agricultural markets and consumer food prices in the EU-28 MSs using three different world agricultural commodity price indices and controlling for certain supply and demand shifters.

It is reasonable to expect that agricultural commodity price rises will in turn increase consumer food prices at least to some extent. The results show that there is a long-term equilibrium relationship between consumer and world market prices in half of the MSs irrespective of the world index used and in up to 21 MSs if using the IMF's index. We find differences among MSs

not only with respect to the integration between world and consumer markets but also regarding the extent and speed of the effect of agricultural commodity price movements on consumer food prices within integrated markets. When MSs are grouped into different categories according to eurozone membership, it becomes clear that MSs behave quite similarly. Even though there is a relationship in many MSs, both the extent and speed at which they, and especially eurozone MSs and founding members, return to equilibrium is insubstantial. Supply and demand shifters are significant in most cases, which shows that they play a key role in the process of price transmission between global and consumer prices.

These results are consistent with Bukeviciute et al.'s findings (2009) as regards the fact that long-term price transmission elasticities vary across MSs and are generally higher in the new MSs than in the eurozone founding MSs. Contrary to our findings, Davidson et al. (2011) report a cointegrating relationship between agricultural commodity prices and retail prices in the U.K. This might be due to time frame differences and the use of a food retail index instead of the unprocessed food HICP used here.

The IMF's world price index was found to be integrated with consumer prices in more MSs than the other world price indices probably because its commodity coverage more closely resembles the HICP structure analyzed in this paper. This suggests that the IMF-compiled world agricultural commodity price index might be better at assessing price transmission to the unprocessed food consumer index in terms of both the number of MSs that have cointegrated food prices and the extent of price transmission. Besides, the indices compiled by the ECB are specifically designed for use in the eurozone, and most of the MSs in which consumer prices are cointegrated with the IMF's world index and not with either or both of the ECB indices are non-eurozone MSs. This means that ECB indices are more relevant for eurozone MSs and less so for other MSs.

World food prices grew by 70% during 2007 and 2008 and then again by 50% in 2011 and 2012, which was followed by drop of about 30%. With transmission elasticities of 0.2 or below, these growth rates will translate into food price increases of 14% and 10% or less, whereas the

increases are at least 2.5 times larger with elasticities above 0.5. Thus, while the impact of increased price levels and volatility of world agricultural commodities on food prices is limited and temporary, increasing food prices in some MSs may have an effect on the consumption and health of households that spend a large share of their income to food. MSs whose households in the lowest income quintile spend a larger share of their income on food consumption (>20% and up to 30% in Bulgaria, Estonia and Romania) generally have larger transmission elasticities (>0.4).

Further research is needed to investigate other additional variables that should be introduced into the price transmission analysis, including competitive market structures in the food sector which might provide a deeper understanding of the differences in price transmission among EU MSs. Finally, more empirical analyses of microdata are needed to give a clearer picture of how consumers react to increasing consumer food prices and how retailers respond with sales, packaging sales and private labels in order to evaluate the welfare effects of agricultural market volatility. Policies could be better targeted to consumers that perhaps enjoy narrower and less competitive purchasing choices because of lower mobility or low population density.

Chapter 3

Do increasing prices affect food deprivation in the European Union?*

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Submitted

* This chapter is based on data from European Commission, Eurostat, EU Statistics on Income and Living Conditions [EUSILC LONGITUDINAL UDB 2005 - version 2005-1 from 15-09-07; EUSILC LONGITUDINAL UDB 2006 - version 2006-2 from 01-03-2009; EUSILC LONGITUDINAL UDB 2007 - version 2007-5 from 01-08-2011; EUSILC LONGITUDINAL UDB 2008 - version 2008-4 from 01-03-2012; EUSILC LONGITUDINAL UDB 2009 - version 2009-4 from 01-03-2013; EUSILC LONGITUDINAL UDB 2010 - version 2010-4 from 01-03-2014; EUSILC LONGITUDINAL UDB 2011 - version 2011-2 from 01-03-2014]. EUROSTAT has no responsibility for the results and conclusions. The responsibility for all conclusions drawn from the data lies entirely with the author(s).

Abstract. The recent rise of prices of agricultural commodities was followed by increased consumer food prices around the world. More expensive food had an impact on consumers, not only in developing countries but also amongst the most vulnerable in developed countries. Using a longitudinal database from the Statistics on Income and Living Conditions and population-averaged models, we test whether increasing food prices had an impact on European Union households' access to an adequate protein intake. Results reveal a significant relationship with the consumer food price index and disposable income. Households in the lowest income quintile in the member states recently acceded to the European Union are the most vulnerable to food deprivation.

JEL classifications: I31, I32, I38, Q18

Keywords: Consumer food prices; Food deprivation indicator; Consumers well-being; Food crises; European Union

3.1 Introduction

Between 2007 and 2012 food prices in the European Union (EU) rose more rapidly than general consumer prices (McCorriston, 2014). Food price increases change consumers' eating habits and purchasing strategies (Beatty, 2010; Antentas and Vivas, 2014). The literature on food access and consumption has focused mostly on developing countries, but a few authors have focused on food consumption, demand and poverty in the U.K. (Beatty, 2010; Jones et al., 2014), the U.S. (Huang and Wu Huang, 2012; Gregory and Coleman-Jensen, 2013; Nord et al., 2014), Spain (Antentas and Vivas, 2014), and Israel (Grethe et al., 2012) amongst others. This literature shows that poverty is associated with the consumption of lower quality goods and that the rise of consumer food prices worsens food security (Gregory and Coleman-Jensen, 2013). Recently, Jones et al. (2014) have shown that healthier food items are significantly more expensive than unhealthy items, suggesting that the price of food might be a major driver of the increase of unhealthy diets in Britain.

Whether or not expensive food may result in worse diets or eating habits (Jones et al. (2014) and Antentas and Vivas (2014) provide conflicting evidence), it can potentially affect other components of households' material well-being. Investigating both spheres of the households' well-being is complex because consumer food price indices do not provide an accurate view of the actual cost of food items paid by consumers, and because the indirect effect of increasing food prices is not easy to measure. Castellari et al. (2013) have shown that retailers in Italy, and most likely in all high-income and middle-income countries too, develop very sophisticated retailing strategies using private labels, special sales and packaging discounts. This is not generally captured in consumer price indices (Dorward, 2011). As to the indirect or second-order effects, the literature has shown abundant evidence of substitution effects within food items groups and across them, but very limited about changes in the consumption or access to other goods caused by food price increases.

The goal of this paper is to test whether increasing food prices had an impact on EU consumers' food deprivation during the food crises of 2007-2008 and 2010-2011. Using the EU Statistics on Income and Living Conditions (EU-SILC), which has cross-section and longitudinal household panels covering the period 2003-2011, we are able to test whether the proportion of EU households suffering some level of material deprivation, specifically in affording a sufficient protein intake, is affected by increasing consumer food prices. To our knowledge, this is the first attempt to study the impacts of food access in the EU caused by the food crises of 2007-2008, with such a detailed and large database of households.

The remainder of the paper is organized as follows. Next section reviews the literature on food consumption and food prices. Sections 3.3 and 3.4 describe the data and the modeling framework and methods used to evaluate the impact of the rise of food prices on food consumption in the EU, respectively. Section 3.5 briefly characterizes statistically the data, section 3.6 presents the results and finally, in the last section, conclusions are synthesized.

3.2 Literature review

Based on the 2012 Household Budget Survey in Spain, Antentas and Vivas (2014) documented that Spanish consumers confronting higher food prices reduce more the expenditures on other goods (-3.2 percent) than on food (-0.2 percent). The economic crisis (2008-2013) caused 41.2 percent of households to decrease their food expenditures, but almost 70 percent reduced the consumption of gas, 64.2 percent of clothes, 69.9 percent in leisure and 66.1 percent in holidays. These authors also report significant changes in the composition of diets, with a notable increase of legumes, fruits and vegetables, food consumed at home and low-quality food items.

Using a partial equilibrium model (AGLINK-COSIMO), Dewbre et al. (2008) concluded that, because consumers react to changes in relative prices of food by shifting to those food products that are relatively cheaper, the changes in the price of a consumption bundle are smaller than would be implied by projected world agricultural commodity price impacts.

The European Commission (2008) conjectured that the effect of higher expenditure devoted to food on the purchasing power and standard of living of consumers in the EU is small because of the relatively low share of food in total household expenditure. However, there are large differences in the share of income spent on food across EU member states (MSs) and even across income classes within each MS. Food price inflation behaved quite differently across MSs, and disposable income differed in 2012 from €7,924 in Latvia to €29,847 in Luxembourg (the average in EU-28 is €20,085; EUROSTAT, 2014). Food demand and consumption is not only a function of income, but also of income distribution (Cirera and Masset, 2010). Grethe et al. (2012), using a CGE model and the Social Accounting Matrix of Israel, assessed the distributional effects on domestic household income of high agricultural prices, showing that the food price shocks would have regressive effects.

As food prices rise, the expenditure devoted to other necessities, such as health or education, falls, hurting poor households. As a consequence the share of food in households' total budget can be considered an indicator of vulnerability to price changes (Dorward, 2011; Schnepf, 2013; García-

Verdú et al., 2012). These authors claimed that the impact of food prices should be better identified by movements of the Engel curve than with models of food demand. The Engel curve is a regularity in economics, which establishes that the percentage of income spent on food consumption diminishes with growing disposable income. It may be the case that poor consumers do not respond to increasing food prices reducing food consumption, but diminishing the consumption of other goods. We may thus observe stable food consumption and purchasing habits but remain ignorant about how increasing food prices hit consumers' material well-being by forcing them to cut consumption on other important goods (home heating, ability to pay the bills among others). Failure to account for leftward (rightward) shifts of the Engel curve gives rise to overestimation (underestimation) of the true cost of living. Estimates of real income growth may be underestimated because of overestimation of the true cost of living (CPI bias), which in developing countries could go beyond 8 percent, much more than in developed countries within the range between 1 and 3 percent (García-Verdú et al., 2012).

Huang and Wu Huang (2012), using the U.S. Economic Census' data on Personal Consumption Expenditures, find that an increase in food and energy prices in the U.S. would give rise to substantial consumer welfare loss, especially for low income households. Gregory and Coleman-Jensen (2013) used the Quarterly Food-at-Home Price Database and the Current Population Survey Food Security Supplement of the U.S., finding that household participants in the Supplemental Assistance Program (SNAP, formerly Food Stamps) in the U.S. are more sensitive to food price increases while the effect on the food security status of non-participants is zero. They found that an increase of \$10 in the food index (less than one standard deviation) results in increases of the prevalence of food insecurity of 5 percent, 5.1 percent and 12.4 percent, respectively for household, adult and child SNAP participants.

Cockx et al. (2015) review the food and nutrition status of the EU. They point out that despite the sufficient availability of food and the stable food security environment, food and nutrition security has not been fully achieved. They identify malnutrition as the main challenge in terms of food and nutrition security. The large food expenditures in the household budget in some new MSs will

potentially affect household food access and shows their vulnerability. The poor, ethnic minorities and the elderly are identified as the more vulnerable groups in the EU.

Figure 3.1 shows the overall food consumption expenditure of households and food consumption expenditure of households in the lowest income quintile in the EU MSs. There are significant differences across MSs, ranging from less than 10 percent of average expenditure devoted to food in Luxembourg, to nearly 30 percent in Romania in 2010 (slightly more than 40 percent in 2005), reflecting widely different income and welfare levels. As would be expected, the share of food consumption expenditure to total household consumption of households belonging to the lowest income quintile is larger than the overall share in most countries. But the share of food expenditure in total household expenditure in the EU-27 as a whole stood in 2007 at about the same level than in 2000 (14 percent) (European Commission, 2012). And in Germany, U.K., Estonia, Hungary, Malta, Greece, France, Finland and Sweden the share increased from 2005 to 2010 for all households indicating that at least in these MSs the vulnerability to increased food prices may have grown. In the U.S. the share of the highest (lowest) income quintile spent 11.6 percent (16.1 percent) of disposable income in food in 2012 (Schnepf, 2013).

Figure 3.1. Share of food consumption expenditure to total household consumption (%).

Note: Authors' elaboration based on EUROSTAT. Household Budget Surveys: Overall Structure of consumption expenditure and Structure of consumption expenditure by income quintile (COICOP level 2). Data for Italy's lowest income quintile (2010) and overall (2005) not available. Data for Luxembourg's lowest income quintile (2010) not available. Methodologies used by the countries for data collection are not totally harmonized.

To our knowledge, the EU-SILC survey has not been used to date to assess food poverty, with the exception of Carney and Maître (2012). These authors developed a food poverty indicator in Ireland and identified the demographic, socio-economic and health profile of those vulnerable to

food poverty. The study is focused on identifying poverty as a multidimensional instrument which also comprises food poverty (other studies which focus on material deprivation include the food deprivation indicator as part of composite indicators of material deprivation).

This paper contributes to the literature in several aspects. First, we evaluate the impact of consumer food price changes on the percentage of EU households that can afford a protein intake at least every other day. Secondly, we measure the impact of the deviation of food prices relative to general consumer prices on the same food access variable. These two questions are addressed taking into account the differences across MSs in the EU-28 and levels of households' disposable income.

3.3 Data

3.3.1 The EU-SILC survey

The EU Statistics on income and living conditions (EU-SILC) is the EU reference source for comparative statistics on income distribution, living conditions and the level and composition of poverty and social exclusion. The aim of the survey is to monitor key EU social inclusion and social protection indicators. Although the survey focuses mainly on income variables (of which the survey computes different indicators), it also contains a wide range of variables that permit measuring indicators of material deprivation, including the variable that checks whether the household can afford an adequate protein intake or the food deprivation indicator analyzed in this paper.

The EU-SILC survey follows a dual approach, containing cross-sectional and longitudinal dimensions. Although priority is given to the cross-sectional dimension, which refers to a specific given time, the longitudinal dimension permits following specific households along time and to study the changes that take place because of changes in socioeconomic variables and policies. The survey is performed annually in all EU MSs. It was started in 2003 in some MSs, while the remaining MSs have been gradually incorporated (see section 3.5.1 for the exact incorporation). The cross-sectional and longitudinal dimensions cover different variables. The cross-sectional

dimension focuses on income, poverty, social exclusion and other living conditions, whereas the longitudinal dimension targets income variables and a series of non-monetary material deprivation variables, which are used to assess the dynamics of poverty and social exclusion.

For most MSs, the EU-SILC longitudinal dimension is a rotational panel. In a rotational panel, the same households are surveyed for a specific period—in most MSs usually for four consecutive years—and each year a quarter of them are replaced by a new sample of households. Both the cross-sectional and longitudinal dimensions are based on a nationally representative probability sample of the population living in private households within the country. The minimum effective sample size is around 131,000 households in the EU as a whole in the cross-section component and 98,000 households for the longitudinal component. The time frame spans nine years (2003-2011).

3.3.2 The food deprivation indicator

The variable that measures food deprivation in the EU-SILC survey is obtained from the questionnaire using the following question: "Can your household afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day?", which has a binary outcome (*Yes(1)* / *No(0)*). This is our models' dependent variable.

3.3.3 Other socio-economic variables

A multivariate panel approach is developed to examine whether increasing food prices had an impact on households' food deprivation. The dependent binary variable "food deprivation indicator" is regressed on a number of MSs's specific economic measures and household level variables. Among the MSs specific economic measures, the consumer food prices and the relative price of food, measured as the ratio of consumer food prices to general consumer prices, are used as independent variables. We also use the equivalised disposable household income and the equivalised household size, which are obtained from each surveyed household.

Data on consumer prices were obtained from EUROSTAT. Consumer food prices were measured as the annual average of the harmonized index of consumer prices (HICP) for food. General

consumer prices were measured as the annual average of the monthly HICP for all items. Thus, the relative prices of food were defined as the ratio of the food HICP index to the general HICP index, expressed as a percentage. The food HICP index is a component of the general HICP index and therefore the ratio between both indicates whether and to what extent food prices run above general prices. Country specific consumer food prices and relative prices of food were used as explanatory variables in the models.

Data on the equivalised household size and equivalised disposable income were taken from the EU-SILC longitudinal files from 2005 to 2011. The equivalised household size accounts for household members which are weighted in order to convert them into equalised adults (the weighting is based on the modified OECD scale, which gives the first adult a weight of 1, the second and each subsequent person aged 14 and over a weight of 0.5 and each child under 14 a weight of 0.3). The equivalised disposable income measures the total income of a household, including social benefits and after taxes and other deductions. It is weighted to take into account household members by employing the same scale used to calculate the equivalised household size. Thus, the equivalised disposable income, available for spending and saving, is attributed equally to each member of the household.

3.4 Statistical description of the data

Table 3.1 summarizes the share of households that report not being able to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day, both for the entire sample — including all income quintiles— and for those that belong to the lowest income quintile across groups of MSs and the EU-28 as a whole. As for the groups of MSs, these were divided into groups according to two criteria so that each MS belonged only to one group. In the first place, MSs were classified according to whether they belonged to the eurozone or not. In turn, non-eurozone MSs were divided into two groups. On the one hand, Denmark, Sweden and the U.K. were grouped together (DSU from now on), on account on being former EU MSs not belonging to the eurozone. On the other hand, the rest of non-eurozone MSs were grouped together (other non-

eurozone from now on). Thus, MSs were classified into three groups, the eurozone group (eurozone from now on), the DSU group, and the other non-eurozone group. MSs which belong to the eurozone group are Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain. Latvia and Lithuania are not considered eurozone MSs but other non-eurozone MSs in this analysis due to the fact that they acceded to the eurozone in 2014 and 2015 respectively, which are not covered in the studied period. MSs which belong to the other non-eurozone group are Latvia, Lithuania, Romania, Hungary, Croatia, Poland, Czech Republic and Bulgaria. Chi squared tests were performed to determine whether there was statistical significant change in the food deprivation indicator along the period covered. Tests show that there was a statistically significant change in the share of households that report suffering food deprivation in the 2003-2011 period for the three groups of MSs considered.

Table 3.1. Share of food deprivation in the entire sample and the lowest income quintile across groups of MSs and the EU-28 (percentage of households that report not being able to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day).

	Eurozone ¹		DSU ²		Other non-eurozone ³ (except DSU)		EU-28 ⁴	
	All sample	Lowest income quintile ⁵	All sample	Lowest income quintile ⁵	All sample	Lowest income quintile ⁵	All sample	Lowest income quintile ⁵
2003	14.3	32.7	1.8	3.5	-	-	10.1	21.2
2004	6.6	13.5	4.2	9.0	-	-	6.4	13.1
2005	7.7	16.8	5.1	9.8	33.9	55.7	10.5	19.8
2006	7.1	15.2	4.5	10.1	30.1	52.4	10.0	19.1
2007	6.1	13.6	3.9	8.0	26.7	49.2	9.9	19.1
2008	6.9	15.7	4.2	8.2	22.8	43.7	9.8	20.0
2009	6.2	14.4	3.8	8.4	22.1	42.4	9.1	18.8
2010	6.6	15.3	4.5	8.8	21.6	42.5	9.4	19.5
2011	7.6	18.1	4.3	9.1	21.5	41.7	9.9	20.9

Note: Authors' calculations based on data from EU-SILC longitudinal waves (2005-2011). Weighted shares according to the household cross-sectional weight included in the survey's longitudinal files. Unweighted shares relative to the population of the MSs that comprise each group. Although the share of self-reported food deprivation described in the table includes data for Croatia and Germany, these MSs were not included in the analysis. ¹MSs belonging to the eurozone. ²Denmark, Sweden and the U.K. ³MSs which do not belong to the eurozone except for Denmark, Sweden and the U.K. ⁴All EU MSs. ⁵Lowest equivalised disposable income quintile specific for each MS.

Several conclusions can be drawn from Table 3.1. First, the share of households belonging to the lowest income quintile that report suffering food deprivation is larger than the overall share of households in all groups that are accounted for. Second, food deprivation is more common for households from the other non-eurozone group than from the eurozone and the DSU groups. Food deprivation is the least frequent within households belonging to the DSU group. These differences are quite large, especially when taking into account the other non-eurozone group, in which the share is much larger than that of the other groups. Third, there is no significant shift in the share of households that report suffering food deprivation following the rise of world agricultural commodities prices in 2007-2008. However, the share of households belonging to the lowest income quintile in the EU-28 who reported suffering food deprivation increased in 2008 (from 19.1percent in 2007 to 20 percent in 2008). The same happens to the share of food deprived

households in the eurozone group in both the lower income segment and the entire sample and to the DSU group for the entire sample. Breaking up the EU-28 in our three country groups conceals differences across MSs belonging to the same group. Lastly, although the share of food deprivation reported by households in the other non-eurozone group is much higher than that of the other two groups, these differences have decreased over time. The percentage of households reporting food deprivation in the other non-eurozone groups has decreased over the period analysed, whereas trends are quite regular for those households belonging to the other two groups. These results are consistent with the reduction of the share of expenditures in food consumption between 2005 and 2010 described in Figure 3.1.

Table 3.2 shows some descriptive statistics for the independent variables used in the models for each of the groups of MSs considered in the previous table in years 2005, 2008 and 2011. As can be seen, the mean of the equivalised disposable income is larger in the DSU group, followed by the eurozone group and finally the other non-eurozone group. When we focus on the food HICP index, we can see that the mean of food prices has increased more in the other non-eurozone group than in the other two groups, taking 2005 as base year. The standard deviation is also larger for this group of MSs. As for the relative prices of food, defined as the ratio of the food HICP index to the general HICP index, we note that generally their means are larger than one, meaning that prices of food run above general prices during the period of study.

Table 3.2. Statistics for independent variables.

Variable	N. observations	Mean	Std. Dev.	Minimum	Maximum
Eurozone²					
Equivalised disposable income (in €)					
2005	118221	15908.1	19825.0	-209100	4980869
2008	116196	17574.5	13467.2	-272640	958396.7
2011	82756	18694.9	16649.4	-388936	1684067
Food HICP ¹ index (Base year 2005)					
2008	-	113.5	5.2	108.5	132.1
2011	-	118.0	7.6	107.4	141.4
Equivalised household size					
2005	118275	1.7	0.6	1	7.3
2008	116196	1.7	0.6	1	6.8
2011	82756	1.6	0.6	1	9
Ratio food HICP ¹ index / general HICP ¹ index (Base year 2005)					
2008	-	103.8	2.3	100.5	110.4
2011	-	102.2	4.5	95.3	114.7
DSU³					
Equivalised disposable income (in €)					
2005	18343	22266.6	20724.8	-39307.4	1237417
2008	21527	22908.8	21838.5	-403987.8	1117414
2011	12201	22221.8	15138.5	-168771.3	693987.1
Food HICP ¹ index (Base year 2005)					
2008	-	115.1	2.8	110.5	117.7
2011	-	124.9	8.9	115.7	134.5
Equivalised household size					
2005	18343	1.6	0.5	1	4.6
2008	21527	1.6	0.5	1	5
2011	12201	1.6	0.5	1	4.4
Ratio food HICP ¹ index / general HICP ¹ index (Base year 2005)					
2008	-	106.9	1.9	103.6	108.5
2011	-	107.5	4.5	103.0	112.4
Other non-eurozone⁴					
Equivalised disposable income (in €)					
2005	27914	3386.9	2644.1	-554.2	95330.1
2008	55343	4498.8	3540.8	-7794.7	118169.2
2011	43289	4901.4	3991.0	-2670.0	133919.1
Food HICP ¹ index (Base year 2005)					
2008	-	125.1	13.2	111.6	146.6
2011	-	137.7	15.1	116.8	156.2
Equivalised household size					
2005	27914	1.8	0.7	1	6.5
2008	55347	1.8	0.7	1	6.9
2011	43297	1.8	0.7	1	10.9
Ratio food HICP ¹ index / general HICP ¹ index (Base year 2005)					
2008	-	106.0	5.4	98.4	114.5
2011	-	105.5	6.6	93.2	115.8

Note: Data on equivalised disposable income and equivalised household size from EU-SILC longitudinal waves (2005-2011), authors' calculations. Data on food HICP index and general HICP index from EUROSTAT (2014), authors' calculations. Although the statistics described in the table includes data for Croatia and Germany, these MSs were not included in the subsequent analysis. ¹Harmonized index of consumer prices. ²MSs that belong to the eurozone. ³Denmark, Sweden and the U.K. ⁴MSs which do not belong to the eurozone except for Denmark, Sweden and the U.K.

3.5 Modeling framework

Despite the uncertain trends of the food deprivation indicator over the period 2003-2011 described in the previous section, a multivariate panel approach was developed to examine more thoroughly whether increasing food prices affected food deprivation in the EU. We focused especially on households in the lowest quintile of disposable income in the EU who spend a larger part of their income to food and are probably more exposed to food deprivation due to changes in the price of food. We first present the compilation of the database used in the analysis and afterwards we outline the specification of the model.

3.5.1 Database compilation

As stated above, the EU-SILC data set covers both cross-sectional and longitudinal dimensions. The latter dimension is used for our analysis because it permits us identifying specific households along time, and thus to account for repeated measures that may be correlated within a household. EUROSTAT provided the authors with different longitudinal files which had been released from 2005 to 2011 on a yearly basis. Despite this, data are available from 2003 for some MSs, since each longitudinal file contains data for the year in which the file is released along with data from the preceding year at least and as far as the three preceding years (as noted by Engel and Schaffner (2012)). As described in the previous section, the survey started in 2003 in some MSs whereas the rest were progressively included. Thus, data availability in the longitudinal dimension differs across MSs. The longitudinal files provided by EUROSTAT cover the 2004-2011 or 2005-2011 period for most MSs. Data for three MSs —Denmark, Greece and Luxembourg— are available from 2003 onwards, data for Bulgaria are available for 2006-2011, for Croatia for 2010-2011, for Germany for 2005-2006, for Ireland for 2004-2009, for Malta for 2006-2011 and for Romania for 2007-2011.

The different longitudinal files from 2005 to 2011 were merged to obtain the longitudinal structure used for the analysis, in order to cover the entire period for which data are available and to increase the sample size. Thus, we generated a single database from 2003 to 2011 that includes

data on all MSs for the entire period although, as described above, not all MSs appear in the entire longitudinal span. Due to the manner used to organize the data —releases in different longitudinal files— the information on almost all households is included in different panel files. Following Engel and Schaffner's (2012) approach, in these cases the information of the most recent longitudinal file is included in the single database used for the analysis. Croatia and Germany were discarded for the statistical analysis due to the fact that longitudinal files only include a two-year period for these two MSs, and the two years for which data are available do not cover the years of the recent increases in world agricultural commodity prices (data for Germany are available for 2005 and 2006 and for Croatia for 2010 and 2011).

3.5.2 Statistical modeling approach

To test whether increasing food prices had an impact on EU consumers' food access, we use population-averaged panel data models by applying the method of generalized estimating equations (GEE), which extends the generalized linear model to account for correlated or clustered dependent data (see Liang and Zeger (1986) and Zeger and Liang (1986) for developments of this approach). Since the dependent variable —the food deprivation indicator— is binomial, the logit link function for binary response variables was used. According to Ballinger (2004), the binomial distribution should be defined when using binary data and the logit link is appropriate for this type of data. This approach seems appropriate due to the longitudinal nature of the EU-SILC data, which entails the correlation of repeated measures.

Different models were specified using various subsamples. Regressions were performed for a subsample of households included in the lowest disposable income quintile, which is estimated in the survey specifically for each MS. To control for potential fixed effects across groups of MSs due to differences in their general economic conditions, control variables (dummies) for groups of MSs were included in the models. To do so, MSs were divided into separate groups so that each MS belonged just to one group.

MSs were classified into three groups, the eurozone group (eurozone), the DSU group (DSU) and the other non-eurozone group (other non-eurozone). Hence, three binary control variables were defined — D_{eurozone} , D_{DSU} and $D_{\text{other-non-euro}}$ — and included in the models. For a list of MSs that belong to each of the three groups see the previous section.

Goodness of fit tests to compare observed and predicted probabilities were performed. To do so, classification tables were elaborated and from these sensitivity (1's correctly classified), specificity (0's correctly classified) and the overall rate of correct classification were derived. We recall that in our models the dependent variable takes value 1 if the household can afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day and 0 otherwise.

3.6 Results

Table 3.3 shows the parameter estimates of the models specified to explain the evolution of the food deprivation indicator. The table includes regression results for households belonging to the lower disposable income quintile of each MS, and account for possible fixed effects of the different groups of MSs detailed in the previous section. For these models, two regressions are included in Table 3.3, one which does not include the relative price of food —model (a)— and one which includes the relative price of food —model (b). Table 3.4 shows the odds ratios of the coefficients presented in Table 3.3 for the different specifications.

Table 3.3. Regression results for the lowest income quintile.

	Lowest income quintile			
	(a)		(b)	
	Coefficient	SE ¹	Coefficient	SE ¹
Equivalised disposable income	0.0000398***	3.97e-06	0.0000403***	4.01e-06
Food HICP ² index	-0.00854***	0.00074	-0.00659***	0.00100
Equivalised household size	0.17265***	0.01570	0.17177***	0.01568
Ratio food HICP ² index / general HICP ² index			-0.00902**	0.00292
D _{eurozone}	1.35935***	0.02791	1.36941***	0.02792
D _{DSU}	1.97616***	0.04622	2.01219***	0.04674
Constant	0.79211***	0.09521	1.48474***	0.23646
No. of observations	282154		282154	
Wald chi2 ³	9104.85(5)		9237.41(6)	
Sensitivity (1's correctly classified)	84%		84%	
Specificity (0's correctly classified)	49%		50%	
Correctly classified	76%		76%	

Note: Dependent variable: Capacity to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day (0=No/1=Yes). *p<0.05; **p<0.01; ***p<0.001. Weighted shares according to the household cross-sectional weight included in the EU-SILC survey's longitudinal files. The other non-eurozone dummy variable was omitted because of collinearity. ¹Robust standard error. ²Harmonized index of consumer prices. ³Degrees of freedom of Wald Chi² statistics in parentheses.

Table 3.4. Odds ratio of regression results for the lowest income quintile.

	Lowest income quintile	
	(a)	(b)
Equivalised disposable income	1.00004***	1.00004***
Food HICP index	0.992***	0.993***
Equivalised household size	1.188***	1.187***
Ratio food HICP index / general HICP index		0.991**
D _{eurozone}	3.894***	3.933***
D _{DSU}	7.215***	7.480***

Note: Based on coefficients presented in Table 3.3.

The parameter estimates of the consumer food price index are negative and significant in both regressions. Therefore, the probability of a household being food deprived appears to increase with an increase in the consumer food price index. As shown in Table 3.4, the odds ratio does not

vary significantly between specifications for the different independent variables. On average for EU consumers, the odds of being food deprived increases by around 0.7-0.8 percent for a unit increase in the consumer food price index.

The relative price of food (ratio of food HICP index to general HICP index) is significant and negative in model (b). Therefore, the probability of a household being food deprived appears to increase with an increase in the ratio of the food HICP index to the general HICP index. In this way, food deprivation appears to be associated not only with food prices but also with the extent to which food prices run above general prices. On average for EU consumers, the odds of being food deprived increases by 0.9 percent for a unit increase in the ratio of the food HICP index to the general HICP index.

The parameter estimates of the equivalised household income are significantly positive in the models presented in Table 3.3. The equivalised household size has a significant and positive impact in explaining food deprivation among EU consumers. Therefore, the probability of being food deprived decreases with a unit increase in the equivalised household income and a unit increase in the equivalised household size. Larger households seem to be more vulnerable to food deprivation.

There are considerable differences in food deprivation across groups of MSs, as suggested by the significance of the control variables grouping MSs included in the models. When considering the dummy variables eurozone and DSU included in the models, both estimated coefficients are significantly positive, as expected and consistent with the descriptive statistics included in Table 3.1. Thus, the probability of being food deprived is higher in those MSs that belong neither to the DSU group nor to the eurozone group. This result is also consistent with the descriptive statistics included in Table 3.1.

Models taking into account the entire sample—including all income quintiles— were also specified. These models have not been included in the table due to the fact that the goodness of fit specificity tests were too low. Even so the parameter estimates of the models not including the

relative price of food are significant and the results for the entire sample are consistent with those obtained for the lowest income quintile. For a unit increase in the consumer food price index, the probability of being food deprived increases more in households belonging to the lowest income quintile than in the entire sample.

The results are consistent with the fact that food deprivation appears to be more severe in the recently acceded EU MSs that do not belong to the eurozone than in former MSs and than in those which belong to the eurozone. Food deprivation is greater in households belonging to the lowest income quintile. This is also consistent with arguments that recognize the large differences existing across the share of income spent on food and across income classes between EU MSs and between income classes within each MS respectively (European Commission, 2008).

As for the goodness of fit tests, a cut-off of 0.5 to generate the classification variable performed poorly in the models, missing true negative cases (food deprived units). According to Hosmer et al. (2013), classification is sensitive to the distribution of the two component groups and always favours classification into the larger group, a fact that is independent of the fit of the model. To overcome this, a cut-off of 0.6 was used instead of 0.5. Using a cut-off of 0.6 significantly improved specificity which increased from 19 percent to 50 percent approximately in both models. The overall rate of correct classification was larger when using a cut-off of 0.6 than when using one of 0.7 in both cases.

3.7 Discussion

Both Headey (2013) and Verpoorten et al. (2013) coincide in the fact that the format used to formulate the question that measures a variable in surveys determines to a great extent the answer. The questions are clear and interviewed subjects can easily respond to questions about affording a certain type of meal (EU-SILC) or being deprived of food (Headey, 2013; Verpoorten et al., 2013).

According to EU-SILC documentation, in the case of the EU's food deprivation indicator, the question refers to affordability, in contrast to not having food due to other reasons. The question is

addressed to the household and defines a non-monetary deprivation variable which is directly linked to current income (Fusco et al., 2010). It is thus a basic need and refers to severe food deprivation (Carney and Maître, 2012).

Apart from the limitations that may arise with the use of subjective data (see Headey (2013)), there are other drawbacks of the EU deprivation indicator. In the first place, respondents may answer subjectively depending on what they understand with meat, chicken, fish (or vegetarian equivalent) and how it suits their diet (see Headey and Verpoorten). On the other hand, as Carney and Maître (2012) point out, the survey variable does not account for the potential uneven distribution of food within households or for some groups that are vulnerable to food deprivation, such as homeless or people in institutions. Lastly, the indicator does not refer to the nutritional quality of the food that the household can afford, providing the issue of food deprivation with a quantitative perspective rather than a qualitative one (Carney and Maître, 2012).

And yet our results are consistent with other studies. Antentas and Vivas (2014) found reductions in the consumption of all items, and significant changes in the composition of the diets among Spanish households. But their work is also capturing the effects of the economic crisis, hurting especially low income households, unemployed adults, and pensioners. Huang and Wu (2014) found that an increase of 20 percent of the price of food and energy would increase the per capita compensated expenditure by US 795\$, which would be equivalent to 14 percent of the disposable income of a household in the lowest income quintile. Gregory and Coleman-Jensen found statistically significant effects of increases of food insecurity among the poorest US households resulting from an increase of food prices by less than one standard deviation.

Based on the importance given by many authors to the percentage of food expenditure, it is clear that increasing food prices must have had a notable impact in the households within the lowest income quintile in Romania, Lithuania, Bulgaria, Malta, Poland, Slovakia and Estonia, reaching possibly to the median income household in Romania. Average households spending more than

20 percent of disposable income in food and non-alcoholic beverages in 2012 are only found in Romania and Lithuania (Schoen and Lang, 2014).

The health consequences of food price increases are difficult to qualify. Jones et al. clearly showed that healthy food items are more expensive than unhealthy ones, but that does not mean that poor households would switch to unhealthier products in result to price increases. Ligon (2008) conjectures that households may switch away from preferred diets to more basic foodstuffs. Antentas and Vivas (2014) suggest that increased food prices may have had a positive health impact because of reduced food-away-from and more home cooking of legumes, and larger consumption of fruits and vegetables. Schoen and Lang (2014) report 78 percent of British consumers in 2013 as being worried about the increasing cost of food, and 41 percent claiming the cost of food as a source of stress. Beatty (2010) found that the poorest households in the U.K. pay less because they benefit more on quantity discounts, but households without a car or sufficient storage space at home may end up paying more. As to the nutrition and healthy consequence of quantity discounts, Beatty does not offer any conclusion.

Despite its overall drawbacks, the EU-SILC survey's indicator appears to be a convenient tool for analysis due to several reasons, such as the regularity, high quality, large sample, annual execution and large coverage both in countries and time period of the survey, which permits comparability between MSs.

3.8 Conclusions

The aim of this paper is to test whether increasing food prices had an impact on EU consumers' food deprivation during the period 2003-2011, which coincided with the increase in agricultural commodities prices occurred in 2007-2008 and 2010-2011. Despite the fact that we find no clear evidence of increases in food deprivation in 2008 following the 2007-2008 food crisis, we do find a significantly negative relationship between the probability of being less food deprived and the consumer food price index, whose level augmented around the world after the food crisis. Although there is a significant relationship, the quantitative effect is not large. Households

belonging to the more recently acceded EU MSs that do not belong to the eurozone would be more sensitive to food price increases and therefore more vulnerable to food deprivation.

There are significant differences in the level of food deprivation across EU MSs, which could be due to differences in disposable income, food price transmission and varied economic situations across them. Further research could be performed to explain these differences across EU MSs by regressing the food deprivation indicator on other MSs-level variables that account for the socio-economic and food markets situation of each MS. These are not contemplated in the analysis — except for consumer food prices and the relative price for food over other consumer prices and for the MSs as such. There is still significant uncertainty about how people actually change their eating and consumption habits in response to changes in food prices. Do they waste less food which it becomes more expensive? Does food waste at home varies across products? How do they respond to discounts? Are there ethnic differences in food deprivation?

From a policy perspective, it is important to delve also into the retailers' strategies too, learn more about how the poorest urban consumers make use of the wide food choice they can find in all EU cities, and evaluate the food assistance programmes in compensating the negative effect of increasing food prices. Our findings provide basis to conclude that more expensive food does have an impact in the poorest households of the poorest EU MSs in affording a meal with meat, chicken, fish (or vegetarian equivalent) every second day.

Chapter 4

The impact of food price shocks on weight loss: Evidence from the adult population of Tanzania

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Submitted

Abstract. Undernourishment is still widespread in Tanzania, while obesity is becoming an issue of magnitude similar to undernutrition in the country. In this paper we examined the impact of an increase in maize prices on the nutritional status of Tanzania's adult population. We found that undernutrition increases as a result of increased prices, while the overweight and obese decrease their energy intake. The study presents evidences of the so called early stage of the nutritional transition that characterize developing countries. All in all, these findings are suggestive of the fact that food price shocks should be taken into consideration when designing policy and programmes aiming at addressing malnutrition in low income countries.

JEL classifications: C31, D12, D13, I31, Q18

Keywords: Food price shocks, Food demand models, Malnutrition, Tanzania

4.1 Introduction

In the last decade, food price crises have been a major issue in sub-Saharan African (SSA) countries, with substantial negative effects on the welfare of the most vulnerable segments of the population given their predominantly food net buyer position. Tanzania is not an exception and its cereal prices are marked by large variability mainly due to weather shocks and seasonality (Baffes et al., 2015) but also because of discretionary policy interventions on markets. Maize represents the main source of calorie intake amongst poor and vulnerable households and it is the main target crop of these policy measures laid down—in principle—to ensure food security and price stability (FAO-MAFAP, 2013). While high agricultural prices benefit net sellers, cereal price levels are critical for nutrition because they can crowd out household consumption and off-set expenditures devoted to other more nutritious foods such as animal-source foods, legumes and vegetables (Block et al., 2004; Torlesse et al., 2003; de Brauw, 2011).

The welfare consequences of changes in food prices remain a matter of serious concern for both researchers and policymakers and understanding their implications is a key element for guaranteeing food security. The usual approach followed in the empirical literature to evaluate the impact of higher food prices on households' welfare focuses on simulating the effects of price changes on several measures of the monetary value of food consumption or total expenditure (Anríquez et al., 2013). More recently, several studies provide support to the idea that the assessment of the impacts of increased food prices on households' welfare should move beyond such money-metric measures. Indeed, price or income shocks ultimately affect the nutritional status of the population, changing households' dietary intake patterns (Ecker and Qaim, 2011). At this purpose, there is a growing body of literature focusing on assessing the impact of price, income and policy shocks on food security and nutrition indicators, concentrating mainly on measures based on calorie and nutrients availability. For example, changes in the prevalence of undernourishment and micronutrient deficiencies due to shocks at the national level have been predicted (see Ecker and Qaim, 2011; Anríquez et al., 2013). Nevertheless, a broader focus that includes the impacts of shocks on anthropometric measures is still missing and could be useful in

order to better understand the determinants of malnutrition in the adult population. In this respect, anthropometric indicators such as the Body Mass Index (BMI) are commonly used to measure the nutritional status of a population since they are directly capturing individual level characteristics, eliminating the effect of other factors such as food losses, intra-household food distribution, individual health and activity levels (de Haen et al., 2011). While the use of anthropometric measures for young children is considered one of the main indicators to monitor change in the nutritional and health status in developing countries (de Haen et al., 2011), broadening the focus to cover the adult population can give critical insights for the formulation of policies aiming at improving Food Security and Nutrition (FSN) over populations affected by malnutrition.

In this paper, we seek bridging this gap by examining the potential impact of price shocks on individual-level nutritional outcomes. Specifically, we simulate the impact of a maize price shock on the BMI of Tanzania's adult population. While undernourishment continues to be a major concern in SSA countries (FAO et al., 2015), the number of countries facing increased prevalence of overweight and obesity in the adult population has been raising (Popkin et al., 2012; Hoffman, 2001). Further, in many poor countries, undernourishment and obesity are usually coupled with micronutrient deficiencies as the result of poor and inadequate diets (Keding et al. 2013; Damms-Machado et al., 2012). The coexistence of hunger, excess of calorie intake and micronutrient deficiency is defined as the 'triple burden' of malnutrition (Gómez et al., 2013; Keding et al. 2013; Pinstrup-Andersen 2007; Labadarios, 2005). Consequences of the three dimensions of malnutrition are multiple and widespread including poor health outcomes, lower levels of cognitive skills and lower income levels, higher unemployment rates, greater public health costs and loss of GDP growth (Horton et al., 1993; Haddad et al., 2003; Alderman et al., 2006 amongst others).

Tanzania is an appropriate example where the consequences of food price changes on malnutrition can be analyzed. Nearly 30 percent of Tanzania's population lived in 2012 under the national poverty line (WB, 2015). At national level, the energy supply does not meet the population's average energy requirements and micronutrient deficiencies are widespread (URT,

2013). While undernourishment continues to be one of the major concerns in the country, overweight and obesity have increased in recent years (URT, 2013). For example, the prevalence of obesity amongst women age 15-49 was equal to 18 percent in 2004 while it increased to 22 percent in 2010 (TDHS, 2010).

For our analysis, we made use of the Tanzania National Panel Survey (TZNPS) collected between 2010 and 2011 by the Tanzanian National Bureau of Statistics (TNBS) in collaboration with the Living Standard Measurement Study (LSMS) project of the World Bank. We first estimate price and expenditure elasticities using a quadratic almost ideal demand system (QUAIDS) in order to evaluate the extent to which changes in prices affected household food, and therefore calorie demand patterns. Second, we simulate the impact of a 20 percent maize price increase on the total calorie intake of the households and then we distribute it across the household's members to evaluate the effect on their nutritional status. Since the TZNPS collected data on consumption at household-level while anthropometrics are registered at individual-level, we are forced to make some assumptions on the intra-household distribution of calorie changes. We address this issue relying on the standard hypothesis that food is distributed within the household in direct proportion to expected members' shares of the household's total adult male consumption equivalent (Fiedler et al. 2012). Finally, we move from individual calorie to weight changes using both a static and a dynamic calorie-to-weight model. The second model was recently developed by Hall et al. (2011) and applied by Lin et al. (2011) to analyze the impact of taxation on sugar beverages on weight loss in the US. This last step allows us to: (i) calculate the impact of the price shock on our indicators of nutritional outcomes; and (ii) predict its effect on underweight, overweight and obesity prevalence at the national level in the short and medium term.

Overall, we find an increase of undernutrition and a decrease in overnutrition as a result of an increase in the price of maize, the main food staple in Tanzania. We conclude that this nutrition pattern is due to the limited substitution possibilities in a country such as Tanzania. Further, our results confirm the increasing prevalence of obesity in Tanzania already noted in previous studies and suggests that the country like other low- and middle-income countries is at an early stage of

the nutritional transition. Finally, as the government of Tanzania appears to be sustainably interested in improving the nutritional status of its population, this study suggests the need to also anticipate interventions to cope with high food prices should these prices soar again in the future.

The remainder of the paper is organized as follows: Section 4.2 reviews the literature on food price shocks and impact on nutritional status of affected population. Sections 4.3 discusses the data as well as variables constructed to carry out the analysis. Section 4.4 describes the methods used. Section 4.5 presents descriptive statistics of variables used in the analysis. In section 4.6 the results of the analysis are discussed while conclusions and policy messages are drawn in section 4.7.

4.2 Literature review

Most of the empirical works on this topic use estimated price and expenditure elasticities to simulate the impact of price and income shocks on different measures of the household's welfare, i.e. living standards based on monetary values such as food and total consumption expenditure. This strand of the literature is quite extensive (for example Ivanic and Martin, 2008; De Janvry and Sadoulet, 2009; De Hoyos and Medvedev, 2011; Vu and Gleewe, 2011; Minot and Dewina, 2013) and it usually relies on the concept of compensating variation, the amount of money that has to be transferred to the household after a price change to make it as well-off as it was before. These studies are based on the methodologies proposed by Singh et al. (1986) and refined by Deaton (1989, 1997) which measures the welfare impacts imputing changes in relative food prices to the household's production and consumption of the corresponding food crops (De Janvry and Sadoulet, 2008). Among these, Tefera et al. (2012) and Magrini et al. (2016) derive the impacts of increased food prices focusing specifically on selected SSA countries —Ethiopia, Tanzania, Niger and Malawi— and specific sub-groups of the population. Brambila et al. (2009) use a series of different poverty indicators based on the simulated food expenditure variation such as the headcount ratio or the poverty gap to evaluate the welfare impacts of food price shocks in Zambia.

Several other papers have examined food, calorie and nutrient demand in SSA countries in order to assess potential outcomes of the different dimensions of malnutrition and their possible policy implications. Some authors have examined food, calorie and nutrient elasticities of demand to provide useful insights on how income and price changes affect household food and nutrient demand patterns. For example, Abdulai and Aubert (2004a) examine the responsiveness of household calorie demand to income in Tanzania, finding a positive and linear relationship. They also identify that lower food prices may improve household calorie intake. Abdulai and Aubert (2004b) analyze the relationship between food demand patterns, food prices and expenditures in Tanzania, extending the analysis to other nutrients related to undernutrition and obesity, apart from calories. Once again, they show the high response of food and macro- and micronutrient demand to changes in food prices and income. Higher maize prices will lead to lower household nutrient availability.

Ecker and Qaim (2011) estimate calorie and some relevant nutrient elasticities in Malawi in order to evaluate the potential impacts of income-related and staple price regulating policies and shocks. They focus on simulating the household prevalence of particular macro- and micronutrient deficiencies based on reference levels that account for household composition after several income and price changes. A maize price increase can lead to a decrease in the consumption of certain micronutrients. They find evidence to support that income-related policies are more appropriate to improve the population's nutritional status. Anríquez et al. (2013) simulate the impact of price shocks on nutritional outcomes in eight developing countries, among which we find Kenya and Malawi. More specifically, they evaluate undernourishment following a similar approach to calculate it to that of Ecker and Qaim. They find a decreasing calorie intake and negative distributional effects of calorie consumption within the country, hurting even more the food insecure. Finally, Harttgen et al. (2015) simulate the impact of income and price shocks on Malawi's food security. In this case, they use calorie availability as a measure of food availability and some poverty measures —poverty headcount, poverty gap and severity index—, this time

using the simulated calorie distribution after the shocks as a threshold to assess food poverty. They also find an increase in poverty and food insecurity in the face of a staple price shock.

The translation from calorie to weight changes has been assessed in several studies in the US (for example Finkelstein et al. 2010; Lin et al., 2011; Ruff and Zhen, 2015), the UK and Ireland (Briggs et al. 2013a,b) and South Africa (Manyema et al. 2014). To the best of our knowledge, the translation from calorie to weight changes is used to examine how trends in the prevalence of overweight respond to changes in food prices specifically resulting from the taxation of unhealthy foods such as soft drinks high in sugar (Lin et al., 2011).

4.3 The data

4.3.1 National Panel Survey for Tanzania

The data used in the analysis were sourced from the 2010/2011 TZNPS. The survey was conducted from October 2010 to September 2011. It is based on a stratified, multi-stage cluster sample design and has a nationally representative sample of 3,924 households.

We primarily used the survey's food consumption and anthropometry modules. In particular, the consumption module reports data on household food consumption and on food expenditures using a seven-day recall. It reports quantities consumed at the household level for 59 food items differentiating them according to their source (purchases, own-production and gifts and other sources) and expenditures for purchased foods. The data sourced from the consumption module provides all the necessary information to estimate the household response to maize price shocks. In a similar manner, the anthropometry module reports data on body weight, height, age and gender of every individual by household and, again, these data allow us to calculate the adult BMI, underweight and overweight prevalence at the country level.

4.3.2 Construction of household and individual level variables

Food items were aggregated into eight groups which include maize, other cereals, livestock and livestock products, fruits and vegetables, starches, pulses, oils and other foods. The selection of

food groups was based on the usual aggregated basic food groups. Maize was disaggregated from the cereal group in order to simulate the shock on it. The “other foods” group comprise the following foods: bread, buns, cakes, macaroni, spices, sugar, sweets, nuts and seeds, tea, coffee and other beverages. While reporting more disaggregated elasticities can provide new insights, we would still be left with only a partial picture of households' demand for maize. Aggregating food groups over a more disaggregated approach has the advantage that estimation becomes simpler because of the more reduced number of parameters (Abdulai and Aubert, 2004a; Ecker and Qaim, 2011; Magrini et al., 2016). Finally, data on food consumption were aggregated by adding up food quantities for each group considered in the analysis and by computing the weighted average of the single item prices, using the consumption shares as weights.

To calculate household calorie consumption from the reported food quantities, we applied conversion factors of the Tanzania food composition tables (Tanzania Food Composition Tables, 2008). For each household and each food item, we matched the survey data on consumed food with their associated calorie intake.

The prevalence of adult underweight, overweight and obesity were computed following the WHO recommended cutoffs (WHO, 2006). The prevalence of underweight was defined as the percentage of population with BMI under 18.5 ($BMI \leq 18.5$), the prevalence of overweight as the percentage of population with BMI between 25 and 29.9 ($25 \leq BMI < 30$) and the prevalence of obesity as the percentage of population with BMI over 30 ($BMI \geq 30$).

After excluding respondents aged under eighteen and over 65 and respondents with implausible energy consumptions, the sample consists of 3,652 households and 8,991 respondents (5,965 correspond to rural respondents while 3,026 to urban respondents; 4,722 to net buyer households split into 2,286 to rural net buyer households and 2,436 to urban net buyer households). Households with energy intakes per capita below 500 and above 5000 kilocalories were considered outliers due to biologically implausible energy intake values (Ecker and Qaim, 2011).

4.4 Methods

4.4.1 Quadratic almost ideal demand models

The impact of a price shock on demand is a result of two components —the substitution effect and the income effect. The substitution effect is the change in the consumption of a commodity due to a change in its price for a constant level of utility. The income effect is the change in consumption due to the increase (or decrease) in purchasing power while relative prices remain constant. To model the demand of the eight food group items specified above we use the QUAIDS model (Banks et al., 1997). This model allows to estimate price and income demand elasticities, taking into account substitution between food groups in response to changes in prices or incomes. The QUAIDS model is a generalization of the Deaton and Muellbauer almost ideal demand system (AIDS) to include a quadratic expenditure term. Although there are several alternative models such as the Linear Expenditure System (Stone, 1954), the Rotterdam Model (Theil, 1965; Barten, 1964) or the Indirect Translog System (Christensen et al., 1975), the AIDS model appears to be more appropriate due to its analytical simplicity and consistency with theory (Magrini et al., 2016).

The introduction of the quadratic expenditure term in the QUAIDS model permits to appropriately model consumer behavior, as it allows goods to be nonlinearly related to expenditure and thus to be luxuries at certain income levels and necessities at other income levels (Banks et al., 1997). This strand of literature considers that household preferences can be defined in the QUAIDS model by the following indirect utility function ($\ln V(p, m)$), which is derived from the generalization of the Price-Independent Generalized Logarithmic (PIGLOG) demand system —demand system with budget shares linear in log total expenditure:

$$\ln V(p, m) = \left[\left\{ \frac{\ln m - \ln a(p)}{b(p)} \right\}^{-1} + \lambda(p) \right]^{-1}, \quad (4.1)$$

where $(\ln m - \ln a(p))/b(p)$ is the indirect utility function of a PIGLOG demand system, m is total household expenditure on food and $\ln a(p)$, $b(p)$ and $\lambda(p)$ are functions of a vector of prices (p) . Specifically, $\ln a(p)$ is defined as the following translog function:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^k \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^k \sum_{j=1}^k \gamma_{ij} \ln p_i \ln p_j, \quad (4.2)$$

where k is the number of food groups in the system, subscripts i and j are food groups in the system and p_i and p_j are the prices of food group i and food group j respectively.

$b(p)$ is the Cobb-Douglas price aggregator function defined as:

$$b(p) = \prod_{i=1}^k p_i^{\beta_i}, \quad (4.3)$$

and $\lambda(p)$ is defined as follows:

$$\lambda(p) = \sum_{i=1}^k \lambda_i \ln p_i, \quad (4.4)$$

where α_i , γ_{ij} , β_i and λ_i are parameters to be estimated. The QUAIDS model is subject to a number of constraints in its parameters derived from demand theory: adding up, homogeneity and Slutsky symmetry. The adding up condition implies that the system of expenditure share equations add up to total expenditure ($\sum w_i = 1$), and thus has to meet the following restrictions:

$$\sum_{i=1}^k \alpha_i = 1; \quad \sum_{i=1}^k \beta_i = 0; \quad \sum_{i=1}^k \lambda_i = 0; \quad \sum_{j=1}^k \gamma_{ij} = 0, \quad (4.5-4.8)$$

Demands are homogenous of degree zero in all prices and income. This requires the compliance with the following restriction:

$$\sum_{j=1}^k \gamma_{ij} = 0, \quad (4.9)$$

And finally, Slutsky symmetry requires that:

$$\gamma_{ij} = \gamma_{ji}, \quad (4.10)$$

The Roy's identity reformulates Shephard's lemma in order to get a Marshallian demand function for an individual and a good from a specific indirect utility function (Roy, 1947). Applying Roy's identity to Equation (4.1), the expenditure share equation for food group i is defined in the QUAIDS as:

$$w_i = \alpha_i + \sum_{j=1}^k \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{m}{a(p)} \right\} + \frac{\lambda_i}{b(p)} \left[\ln \left\{ \frac{m}{a(p)} \right\} \right]^2, \quad i = 1, \dots, k \quad (4.11)$$

where w_i is the expenditure share for food group i , m is total household food expenditure and p_j is the price of food group j . Note that when λ_i is 0 for all i then the expenditure share equation would be that of the AIDS model.

A total of 4 demographic effects —household size, age of the household head, number of children in the household and the household head's level of education— are controlled for in the model to account for other additional factors apart from prices and total expenditure affecting household food demand. For example, increasing household size may affect food demand by increasing the consumption of cheaper sources of calories and decreasing the consumption of more expensive foods.

Following Ray (1983) and Poi (2012), the expenditure share equation for food group i including demographics modifies Equation (4.11) in the following way:

$$w_i = \alpha_i + \sum_{j=1}^k \gamma_{ij} \ln p_j + (\beta_i + \eta'_i z) \ln \left\{ \frac{m}{\bar{m}_0(z)a(p)} \right\} + \frac{\lambda_i}{b(p)c(p,z)} \left[\ln \left\{ \frac{m}{\bar{m}_0(z)a(p)} \right\} \right]^2, \quad (4.12)$$

where z is a vector of demographic variables and $\bar{m}_0(z)$ and $c(p, z)$ are defined by the following equations:

$$\bar{m}_0(z) = 1 + \rho' z; \quad c(p, z) = \prod_{j=1}^k p_j^{\eta'_{jz}}, \quad (4.13-4.14)$$

One critical problem of using survey data to model demand systems is that surveys report zero expenditure shares for food items for those households in which the specific food item is not consumed. This causes censored dependent variables that lead to biased elasticity estimates. We use the two step procedure developed by Shonkwiler and Yen (1999) to correct for this. The procedure consists in first estimating a multivariate probit regression to calculate the probability of consuming each specific food aggregate. From the multivariate probit we estimate the standard normal cumulative distribution function and the standard normal probability density function. The latter permits to modify Equation (4.12) to account for zero expenditure shares as follows:

$$w_i^* = \Phi(\hat{\tau}'_i z) w_i + \delta_i \varphi(\hat{\tau}'_i z) + \xi_i, \quad (4.15)$$

where w_i^* is the observed expenditure share for food group i , $\Phi(\cdot)$ and $\varphi(\cdot)$ are the cumulative distribution function and the probability density function based on the multivariate probit regression, $\hat{\tau}'_i$ is the vector of associated parameters from the multivariate probit and δ_i is the covariance between the error terms in the QUAIDS model and the multivariate probit. Finally, the uncompensated price elasticity of good i with respect to changes in the price of good j and the expenditure elasticity can be defined, respectively, as follows:

$$\begin{aligned} \epsilon_{ij} = \frac{\partial w_i^*}{\partial \ln p_j} = \frac{1}{w_i} \left(\gamma_{ij} - \left[\beta_i + \eta'_i z + \frac{2\lambda_i}{b(p)c(p,z)} \ln \left\{ \frac{m}{\bar{m}_0(z)a(p)} \right\} \right] \times (\alpha_j + \sum_l \gamma_{jl} \ln p_l) - \right. \\ \left. - \frac{(\beta_j + \eta'_j) \lambda_i}{b(p)} \left[\ln \left\{ \frac{m}{\bar{m}_0(z)a(p)} \right\} \right]^2 \right) \Phi(\hat{\tau}'_i z) + \varphi_i \tau_{ij} \left(1 - \frac{\delta_i}{w_i} \right) - \delta_{ij}, \end{aligned} \quad (4.16)$$

$$\mu_i = \frac{\partial w_i^*}{\partial \ln m} = 1 + \frac{1}{w_i} \left[\beta_i + \eta'_i z + \frac{2\lambda_i}{b(p)c(p,z)} \ln \left\{ \frac{m}{\bar{m}_0(z)a(p)} \right\} \right] \Phi(\hat{\tau}'_i z), \quad (4.17)$$

The compensated price elasticity of good i with respect to changes in the price of good j can be defined from the Slutsky equation as:

$$\epsilon_{ij}^c = \epsilon_{ij} + \mu_i \omega_j, \quad (4.18)$$

Since food prices are not usually included in households' expenditure surveys they are typically approximated by their unit values. The unit values are computed as the ratio of the expenditure on the purchased food item to the purchased quantity. However, some authors consider that using unit values as proxies of prices can lead to inconsistent estimates of price elasticities of demand because they do not account for quality effects and measurement errors (Deaton, 1988; Alfonzo and Peterson, 2006). Following the approach used by Alfonzo and Peterson (2006) and Ecker and Qaim (2011), price indices are approximated using predictions of unit values which specifically account for geographical location and seasonal changes in prices. Unit values were calculated item-specifically and used to impute prices to non-purchased consumed quantities accounting for location and time, for which the survey does not report expenditures. Unit values were then corrected to account for food item expenditures, household characteristics and geographical and seasonal variations in prices. Geographical and seasonal characteristics in prices are taken into account by determining clusters of households defined by region, whether the household belongs to rural or urban areas and the month in which the survey was conducted. In this way, prices are corrected for quality by considering only the part of the unit value which is constant within the

same location and time (Alfonzo and Peterson, 2006). Thus prices were approximated by the following two equations:

$$\ln u_i = \alpha_i + \beta_i x_i + \sum_{k=1}^K \gamma_{ik} z_k + \sum_{c=1}^{C-1} \rho_{ic} D_c + \sum_{ae=1}^{AE} \epsilon_{iae} D_{ae} + \sum_{m=1}^M \mu_{im} D_m + \varepsilon_i \quad (4.19)$$

where u_i is the item-specific unit value, x is food expenditure, z_{ik} is a vector of household characteristics and D_c are the cluster dummies, D_{ae} dummies for each agroecological zone and D_m monthly dummies.

$$\ln \hat{\pi}_i = \hat{\alpha}_i + \sum_{c=1}^{C-1} \hat{\rho}_{ic} D_c, \quad (4.20)$$

where $\ln \hat{\pi}_i$ is the price approximation and $\hat{\alpha}_i$ and $\hat{\rho}_{ic}$ are the estimates of α_i and ρ_{ic} from Equation (4.19).

Once we estimate the elasticities using the QUAIDS model we use them to derive the changes in calories (ΔE) consumed by each household from the uncompensated own- and cross-price elasticities specified in Equation (4.16), i.e.

$$\Delta E = \frac{\Delta p_j}{p_j} \sum_{i=1}^k \epsilon_{ij} e_i q_i, \quad (4.21)$$

where ϵ_{ij} is the uncompensated elasticity of food group i with respect to the change in the price of food group j ($\Delta p_j/p_j$), q_i is the quantity consumed of food item i and e_i is the technical coefficient measuring the caloric content of food item i contained in each unit of q_i . From equation (4.21) we obtain an aggregate measure of the total change in calories experienced by the households. Since the ultimate objective of the present exercise is to look at the impact of the price shock on the anthropometric indicators at individual level, we still need two further steps. First, we need to distribute the aggregate calorie consumption variation (ΔE) across household's members to see how it affects the individual level of calorie intake. Second, we need to convert

the variation of the calorie intake into a change of the body weight so that we can compare the anthropometric indicators before and after the price shock.

4.4.2 Intra-household distribution of changes in calorie consumption

The LSMS–ISA project collected food consumption data at household level and individual-level anthropometric data of the household members. However, no individual level on food consumption was collected thus raising concerns on how to deal with intra-household allocation of food. Using per capita measures to estimate the allocation of food and thus calories is likely to lead to biased estimates of calorie loss. Supporting this hypothesis, Hyder et al. (2005) show that in some countries like Tanzania inequities favor men. In fact, intra-household allocation of food amongst family members might be unequal and ultimately determine different patterns of individual food and nutrient intake with respect to the recommended one (Carletto et al. 2013).

Keeping this caveat in mind, we relied on the standard hypothesis that food is distributed within the household in direct proportion to expected members' shares of the household's total adult male consumption equivalent (Fiedler et al. 2012). In other words, we assume that calories are distributed within the household according to the recommended calorie needs of each member. To compute the relative calorie requirements of each household member, we use the recommended daily calorie intakes from the UNU/WHO/FAO expert consultation (FAO, WHO and UNU, 2004). Further, we assumed a “moderate” Physical Activity Level (PAL) to calculate minimum calorie requirements. While assuming a “moderate” level of PAL might underestimate energy requirement of population subsets engaged with agriculture activities (D'Souza and Tandon, 2015), assuming a higher PAL could conversely overestimate calorie requirements for sedentary individuals. Thus, we set the required PAL equal to moderate.

Table 4.1 provides an example on how change in calorie intake was distributed for a household composed of two adults and two children including age, gender and physical activity of family members.

Table 4.1. Intra-household calorie allocation for a standard household

	Age (years)	Gender	Physical activity	Weight (kg)	Recommended Energy requirement (kcal/day)	Recommended share of HH energy allocation (%)	Total HH Energy Changes (kcal/day)	Intra- household calorie change allocation (kcal/day)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Man	34	Male	Moderate	72	3,163.00	37%	-500.00	-185.00
Woman	30	Female	Moderate	58.4	2,427.60	28%	-500.00	-140.00
Child	5	Male	Moderate	-	639	7%	-500.00	-35.00
Child	13	Female	Moderate	-	2,375	28%	-500.00	-140.00
Total					8,604.60	100%		-500.00

Note: Authors' analysis of 2010/2011 TZNPS

After computing each household member's recommended energy requirement, the change in total household calories resulting from equation (4.21) is allocated proportionally to each household member according to his/her share. The share is calculated by first computing the individual level required calorie intake based on gender, age and PAL, summing it up and then dividing individual energy requirement by the total (column (6)). Then, the estimated household calorie loss (column (7)) due to increased price of maize is distributed within the household based on shares presented in column (6). For example, due to an upward maize price shock, an adult woman in the family would experience a decrease in consumption of calories equal to 140 kcal on a daily basis.

4.4.3 Calorie to weight models

Once we determine the intra-household distribution of the calorie changes, we need to convert it in a weight-equivalent measure to be used for simulating the counterfactual BMI after the price shock. Changes in body weight are the result of an imbalance between energy intake and total energy expenditure (Chow and Hall, 2008). On the contrary, when energy intake and energy expenditure are balanced over a period of time, the individual reaches a steady state (FAO, WHO and UNU, 2004). Usually, to test how a change in energy calorie intake would affect body weight, a static model is used. The static model states that a cumulative energy deficit of 3,500 kilocalories is needed per pound of body weight loss (Chow and Hall, 2008) based on the assumption that each unit of body weight change corresponds to a fixed 75 percent of fat tissue and 25 percent of lean tissue change. Thus, the relation between changes in calorie intake and

body weight is assumed to be a constant process such that it predicts a linear change in body weight over time (Lin et al., 2011).

However, weight change is actually a dynamic process that diminishes over time (Lin et al., 2011; Ruff and Zhen, 2015) and so the static model can overestimate weight loss or gain significantly (Katan and Ludwig, 2010; Lin et al., 2011; Ruff and Zhen, 2015). These authors give several reasons for this. First, the actual energy requirements of the individual depend on several factors—i.e. age, gender, weight, activity level and body composition—and energy requirements decrease (increase) with decreasing (increasing) weight. Thus, weight loss (or gain) slows down asymptotically under a constant change in calorie intake over time until a new steady state is again achieved. Second, the fixed percentage of fat and lean tissue lost per unit of body weight assumed by the static model actually does not hold. As a consequence, changes in total weight depend nonlinearly on body fat mass, so the relation between energy and weight change varies over time. In addition, energy intake and energy expenditure are also affected by this dynamic change in body fat and lean tissue, due to the fact that the energy expenditure rate of lean tissues is larger than that of fat tissues.

For all these reasons, in the paper we use both the static model and the recently developed dynamic model (see Appendix A.3 for more details) proposed by Hall et al. (2011) and applied by Lin et al. (2011) to analyze the impact of taxation on sugar beverages on weight loss in the US.

4.5 Descriptive statistics

Table 4.2 presents the budget shares for the different food groups considered in the analysis and the average daily calorie consumption per adult household member. The data are further disaggregated by rural and urban households as food consumption may respond differently to changes in food prices across households' categories.

Table 4.2. Budget shares referring to overall consumption and average overall calorie consumption in the baseline (2010/2011).

	Total	Rural	Urban	Net buyer	Rural net buyer	Urban net buyer
Budget Shares (%)						
Maize	0.18	0.19	0.14	0.16	0.19	0.13
Other cereals	0.12	0.12	0.14	0.14	0.13	0.14
Livestock and Products	0.20	0.19	0.21	0.20	0.19	0.21
Fruits and Vegetables	0.14	0.13	0.14	0.13	0.13	0.14
Starches	0.09	0.11	0.07	0.08	0.09	0.06
Pulses	0.05	0.06	0.04	0.05	0.05	0.04
Oils	0.05	0.04	0.05	0.05	0.04	0.06
Other Foods	0.17	0.16	0.21	0.19	0.17	0.21
Average calorie intake (kcal / day) per adult household member						
Maize	701.1 (577.4)	737.5 (633.2)	629.4 (438.6)	679.0 (494.4)	733.8 (573.9)	627.5 (399.0)
Other cereals	345.4 (368.9)	310.9 (387.8)	413.5 (317.7)	404.4 (345.7)	372.5 (383.4)	434.3 (303.0)
Livestock and Products	207.9 (246.3)	197.1 (242.1)	229.1 (253.0)	208.7 (244.0)	183.9 (224.7)	231.9 (258.7)
Fruits and Vegetables	64.5 (65.2)	58.0 (62.5)	77.1 (68.6)	70.9 (69.5)	62.2 (68.6)	79.1 (69.4)
Starches	310.7 (433.4)	364.3 (484.7)	204.9 (279.2)	240.2 (303.4)	302.2 (367.0)	181.9 (212.1)
Pulses	84.0 (87.6)	83.4 (94.7)	85.2 (71.6)	83.1 (81.0)	77.4 (89.4)	88.4 (71.8)
Oils	159.1 (125.5)	123.8 (129.9)	229.1 (175.6)	190.8 (165.5)	137.4 (131.3)	241.1 (178.2)
Other Foods	338.6 (316.0)	273.7 (289.8)	466.9 (326.1)	419.4 (328.7)	338.9 (313.3)	495.1 (324.9)
Total	2,211.4 (917)	2,148.6 (917)	2,335.4 (905)	2,296.5 (904)	2,208.4 (895)	2,379.3 (905)

Note: Standard deviations in parenthesis. Source: Authors' calculation based on 2010/2011 TZNPS

In addition, we examined (urban and rural) net buyers of maize since we believe they constitute two sub-segments of the population that could be highly affected by a shock in the price of maize. Average calorie consumption has been converted into daily adult household member to facilitate its comparison with reference levels from the literature.

Slightly more than 30 percent of the budget was devoted to cereals in both rural and rural net buyer households while urban and urban net buyer households allocated 28 and 27 percent of their budget respectively to the maize and the “other cereals” groups combined. Rural households and rural net buyer households allocated a higher proportion of their budget to maize (19 percent and 16 percent respectively), while urban and urban net buyer households allocated a larger or at least the same share to the “other cereals” group, showing that the share of consumed maize is larger in maize producing areas. There are no large differences in the budget devoted to livestock and its products, fruit and vegetables, pulses and oils between rural and urban households and rural and urban net buyer households.

The average calorie consumption reached 2,167 kilocalories per capita in 2011 (FAO-FAOSTAT, 2015), which suggests that our estimate of 2,211 for the total population is reasonable. On average, urban households consumed more calories than rural households (2,335 kilocalories per adult household member in urban households against 2,148 in rural areas). This pattern is repeated for net buyer households, although calorie consumption is higher in net buyer households both in rural and urban areas. Maize was the main source of calories for all households irrespective of their classification. This suggests high dependency on maize amongst Tanzanian population and thus high vulnerability to maize price shocks. The second source of calories in rural households was starches, whereas in rural net buyer households was the “other cereals” group. In contrast, in urban areas, the second source of calories was the “other foods” group followed by the “other cereals” group.

To set the percentage increase in the price of maize, we used information from the TZNPS. We calculated real retail prices based on what was reported in the household survey, as displayed in Figure 4.1 (below).

Figure 4.1. Evolution of real retail maize prices in Tanzania in the study period (Tanzanian Shilling/kg)

Note: Authors' calculation based on 2010/2011 TZNPS

We found that the retail maize price increased from 600 to 700 TZS between January and March 2011 and then remained above this level until the end of the year. In other words, the initial 17 percent shock in the real retail maize price has not been reabsorbed for at least 6 months and thus, in our exercise, we simulated an average increase of 20 percent to also account for price spike in July 2011. Our model does not account for price co-movements potentially arising from price shocks in international markets and leading to more complex substitution between food groups as well as real income effects. Moreover, given that the data set includes one observation per household during the period examined, we cannot account for the household specific price variation. As a result, the price variation Δp_j is considered fixed across households.

4.6 Results

4.6.1 Quadratic almost ideal demand models

The mean expenditure and uncompensated and compensated price elasticities of food demand for the rural and urban samples are given in Tables 4.3 and 4.4.

Table 4.3. Expenditure and price elasticities of food demand for rural households, means

	Maize	Other cereals	Livestock	Fruit and veg	Starches	Pulses	Oils	Other foods
Expenditure elasticities								
	0.534 (0.037)	1.554 (0.176)	1.414 (0.075)	0.737 (0.029)	0.653 (0.153)	0.602 (0.061)	0.636 (0.068)	1.345 (0.082)
Marshallian (uncompensated) price elasticities								
Maize	-1.064 (0.025)	0.188 (0.021)	0.090 (0.014)	-0.015 (0.011)	0.084 (0.016)	-0.068 (0.018)	0.043 (0.012)	0.209 (0.019)
Other cereals	0.052 (0.037)	-1.235 (0.065)	-0.153 (0.033)	-0.031 (0.024)	-0.012 (0.024)	-0.067 (0.025)	-0.005 (0.019)	-0.102 (0.039)
Livestock	-0.086 (0.019)	-0.096 (0.021)	-0.943 (0.018)	-0.028 (0.011)	-0.076 (0.013)	-0.038 (0.011)	-0.031 (0.007)	-0.116 (0.020)
Fruits and vegetables	-0.014 (0.018)	0.023 (0.022)	0.072 (0.012)	-0.904 (0.014)	0.015 (0.015)	0.067 (0.013)	-0.003 (0.008)	0.008 (0.015)
Starches	0.146 (0.034)	0.204 (0.046)	0.009 (0.029)	0.013 (0.021)	-1.145 (0.031)	-0.051 (0.019)	-0.099 (0.020)	0.270 (0.058)
Pulses	-0.081 (0.032)	0.212 (0.051)	0.021 (0.021)	0.095 (0.022)	0.067 (0.029)	-1.036 (0.053)	0.057 (0.027)	0.063 (0.028)
Oils	-0.104 (0.029)	-0.141 (0.046)	0.026 (0.020)	0.035 (0.020)	0.162 (0.025)	0.049 (0.035)	-0.813 (0.032)	0.150 (0.027)
Other foods	0.117 (0.022)	-0.132 (0.024)	-0.149 (0.017)	-0.056 (0.013)	0.017 (0.017)	0.160 (0.024)	-0.013 (0.017)	-1.289 (0.045)
Hicksian (compensated) price elasticities								
Maize	-0.961 (0.025)	0.250 (0.021)	0.194 (0.013)	0.056 (0.010)	0.141 (0.015)	-0.038 (0.018)	0.066 (0.012)	0.292 (0.016)
Other cereals	0.353 (0.027)	-1.053 (0.052)	0.150 (0.019)	0.174 (0.016)	0.153 (0.025)	0.020 (0.024)	0.061 (0.016)	0.142 (0.025)
Livestock	0.188 (0.014)	0.070 (0.017)	-0.667 (0.015)	0.158 (0.008)	0.074 (0.012)	0.042 (0.009)	0.029 (0.005)	0.106 (0.014)
Fruits and vegetables	0.129 (0.017)	0.110 (0.021)	0.216 (0.012)	-0.807 (0.014)	0.093 (0.014)	0.108 (0.013)	0.028 (0.008)	0.124 (0.014)
Starches	0.273 (0.026)	0.280 (0.035)	0.137 (0.019)	0.099 (0.015)	-1.076 (0.031)	-0.014 (0.020)	-0.071 (0.021)	0.372 (0.041)
Pulses	0.036 (0.033)	0.283 (0.049)	0.138 (0.022)	0.174 (0.022)	0.131 (0.028)	-1.002 (0.053)	0.082 (0.026)	0.158 (0.029)
Oils	0.020 (0.028)	-0.066 (0.044)	0.150 (0.018)	0.118 (0.018)	0.229 (0.025)	0.085 (0.034)	-0.786 (0.032)	0.250 (0.027)
Other foods	0.378 (0.020)	0.026 (0.021)	0.113 (0.014)	0.121 (0.011)	0.160 (0.017)	0.235 (0.023)	0.045 (0.019)	-1.078 (0.036)

Note: Standard errors in parenthesis. Source: Authors' calculation based on 2010/2011 TZNPS

Table 4.4. Expenditure and price elasticities of food demand for urban households, means

	Maize	Other cereals	Livestock	Fandv	Starches	Pulses	Oils	Other foods
Expenditure elasticities								
	0.303 (0.073)	1.198 (0.209)	1.441 (0.075)	0.891 (0.034)	0.774 (0.247)	0.515 (0.093)	0.720 (0.069)	1.198 (0.043)
Marshallian (uncompensated) price elasticities								
Maize	-1.009 (0.042)	0.242 (0.040)	0.136 (0.022)	-0.012 (0.019)	0.134 (0.026)	-0.030 (0.023)	-0.001 (0.013)	0.237 (0.036)
Other cereals	0.095 (0.034)	-1.142 (0.106)	-0.163 (0.031)	0.028 (0.033)	-0.011 (0.032)	0.018 (0.025)	-0.006 (0.024)	-0.019 (0.053)
Livestock	-0.062 (0.015)	-0.161 (0.034)	-0.935 (0.016)	-0.034 (0.012)	-0.038 (0.014)	-0.035 (0.009)	-0.039 (0.007)	-0.136 (0.022)
Fruits and vegetables	-0.076 (0.016)	0.062 (0.022)	0.057 (0.012)	-0.929 (0.014)	-0.022 (0.014)	0.031 (0.013)	-0.006 (0.007)	-0.008 (0.015)
Starches	0.227 (0.047)	0.103 (0.111)	0.016 (0.041)	-0.032 (0.039)	-1.102 (0.055)	-0.053 (0.032)	-0.130 (0.035)	0.198 (0.099)
Pulses	-0.077 (0.044)	0.271 (0.073)	0.022 (0.030)	0.110 (0.032)	0.079 (0.041)	-1.029 (0.077)	0.049 (0.036)	0.060 (0.042)
Oils	-0.129 (0.029)	-0.033 (0.051)	0.002 (0.018)	0.021 (0.019)	0.085 (0.025)	0.026 (0.033)	-0.835 (0.030)	0.144 (0.029)
Other foods	0.034 (0.019)	-0.024 (0.022)	-0.094 (0.012)	-0.043 (0.010)	-0.033 (0.014)	0.038 (0.012)	0.036 (0.012)	-1.111 (0.032)
Hicksian (compensated) price elasticities								
Maize	-0.967 (0.042)	0.284 (0.035)	0.200 (0.021)	0.031 (0.016)	0.154 (0.026)	-0.017 (0.022)	0.015 (0.013)	0.300 (0.030)
Other cereals	0.259 (0.034)	-0.975 (0.081)	0.090 (0.031)	0.197 (0.018)	0.069 (0.040)	0.071 (0.024)	0.058 (0.017)	0.231 (0.028)
Livestock	0.134 (0.014)	0.040 (0.025)	-0.632 (0.017)	0.169 (0.008)	0.057 (0.016)	0.029 (0.009)	0.038 (0.005)	0.165 (0.014)
Fruits and vegetables	0.045 (0.016)	0.186 (0.020)	0.245 (0.012)	-0.804 (0.013)	0.037 (0.014)	0.071 (0.012)	0.042 (0.007)	0.178 (0.014)
Starches	0.332 (0.046)	0.211 (0.083)	0.179 (0.040)	0.077 (0.025)	-1.051 (0.062)	-0.019 (0.032)	-0.088 (0.035)	0.359 (0.066)
Pulses	-0.007 (0.043)	0.343 (0.069)	0.131 (0.031)	0.182 (0.032)	0.113 (0.041)	-1.006 (0.076)	0.076 (0.035)	0.168 (0.044)
Oils	-0.031 (0.028)	0.067 (0.046)	0.154 (0.019)	0.122 (0.017)	0.132 (0.026)	0.057 (0.033)	-0.796 (0.030)	0.295 (0.028)
Other foods	0.198 (0.019)	0.142 (0.019)	0.158 (0.012)	0.126 (0.009)	0.046 (0.015)	0.091 (0.012)	0.100 (0.012)	-0.861 (0.028)

Note: Standard errors in parenthesis. Source: Authors' calculation based on 2010/2011 TZNPS

The positive expenditure elasticities revealed that the consumption of all food groups increased with raising incomes. Maize had an expenditure elasticity below one, which indicates that it is a necessity good. This comes as no surprise as the population relies to a large extent on this staple to feed itself. Fruits and vegetables, pulses, oils and starches showed up as necessity goods too. On the other hand, livestock products, other cereals and the “other foods” group had expenditure elasticities above one, indicating that they are luxury goods. All this suggests that consumers tend to spend proportionally less on maize, fruits and vegetables, starches, pulses and oils and more on other cereals, animal-source products and the “other foods” group with raising incomes. These

results appear to be in line with the consumption patterns typical of Tanzania: there is a high reliance on staples, especially on maize and cassava, while wheat and rice are considered more expensive sources of calories (Minot, 2010). Animal-source products are still not a large share of the diet, and fruits, pulses and vegetables are usually considered as less preferred foods (Keding et al., 2013).

All of the uncompensated and compensated own-price elasticities were statistically significant and negative, and thus consistent with demand theory. The relatively large uncompensated own-price elasticities revealed a high responsiveness of both rural and urban households to changes in food prices and indicated their vulnerability to food price shocks, especially a shock on maize prices. From now on we concentrate on the uncompensated own- and cross-price elasticities of maize because the focus of the study is an increase in its prices. Maize appeared to be more price elastic among rural households than among urban ones: urban households may respond less to changes in maize prices because it comprises a smaller share of their diet, despite being an important staple in urban settings too. We found substitution relationships between maize and the “other cereals” group, starches and the “other foods” group both in rural and urban settings. In other words, it looks like the demand for other energy-dense foods would increase following the maize prices rise. This suggests that calorie consumption is still the main concern of Tanzanian households, which tend to shift consumption towards similar high caloric content foods. Moreover, we found complementary relationships between maize and livestock products, fruits and vegetables, pulses and oils. This means that the demand for these foods would fall as maize prices rise. It is important to note that substitution possibilities could help reduce the impact of the maize price increase by softening the fall in energy intake caused by the shock and could even improve the protein and micronutrient intake. In this particular case, these substitution possibilities seem to be limited to other energy-dense foods with a low content in micronutrients, while the consumption of more nutritious foods would fall further.

4.6.2 Calorie consumption, weight and prevalence of underweight, overweight and obesity simulation results

A twenty percent maize price increase would result in an overall average reduction of calorie intake irrespective of the household classification, which is what Table 4.5 shows (for ease of interpretation, results have been converted to a daily basis). This result may be surprising as households that are net sellers of maize should observe a real income boost when maize prices increase. However, the net sellers included in our sample (1,229 as opposed to 4,722 net buyers) experience a slightly larger calorie loss on average than net buyers (-205 kcal for all net sellers, -208 kcal for rural net sellers and -170 kcal for urban net sellers) because their average calorie consumption of maize in the baseline is larger than in net buyer households. This could be related to the fact that we overlook the potential income boost by not capturing the supply side effects of the price increase in the analysis, should the income boost be sufficient to compensate the overall increase in food prices driven by the increase in maize price. In this way, we could be overestimating to some extent the calorie loss as a result of the shock.

Table 4.5. Effects of a 20 percent maize price shock on calorie consumption (changes in calorie intake (kcal/day) per adult household member)

	Maize		Foods other than maize		All foods	
	Mean	Median	Mean	Median	Mean	Median
Total	-145.4	-121.7	6.6	4.9	-138.8	-117.6
Rural	-155.0	-133.3	7.9	5.4	-147.2	-126.0
Urban	-126.4	-108.3	4.1	4.1	-122.3	-105.4
Net buyer	-140.1	-115.5	5.7	5.0	-134.4	-110.8
Rural net buyer	-154.9	-126.1	7.6	6.4	-147.3	-118.8
Urban net buyer	-126.1	-109.9	3.9	4.1	-122.3	-106.3

Note: Authors' calculation based on 2010/2011 TZNPS.

From the perspective of calorie intake, substitution possibilities would not be enough to compensate for the drop in energy consumption. It appears that the total cross-price effects that result from the substitution and complementary relationships of maize would be relatively small compared to its own-price effects and would offset each other. Even if the price of maize

increased by 20 percent, households would decrease their consumption of more expensive and nutritious foods in order to be able to purchase more of the staple or other cheap sources of calories.

The fall in calorie intake would be larger in rural settings. This can be associated with the difference in either the dietary patterns or the consumption response to the price shock across urban and rural areas. The mean own-price elasticity of demand is quite similar, yet somewhat higher in absolute value in rural areas. The share of maize in the diet is larger in rural areas, most likely because it is where it is produced. Imported cereals that compete with domestically produced maize are more available in urban areas. Surprisingly, the total cross-price effects that result from the substitution and complementary relationships of maize are slightly larger in rural areas, probably due to the larger share of the substitute starches in rural diets and of the complementary animal-source foods, fruits and vegetables and oils in urban ones. The fall of calorie intake of men would be larger relative to women but this is the result of the way the change in calories has been allocated across households, as men have higher energy requirements than women.

The overall average reduction in calorie intake resulted in the subsequent loss of average weight per adult household member when considering both the static and the dynamic models, as shown in Table 4.6.

Table 4.6. Weight changes predicted by the static and dynamic models over a 3, 6, 9 and 12 month period (kg/adult household member).

	Static model	Dynamic model
Total		
Baseline	58.7	58.7
3 months	-1.7	-1.5
6 months	-3.3	-2.6
9 months	-4.9	-3.5
12 months	-6.6	-4.2
Rural		
Baseline	57.3	57.3
3 months	-1.7	-1.6
6 months	-3.5	-2.8
9 months	-5.2	-3.7
12 months	-7.0	-4.4
Urban		
Baseline	61.6	61.6
3 months	-1.5	-1.3
6 months	-2.9	-2.3
9 months	-4.4	-3.1
12 months	-5.9	-3.7
Net buyer		
Baseline	60.3	60.3
3 months	-1.6	-1.4
6 months	-3.2	-2.5
9 months	-4.8	-3.4
12 months	-6.4	-4.0
Rural net buyer		
Baseline	58.3	58.3
3 months	-1.7	-1.5
6 months	-3.4	-2.7
9 months	-5.1	-3.6
12 months	-6.9	-4.4
Urban net buyer		
Baseline	62.3	62.3
3 months	-1.5	-1.3
6 months	-3.0	-2.3
9 months	-4.4	-3.1
12 months	-5.9	-3.7

Note: Baseline reports the average weight.

However, the results predicted by the dynamic model are much smaller and the difference between the results predicted by each of the models becomes larger over time. The static model generates a constant rate of decrease in weight over time, whereas the weight change predicted by the dynamic model tends to diminish over time, as can be seen clearly in Figure 4.2.

Figure 4.2. Evolution of average weight change over one year (kg/adult household member).

Note: Authors' calculation based on 2010/2011 TZNPS

If the study period were longer, the weight loss predicted by the dynamic model would level off at a certain stage in which the individual steady state would be once again attained. The results show that the static model overestimates the results of the dynamic model, making the results of the dynamic model more realistic. As expected from the results shown above on calorie consumption, average weight loss was higher in rural settings and higher for men than women.

As we showed that the results of the static model overestimate those of the dynamic one, in Table 4.7 we only reported the underweight, overweight and obesity prevalence predicted by the dynamic model.

Table 4.7. Percentage of underweight, overweight and obesity prevalence of adults predicted by the dynamic model

	Male			Female		
	Underweight	Overweight	Obese	Underweight	Overweight	Obese
Total						
Baseline	10.1	10.6	3.1	8.4	18.7	9.9
3 months	19.2	9.3	2.8	13.0	16.7	9.1
6 months	25.9	8.1	2.6	17.5	15.0	8.7
Rural						
Baseline	10.2	7.6	2.0	9.3	16.3	6.7
3 months	19.8	6.6	1.8	14.4	14.3	6.1
6 months	27.4	5.6	1.7	19.8	12.7	5.8
Urban						
Baseline	10.0	17.3	5.7	6.5	23.7	16.4
3 months	17.9	15.5	5.1	10.3	21.6	15.1
6 months	22.5	13.7	4.7	12.7	19.7	14.5
Net buyer						
Baseline	10.2	13.5	4.3	8.6	21.1	14.3
3 months	18.9	12.2	3.8	13.1	19.3	13.3
6 months	24.5	10.5	3.5	17.0	17.8	12.7
Rural net buyer						
Baseline	10.8	8.7	2.8	10.5	18.2	9.7
3 months	20.5	7.9	2.5	15.7	16.0	9.1
6 months	27.0	6.8	2.3	21.1	15.0	8.7
Urban net buyer						
Baseline	9.5	18.6	6.0	6.8	23.9	18.7
3 months	17.2	16.7	5.2	10.5	22.4	17.4
6 months	21.9	14.5	4.7	13.0	20.4	16.6

Note: Authors' calculation based on 2010/2011 TZNPS

The results are reported by gender because women are usually more vulnerable to nutrition outcomes (Keding et al. 2012) and because in developing countries they commonly tend to have higher rates of overweight and obesity. The table shows a steady increase in the short to medium term in the underweight rate and a fall in the overweight and obesity rates. This result was expected due to the reduction in calorie intake and the subsequent fall in weight of the population after the price shock seen above. We have to keep in mind that by not capturing the supply side effects of the price increase in the analysis, we could be overestimating to some extent the fall in average calorie loss and therefore we could be overestimating too the increase in the underweight and rate and the fall in the overweight and obesity rates. But what is striking about the results in Table 4.7 is that the maize price increase had a relatively much larger effect in the underweight

rate than in the overweight and obesity rates. Moreover, it had a larger effect in the overweight and obesity rates in rural settings than in urban ones.

These results are likely associated either with the dietary patterns of the overweight and obese individuals being less dependent on maize or with differences in the response of the demand of food to the price shock across the overweight and obese population. We classified households into three categories in order to reveal potential differences in baseline consumption patterns and in the change in calorie intake caused by the price increase among the overweight and obese population: (a) households with at least one underweight individual; (b) households with at least one overweight and/or obese individual; and (c) households with no underweight, overweight and/or obese individuals. Upon closer examination of the different dietary patterns across households, we see that households with at least one overweight or obese individual indeed consumed a smaller share of maize both in terms of budget and calorie shares. Households with at least one overweight or obese individual located in urban settings consumed a smaller share of maize than those located in rural areas. Apart from maize, households with at least one overweight and/or obese individual consumed less fruits and vegetables, starches and pulses and consumed more livestock products, oils and other foods —some of the obesogenic food items included in this group are common among overweight and obese women's diets in Tanzania (Keding et al., 2013).

These dietary patterns identified for households with at least one overweight and obese individual are consistent with previous studies in Tanzania (Keding et al., 2013) suggesting an early stage of the nutritional transition characterized by higher rates of overweight and obesity relative to those of underweight (Popkin et al., 2012; Keding et al., 2013). As seen above, the complementary and substitution relationships of maize would only favor the consumption of other energy-dense foods with a low content in micronutrients. In the face of the maize price increase two things might happen. On the one hand, the prevalence of underweight would rise contributing to undernutrition both in terms of calorie and micronutrient intake. On the other hand, the prevalence of overweight and obesity would also evolve but to a lesser extent. The overweight and obese individuals would

be less vulnerable to the maize price increase in terms of calorie intake. Actually the impact could be considered positive from a nutrition standpoint although the maize price shock would worsen their micronutrient intake further negatively affecting their nutritional status.

The risk of food price increases on the burden of malnutrition at this early stage of the nutritional transition arises from the fact that dietary patterns generally shift towards energy-dense foods with low micronutrient contents. Even though this transition has not been yet achieved in Tanzania —Table 4.7 shows that while underweight becomes more prevalent, overweight and obesity become less prevalent— the evolution appears well under way. Moreover, this study shows that a 20 percent price increase of maize could contribute to both an increase of undernutrition (price increase effect for net buyers) and overnutrition (substitution effect to energy-dense foods) as the nutrition transition continues to develop. This calls for better targeted programmes that address at the same time all aspects of malnutrition, broadening their target to include more nutritious foods and promoting the availability of certain food products that can improve the diversity of the diet. In this way, the nutritional status of the population could improve.

A few limitations of this work are acknowledged. It is recognized that these results depend on a few assumptions including (i) an appropriate demand model associated with the fact that prices in 2011-12 were already high compared to the long term trend; (ii) a correct intra-household calorie distribution; (iii) an accurate calorie-to-weight model; (iv) the exclusion of children from the analysis, and (v) the fact that by not capturing the supply side effects of the price increase we overlook a potential income boost in net seller households, possibly overestimating to some extent the increase in the underweight rate and the fall in the overweight and obesity rates. Future work could study the validity of these assumptions using an adequate dataset.

Despite these caveats, the study provides a clear picture of the impacts of a twenty percent increase of maize prices on selected nutrition outcomes of the Tanzanian adult population. However, we recognize that measuring changes in total calorie intake does not give all the

necessary insights on the potential impacts of a price shock on the nutritional status of the population. The complementary relationships that we find between maize and micronutrient dense foods such as pulses, livestock or fruit and vegetables, indicate that the increase in the price of maize would also result in a fall of the consumption of these foods. This point suggests that further research is needed to analyze the impacts of a price shock from the perspective of the nutritional quality of food. Such a research could further reveal undernutrition and overweight aspects of malnutrition as well as micronutrient outcomes in order to assess the whole extent of the problem.

4.7 Conclusions

This paper evaluates the potential impact of a twenty percent maize price increase on calorie intake and its resulting incidence in the body weight in terms of the BMI in Tanzania's adult population and therefore in the change of underweight, overweight and obesity rates used as proxies for aggregate nutritional outcomes.

All results exploit the National Panel Survey of 2010/11. Methodologically, we first estimate a food demand model that allows us to undertake the calorie-to-weight simulation. The QUAIDS model we use adequately captures consumers' behaviors by disentangling expenditure on necessity as opposed to luxury goods and capturing both the substitution and income effects of a price increase of maize. We then account for the inequitable intra-household redistribution of calories as a result of the price shock. Finally, we transpose the change in calorie intake into weight changes based on a static and a dynamic model concluding that in the context of this study the dynamic model proposes more realistic and convincing weight change patterns.

We find an increase of undernutrition and a decrease of overnutrition as a result of an increase in the price of maize, the main food staple in Tanzania. We conclude that this nutrition pattern is due to the limited substitution possibilities in a country such as Tanzania. We further suggest that the country could be undergoing an early stage of the nutritional transition as is the case of other low- and middle-income countries.

More precisely, the results reveal that households in Tanzania still rely to a great extent on maize consumption as the primary source of calories, and are therefore quite vulnerable to an increase in its price. It appears that the main aim of households in the face of a price increase is to meet their energy requirements under two main constraints (i) the substitution relationships of maize are restricted to other energy-dense foods with a low content in micronutrients, and (ii) the complementary relationships comprise protein and micronutrient rich foods. In the current production and market context of Tanzania, the substitution possibilities that would be necessary to compensate a lower consumption of maize are not enough to avoid the large fall of calorie intake and the subsequent drop of average weight. As a consequence, the prevalence of underweight rises resulting in increased undernutrition in terms of calories as well as micronutrients.

However, our results suggest that the impact of the increase in maize prices would only increase undernutrition, while the overweight and obese individuals would actually improve their nutritional status, even if it is only from the perspective of calorie intake. Even though we find a positive impact on the overweight and obesity rates in terms of calorie consumption, the intake of micronutrient rich foods would be reduced.

Moreover, we do find an indication of changing food consumption habits towards the distinctive dietary patterns of an early stage of the nutrition transition when comparing the dietary patterns of the overweight and obese individuals to those of the rest of the population.

We conclude that a maize price increase could not only negatively impact the prevalence of underweight in terms of calorie intake, but also the prevalence of overweight and obesity considering the current trends in dietary patterns. In the early future, policies will need to address simultaneously undernutrition and overnutrition, as well as promote the availability, access and utilization of more nutritious foods as the nutrition transition progresses.

Chapter 5

Final conclusions

The thesis was motivated primarily by the recent developments in world agricultural commodities prices which gave rise to serious concerns in relation to their potential impact on the welfare of the poor not only of developing countries but also of developed countries. The thesis investigates the welfare consequences of agricultural commodity and food price increases, and in this sense sheds light on the probable consequences of future price shocks.

The research addresses different aspects of the potential welfare consequences of increased food prices at different regional scales using different methodological approaches. First, the thesis examines whether and to what extent EU consumer food prices respond to price movements in global agricultural markets, with a special concern about the impact increased price levels may have on the consumption of the more vulnerable segments of the EU population. To do so, time series analysis and in particular ECMs are used. Second, the thesis explores whether increased consumer food prices affect the self-reported access of EU households to an adequate protein intake using a micro-level approach and population-averaged models estimated by GEE. Third, the thesis evaluates the effect of a 20 percent maize price increase on the anthropometric status of the adult population in Tanzania in terms of the body weight and the BMI. To do so, a household budget approach, a QUAIDS analysis and calorie-to-weight models are used.

Evaluations of the welfare consequences of increased food prices reveal a diversity of situations from the perspective of both the problems faced and the results. This diversity depends on several

factors such as the level of economic development, the regional context or the policy environment. Taking into account this diversity of situations in order to assess the welfare impacts of price increases may provide useful insights into an issue which has global dimensions. The thesis concludes that even if the impact of higher agricultural commodities or food prices is limited and temporary, they may affect the consumption and the food and nutrition status of the more vulnerable households that spend a large share of their income to food. The research provides relevant findings that show the vulnerability of the poorer segments of the population with a global dimension and that are relevant for policy decision-making. This section presents the thesis main conclusions and research contributions, its limitations and possible paths for future improvements.

5.1 Main conclusions and research contributions

5.1.1 Conclusions on the empirical research

The impacts of increased food prices on consumers will depend not only on the country but also on the segment of the population within the country considered in the assessment, the time frame studied and the cause of the price increase and its magnitude. Even in the case of the EU, the findings show a wide range of situations across MSs in spite of the fact that they belong to the same economic and political union.

Share of household expenditure on food

There is no doubt about the fact that increasing food prices do not affect developed and developing countries to the same extent, and that developed countries will have a higher resilience to price increases or shocks. More developed and more robust social protection policies and a greater capacity to cope with increased food prices are the distinctive elements that characterize developed countries. The share of household expenditure on food is particularly important when assessing the consequences of increased food prices on welfare. As the share of household expenditure on food increases (decreases), there is less (more) scope to deal with price increases and shocks. While the average aggregate share of household expenditure on food in developed

countries is around 15 percent, it can reach 80 percent in developing countries. Therefore the problems faced by developed and developing countries are considerably different. For this reason, the evaluations for developed and developing countries have been dealt with independently. The average aggregate share of household expenditure on food is also very heterogeneous between developed countries, and varies greatly across EU MSs. As seen in Chapter 3, there is a large heterogeneity across specific sub-groups of the population within MSs too. But the share of households' food expenditure is still an unambiguous indicator for detecting the most vulnerable households and the target for assistance policies.

Horizontal and vertical price transmission

Related to horizontal price transmission between global and domestic markets, the effects of increased food prices will depend on the extent to which countries are integrated into world markets and the rate of transmission between world prices and consumer food prices. In principle, developed countries should be more integrated into world markets than developing countries because of the evolution of agricultural support and trade measures towards less distorting schemes. This is accounted for in the EU analysis undertaken in Chapter 2 by assuming that there are no key differences in the trends of world and domestic agricultural commodities prices in the price transmission modeling framework. Even if this is the case, the price transmission process in developed countries is considerably diminished by the fact that price transmission from global to consumer prices also depends on many other determinants. These determinants include macroeconomic factors such as developments in the exchange rate and the structure and efficiency of the food sector. The analysis of the evolution of EU consumer food prices carried out in Chapter 2 gives this idea of a limited extent of price transmission to consumer food prices when compared to the evolution of world agricultural commodity prices. All in all, the relation between world and EU consumer prices does not appear to be strong at first sight. Hence the introduction of a comprehensive collection of demand and supply shifters in the price transmission models to account for the many factors that determine the process —the exchange rate, a world crude oil price index and wages as supply shifters and the unemployment rate and

economic growth as demand shifters. The analysis of price transmission in the EU undertaken in Chapter 2 confirms the notion of the limited impact of world prices on consumer food prices. Even if the findings show that long-term equilibrium relationships between world and consumer prices exist for at least a majority of MSs, this relation is, in general, weak. In addition, the significance of the parameters of the selected supply and demand shifters show that they are key in most cases to the price transmission process.

Even though the findings show that the relation between world and consumer food prices in the EU is, in general, weak, there are large differences across MSs. For example, as regards the extent of price transmission, the long-term equilibrium relationship ranges from 0.11 in Portugal to 0.78 in Latvia when taking into consideration the IMF's world agricultural commodity price index. Similar though somewhat smaller magnitudes of price transmission elasticities are obtained when considering the two world price indices compiled by the ECB. MSs with a large average share of household expenditure on food generally have larger transmission elasticities —the long-term price elasticities of the traditional MSs are generally lower than 0.3 with the exception of Spain, while the long-term price elasticities of the MSs that have recently acceded to the eurozone and the non-eurozone MSs are in general higher than 0.3 with the exceptions of Croatia and Slovakia. This is potentially attributed to several reasons, such as commodity costs in the traditional eurozone MSs accounting for a smaller proportion of the final food product or the average size of retail firms in the traditional eurozone MSs being generally bigger than in the new MSs. The latter suggests that firms in the traditional eurozone MSs may be more concentrated than in the new MSs leading to a less competitive market.

The effects of domestic horizontal price transmission are also reflected in the analysis of the welfare effects in Tanzania undertaken in Chapter 4, even if price transmission is not directly evaluated. In the food demand analysis, elasticities are examined separately in urban and rural settings. Maize is somewhat more price elastic in rural settings than in urban ones. This is potentially attributed to the fact that maize comprises a smaller share of the diet in rural areas. This is in turn attributed to the fact that maize is produced in rural areas while imported cereals

that compete with domestically produced maize are more available in urban areas. It seems implicit in this reasoning that there is horizontal price transmission with certain transaction costs such as transportation or distribution costs between rural and urban areas. Similarly, the total cross-price effects that result from the substitution and complementary relationships of maize are slightly higher in rural than in urban areas. In this occasion, this is in part potentially attributed to the larger share of the substitute starches in rural diets which is in turn attributed to the fact that starches are produced in rural areas.

Price and income responsiveness

In principle, a price increase of a specific food item increases its relative price in relation to other food products and erodes household purchasing power. Consumers or households will tend to purchase substitutive products which are now relatively less expensive. The thesis investigates the impacts on welfare of two different price increases as far as commodity coverage is concerned: one affecting all food products and the other affecting a specific commodity. The analysis conducted in Tanzania simulates a price shock to a specific commodity, contrary to the EU case in which a global shock is considered.

Theoretically, the price increase evaluated in the EU affecting all food products can lead to the reallocation of the household budget across food products in order to try to meet the household requirements. As household purchasing power deteriorates, households with limited income may have to restrict their spending on some foods in favour of others. As a result, they may have to restrict the consumption of most costly food products such as meat, fish or fruit and vegetables to be able to purchase enough basic food staples. Some of these more costly food products, which are considered nutritious, are the ones contemplated in the food deprivation indicator evaluated in the EU in Chapter 3. In fact, the analysis of the evolution of the prevalence of the indicator shows that in some MSs such as Belgium, Estonia, Greece, France, Hungary, Italy, Lithuania, Latvia and Slovakia food deprivation has rebounded in the 2003-2011 period after some years of improvement.

Despite the fact that no clear evidence of an increase in food deprivation in 2008 following the 2007/2008 food crisis is identified, higher consumer food prices are found to be associated with the increase in the percentage of food deprived households. In this sense, a remark has to be made. The literature holds that the food crisis gave rise to significant but varying increases in consumer food prices across EU MSs. At the same time, the price transmission analysis carried out in Chapter 2 confirmed that agricultural commodities prices had an effect in EU consumer food prices at least in some MSs, even if consumer food prices did not change to the same extent as agricultural commodities prices did. More expensive food was immediately followed by the economic crisis, which led to the increase of unemployment rates and the reduction of household real disposable income. It is against this background that the analysis of the prevalence of food deprived households undertaken in Chapter 3 takes place, and thus, the prevalence of food deprived households responds to these increased food prices. These results hold even when controlling for the household's disposable income and its size and the type of MS it belongs to. Further, the deviation of consumer food prices over general prices might also contribute to the increase of the prevalence of food deprived households. Even though the effect of the food price rise is significant, it is moderately small. This quantitative effect depends on a number of other factors, being the household's disposable income one of them. The analysis shows that the household disposable income level softens the effect of the price increase in conformity with Engel's law. This comes as no surprise as the food deprivation indicator analyzed measures the household's ability to afford food. When focusing on the type of MS the households belongs to, significant differences in the level of food deprivation are identified. These differences could be due to differences in disposable income, food price transmission and varied economic situations across them.

It is worth mentioning at this point that the EU-SILC survey does not include certain segments of populations which in principle should be vulnerable to food insecurity such as homeless or people in institutions and therefore the estimates of food deprivation are likely to be conservative and

underestimate somewhat food insecurity (as addressed by Carney and Maître (2012) and Loopstra et al. (2016)).

On the other hand, the price increase simulated in Tanzania affects a specific commodity — maize— which is basic to its food security. Thus, maize price increases relative to the price of other foods. Households would in principle substitute to other relatively less expensive food. But maize comprises a large share of the food household budget and food consumption is largely constrained by household income. As a result, households are very responsive to the maize price increase and calorie intake falls in the face of the price increase. The increase in the price of maize decreases the available budget to substitute to other foods and substitution possibilities cannot be sufficiently used to avoid the calorie fall.

In the aggregate, the income level has an effect on food consumption patterns. In general terms, the consumption of certain foods such as meat and dairy products increase as income rises and diet patterns shift towards a westernization of the diet as socioeconomic growth develops. One of the reasons why the research identifies significant differences in the level of food deprivation across EU MSs could therefore be the varied economic situations that exist within MSs. On the other hand, the income elasticities resulting from the food demand analysis carried out in Tanzania in Chapter 4 show the typical consumption patterns of developing countries, where there is a large dependence on staples and animal-source products are still not a large share of the diet.

Impact on nutritional status

The study of nutritional aspects in the EU food deprivation assessment, in which the access of households to protein-source food products is evaluated, is limited. The analyzed variable measures a basic necessity. Indeed, EU dietary guidelines recommend protein-source foods to be consumed one or two times a day (European Food Information Council, 2009; Loopstra et al., 2016). In this way, it measures one essential component of a nutritionally adequate diet. The literature shows that consumers in developed countries respond to changes in relative food prices or income by shifting to relatively cheaper food products which may or may not result in worse

quality diets. For this reason health and nutritional effects are an important cause of concern when considering the consequences of increased food prices. The analysis undertaken in Chapter 3 does not give information about towards which foods consumption shifts. Despite the fact that it does not provide information about towards which foods consumption shifts, the analysis does show that some EU households have difficulties in accessing a protein intake when food prices increase. This may have consequences for the health of the members belonging to these households. The inability to afford protein-source foods is more prevalent in low-income households and in certain MSs or groups of MSs. The fact that the inability to afford protein-source foods is more prevalent in certain MSs could be related to economic development or other factors, such as the demographic characteristics or the dietary patterns typical of each MS.

On the other hand, the assessment conducted in Tanzania permits to get much deeper insights into the nutritional outcomes derived from a food price increase. First, the food demand model results convey information about the shifts in consumption in the face of a price increase. It is clear from the findings that the main nutritional goal of Tanzanian households is to meet their energy requirements. The substitution and complementary relationships between maize and the other food groups show that Tanzanian households shift towards other energy-dense foods when maize prices rise while the demand for more nutritious foods such as meat and livestock products, fruits and vegetables, pulses and oils falls. Second, overall average calorie consumption falls. This suggests that the population depends to a large extent on the consumption of maize and that a shock to its prices can affect the energy intake of a substantial part of the population. Third, this average calorie fall translates into an increase in the prevalence of the underweight population and a decrease in the prevalence of the overweight population. While the decrease of the overweight population is actually a positive outcome, the results also show that the rate of change in the decrease in the prevalence of overweight is smaller than the rate of change in the increase of the underweight population. This difference in the rates of change is attributed in the research to the fact that the country could be undergoing an early stage of the nutritional transition. The shifts in dietary patterns coupled with the change in activity levels that take place in this early phase of the

nutrition transition are reflected in the population's increasing rates of overweight and obesity, while the rate of underweight usually continues to be high. At this point it should be mentioned that by not taking into account in the study the potential increase of income of net seller households, the analysis could be overestimating both the increase in the underweight and the decrease in the overweight population.

These different food consumption patterns that exist across high- and low-income countries leads to consider the analysis of the access to a healthy diet when assessing the consequences of increased food prices in the EU, while the focus is placed on the response to a staple price increase when analyzing Tanzania, given its importance in the diet.

Grouping of MSs

Even though the price transmission analysis finds differences across MSs, when MSs are grouped into different categories according to date of accession to the EU and eurozone membership they behave more similarly. As stated previously in this section, MSs with a large average share of household expenditure on food generally have larger transmission elasticities. This leads to the conclusion that increasing food prices may have an effect on the consumption and health of households that spend a large share of their income to food. When analyzing the EU, it is common to compare between EU-15 and EU-12 MSs. Given the role that exchange rates play in the process of price transmission between world and EU consumer food prices, eurozone and non-eurozone members were compared too in order to reveal more insights into the potential differences and similarities in price transmission across MSs. Other authors have made a similar distinction across MSs according to geographical and political criteria when studying price transmission and developments of consumer food prices across EU MSs (see for example Bukeviciute et al. (2009) or Lloyd et al. (2011)). For example, it has been documented that food inflation in the EU-12 MSs was more volatile than in other MSs but that the eurozone MSs as a whole did not follow similar patterns (McCorriston and Von Cramon-Taubadel, 2016). Future work may address this issue and provide more insights in order to improve the understanding of

the determinants that lead to the differences in price transmission and developments of consumer food prices across EU MSs.

As previously mentioned in this section, significant differences in the level of food deprivation are identified when focusing on the type of MS the households belongs to. Indeed, control variables for groups of MSs were included in the modeling framework, as the differences in economic and social development across them were expected to affect food deprivation. MSs were grouped following a similar criteria to that of the price transmission analysis basically based on membership of the eurozone in an attempt to ensure some consistency across studies. This classification clearly shows similarities in the level of food deprivation across MSs belonging to the same group, being the MSs that have recently acceded to the EU and belong to the eurozone more food deprived. Consistent with the reduction of the share of expenditures on food consumption across MSs that have recently acceded to the EU, the prevalence of households reporting food deprivation has decreased over the period analyzed. However, trends were quite stable for households belonging to the other groups. The results of the multivariate panel approach are in line with the fact that food deprivation is more severe in the MSs that have recently acceded to the EU and that do not belong to the eurozone.

It is precisely because of the inequalities existing between and within MSs in terms of consumer food prices, household food budget and household income that the focus of this research on the EU is interesting. In addition to the reasons already mentioned, other factors can also be responsible for the disparities. For example, food patterns and trends and diet diversification also vary greatly across regional contexts. This is too related to economic development. Not only are food patterns and trends and diet diversification specific to different countries and regions, but also eating pattern shifts (Adair and Popkin, 2005; Popkin, 2006). When all these considerations are taken into account, it is clear that the income and wealth situations across MSs are making the difference between their food deprivation status.

Policy implications

The vulnerability of certain segments of the EU population seen throughout the research demonstrate the importance that food-related price shocks can have in developed countries and that food security issues can pose a significant challenge to them, despite having stable structures and regulatory environments and developed food assistance programmes. When predicting the impacts of global food price rises, governments should pay attention to the most vulnerable households. From a policy perspective, it is important to have a clearer picture of how consumers react to increased food prices and evaluate food assistance programmes focusing on the segments of the population most at risk of food deprivation.

The findings concerning the evaluation of the impact of increased food prices on nutrition outcomes in Tanzania suggest that interventions should be anticipated to deal with increased prices and that better targeted programmes that address at the same time all aspects of malnutrition are needed. These programmes should include the promotion of more nutritious foods as well as the improvement of the diversity of the diet. Broadening their focus to cover all aspects of malnutrition is necessary, especially taking into account that the findings confirm the increasing prevalence of obesity in Tanzania and suggest that the country is at an early stage of the nutritional transition.

5.1.2 Conclusions on the methodological approach

Error correction models

Given the nature of the data, ECMs were considered the more appropriate models to undertake the analysis on price transmission. While both ECMs and VECMs allow to capture the long-run equilibrium relationships and the short-run dynamics between world and consumer prices, the ECMs are conditioned to weak exogeneity between the cointegrating variables and to a single cointegrating relationship. Under the assumptions that causality runs from world agricultural commodity prices to consumer unprocessed food prices, which is the direction of causality in which the analysis focus, and that there is a single cointegrating relationship, these models

estimate both the extent to which movements in agricultural commodity prices affect consumer prices and the time it takes for a shock in commodity prices to pass through to consumer prices.

However, the approach presents some limitations. Even though practically all the series were found to be non-stationary and integrated of order one, there are some exceptions. Country exceptions for the unprocessed food HICP index are Ireland and Romania, which were excluded from the error correction model analysis. This may be seen as a limitation, but the study is meant to offer a homogenous approach to 28 different countries, all of them quite different in many relevant issues (income, food industry, currency, integration, eating and purchasing habits,...) and the same approach was maintained at the expense of excluding these MSs of that part of the analysis.

Population-averaged panel data models

There are several primary reasons for choosing the population-averaged panel data modeling framework to perform the analysis on food security in the EU. First, the binary nature of the dependent variable conditions the selection of the methodological approach because responses are not normally distributed. Second, the fact that the dependent variable is a correlated measure collected within households across time. This method provides efficient and unbiased parameter estimates (Ballinger, 2004) taking into account these two considerations.

It is indeed the latter consideration of the modeling framework that allows to exploit the longitudinal dimension of the EU-SILC data. If correlation of responses are not accounted for, incorrect parameters can be estimated, particularly when correlations are large (Ballinger, 2004), which is why the cross-sectional dimension of the EU-SILC has not been used. Despite the fact that the sample of the cross-sectional dimension is larger, in some cases it does not permit identifying specific households along time, and thus to take into consideration repeated measures that may be correlated within the household.

Food demand models (QUAIDS)

The QUAIDS model used in this research adequately captures consumers' behaviors because (i) it allows to estimate price and income demand elasticities, taking into account substitution and complementary relationships between food groups in response to changes in prices or incomes; (ii) it allows goods to be luxuries at certain income levels and necessities at other income levels by adding a quadratic term to the AIDS model; (iii) it accounts for household zero expenditure shares of particular foods by using the two step procedure developed by Shonkwiler and Yen (1999), preventing in this way biased elasticity estimates, and (iv) it permits to account for demographic variables that also affect food demand.

While consumer preferences involve a large number of goods, one problem faced by food demand models is that they do not permit to include a large number of goods. The aggregation of goods facilitates the estimation but at the same time provides only a partial picture of actual demand. Generally, several assumptions are made to overcome this problem: a multi-stage decision process which is underpinned in weak separability of consumer preferences and low variability of group price indices with expenditure is usually assumed (Edgerton, 1997; Ecker and Qaim, 2011). As a result, the demand for food in the approach used in this research is independent of the demand for non-food goods, overlooking possible substitution and complementary effects across food and non-food items and the increase of the price of maize affects in the same way the demand for all the food-items grouped together.

Calorie-to-weight models

As the literature had already made clear, the results predicted by the static calorie-to-weight model in the analysis of anthropometric outcomes in Tanzania largely overestimate the results of the dynamic model. By accounting for the physiological changes that occur during the process of body change, the dynamic model predicts more reliable measures.

The dynamic calorie-to-weight model used in this research is based on the dynamic model proposed by Hall et al. (2011). The model proposed by Hall et al. (2011) is a mathematical model of human metabolism that predicts body weight change responding to changes in diet and physical activity. The model is based on laboratory data and has been validated by comparing model predictions with experimental results from several studies (Lin et al., 2011). Initial body conditions (weight, height, body fat mass and lean body mass, resting metabolic rates, amongst other) and several metabolic parameters are used to measure the effect of a persistent average daily energy imbalance between intake and expenditure. Even if results are much more precise than results from static models, the dynamic model presents several limitations which are contemplated by Hall et al., 2011. First, limitations on the precision of measuring individual baseline energy requirements translate into an expected inter-individual variability of weight loss. By taking the average over the population this measurement limitation is reduced to a insignificant value, resulting the average weight change more precise than the individual one (Hall et al., 2011). Second, the model assumes that changing physical activity does not alter energy intake but there is evidence of the contrary (Blundell et al., 2003; King et al., 2007; Hall et al., 2011). In any case, the dynamic model applied in this research assumed no change in physical activity through the study period and a fixed PAL across the population. Third, even though the metabolic parameters used in the model adequately represent the average weight change process, an individual might present different physiological characteristics due to for example genetic reasons that could result in a different weight change development.

The results on weight changes depend on the accurate application of the calorie-to-weight model. According to Lin et al. (2011), the dynamic model predicts an annual weight reduction equal to 63 percent of the weight reduction predicted by the static model. This difference in the prediction of weight changes between the dynamic and static models is met in the present research and gives consistency to its results.

5.2 Limitations and paths for further research

The main limitations of the research refer to data availability and the methodological approaches used. The availability of data strongly determines the scope of the analysis and the methodological framework used.

The research addresses different aspects of the potential welfare consequences of increased food prices: the extent to which consumer food prices are affected by changes in world agricultural commodities prices, the relationship between increased food prices and the access of EU households to an adequate protein intake and the impact of a maize price increase on household food consumption and on anthropometric indicators of the Tanzanian adult population. Even though the research sheds light on a variety of welfare consequences, the implications of increased food prices for the welfare of the poor and vulnerable can be defined from different dimensions and by a wide array of indicators. Food and nutrition security issues cannot be completely captured by focusing on a certain dimension and a limited number of indicators. The evaluation of the ability of EU households to purchase healthy and affordable food definitely gives valuable insights into the food and nutrition security status of the EU population. The food deprivation indicator used in this research has been in fact used to evaluate food insecurity related issues by Carney and Maître (2012), EUROSTAT (2015e) or Loopstra et al. (2016). However, the evaluation may not deal with certain key aspects of other dimensions of food and nutrition security. This suggests that more empirical analyses of microdata are needed to give a clearer picture of the consequences of increasing food prices on EU food consumption, the extent to which the cost of food affects household food insecurity and the factors that are driving food insecurity in the EU.

The same holds true for the analysis of the welfare consequences of increased food prices in Tanzania. While the analysis provides relevant insights, it does not give a complete picture of the potential impacts of a price shock on the nutritional status of the population. For example, measuring changes in total calorie intake does not give all the necessary insights into their

nutrition status. Even if the complementary relationships between maize and micronutrient rich foods such as pulses, livestock or fruit and vegetables identified indicate that the increase in the price of maize would result in a fall of their consumption, the actual impact of this fall of the consumption of micronutrient rich foods on the population is not measured. Further research is therefore needed to analyze the consequences of the maize price increase from the viewpoint of the nutritional content of food.

Related to the issue of price transmission from agricultural commodities prices in world markets to consumer food prices, the selection of shifters introduced in the price transmission models were somewhat conditioned by data availability. Other potentially important determinants, such as changes in retail market concentration or the role of retailers' pricing strategies along the value chain, were not considered in the analysis due to the lack of comparable data. Nevertheless, these determinants can definitely contribute to gain a deeper understanding of price transmission along the food supply chain and of the actual contribution of global agricultural commodities prices to changes in EU consumer food prices. Further research in this sense could help disentangle which factors may have a bearing in determining the differences both in the price transmission process and the developments of consumer food prices across EU MSs, which are at the same time related. Other limitations related to the price transmission models that have been also addressed by other authors are that food price indices may not be in some circumstances the most adequate to investigate consumer food price dynamics and adjustment (see Garrido, 2016), even if they are commonly used.

The nature of the food insecurity indicator used in the EU analysis, which is a self-reported and a subjective indicator, may somewhat condition the results of the analysis. The fact that survey data presents limitations characteristic of their nature that condition the analysis is acknowledged in the literature (for example, see Headey, 2013 or Ecker and Qaim, 2011). The exact phrasing of the question and what respondents understand with meat, chicken, fish (or vegetarian equivalent) may lead to subjective answers. However, the questions in this case are clear and interviewed subjects can easily respond to questions about being able to afford a certain type of meal. The food

insecurity indicator appears to be an appropriate measure to undertake the analysis because of the large coverage and quality of the EU-SILC survey and because it is the only comparable food insecurity variable measured annually across EU MSs (Loopstra et al., 2016). In addition, the survey contains relevant demographic, socio-economic, living conditions and income indicators that enable the undertaking of the analysis. The survey data limitation issue also affects the LSMS survey used in the Tanzania analysis. Just to give an example, household food consumption actually measures food access rather than food consumption.

The EU-SILC survey used in the analysis of the access to a healthy diet in the EU does not provide detailed data on household consumption of different food items. Thus, a complete food demand model that would give information about the extent to which changes in prices affect household food consumption by means of price and income elasticities cannot be estimated. In this way, the evaluation undertaken in the EU does not give information about the substitution and complementary relations that exist between foods nor gives information about towards which foods consumption shifts in the face of a price increase. However, the survey does provide the variable that measures the ability to access a healthy diet and the relations between the variable and food prices and household income can be evaluated. On the other hand, the LSMS survey used to undertake the analysis in Tanzania provides data on food consumption at the household level and therefore permits to estimate a food demand model at the household level that captures substitution and complementary relations between foods.

None of the two surveys provide data on food access or consumption at the individual level. The EU-SILC survey provides the data on the access to an adequate protein intake at the household level. The variable measured in the EU-SILC survey refers to household consumption and does not capture possible inequalities in the allocation of the consumption of protein-source foods within household members. In this manner, the analysis does not identify the more vulnerable members within the household. Similarly, the LSMS survey used in the Tanzania analysis collects data on food consumption only at the household level. In this way, food consumption patterns do not account for the potential unequal distribution of food within the household. This limitation of

the data obliges to do an assumption about the allocation of food in order to translate changes in calorie intake from the household to the individual level.

The dynamic calorie-to-weight model applied in evaluation of the impact of increased food prices on anthropometric measures in Tanzania was developed by Hall et al. (2011) for adult subjects. This limits the scope of the analysis to the adult population. Nevertheless, focusing on adult subjects can widen the insights about populations affected by malnutrition and support the formulation of policies aiming at improving food and nutrition security.

In addition to the further developments already acknowledged, the following topics for future research have been identified. It has already been mentioned that more empirical analyses of microdata are needed to give a clearer picture of the consequences of increasing food prices on EU food consumption. First amongst these, the estimation of a food demand model that captures substitution and complementary relations between food items would give very useful information about the shift in consumption patterns in the face of increased food prices. This would also give important insights into whether consumers respond to changes in relative food prices by shifting to relatively cheaper food products and worse quality diets and their related health effects. Second, there is still significant uncertainty about how people actually change their eating and consumption habits in response to changes in food prices. A series of factors that affect food consumption in light of changes in food prices, such as the strategies developed by retailers to respond to changes in food prices and the way in which poor consumers respond to these retailing strategies, should be further studied. Third, while the expenditure devoted to food increases as food prices rise, the expenditure devoted to other necessities such as health or education fall. Food consumption and purchasing habits might remain the same while increasing food prices might be affecting consumers' material well-being by forcing them to reduce consumption on other basic necessities such as home heating or the ability to pay the bills, amongst others. This suggests that further research should be conducted to investigate whether increased food prices have an impact on other material deprivation indicators apart from food deprivation, such as fuel poverty or financial exclusion.

On the other hand, the assessment conducted in Tanzania does not account for the fact that higher food prices can improve the situation of net seller households. By focusing only on consumption patterns rather than on production and consumption patterns, the analysis overestimates the increase in the underweight as well as the decrease in the overweight population. This suggests that further research should take into account the income increase that net seller households might experience in the face of the price increase.

Finally, the scope of the research could be extended to other countries in order to consider the impacts of increased food prices on the welfare of the poor and vulnerable population across more regional contexts. In this sense, a broader focus that includes the impacts from more regional perspectives may provide useful insights into an issue which has global dimensions.

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Appendices

Appendix A1. Data description

Table A1.1. Commodity coverage and weighting scheme used to compile each of the world agricultural commodity prices

Index	Commodity coverage	Weighting scheme
IMF world price index	Cereals (wheat, maize, rice, barley), vegetable oils and protein meals (soybeans, soybean meal, soybean oil, palm oil, sunflower/safflower oil, olive oil, fishmeal, groundnuts, rapeseed oil), meat (beef, lamb, swine meat, poultry), seafood (fish, shrimp), sugar, bananas and orange	"Group indices are weighted averages of individual commodity price indices, with respective commodity weights derived from their relative trade values compared to the total world trade as reported in the UN Comtrade database"
ECB world price index (import-weighted)	Bananas, barley, beef, cocoa, coconut oil, coffee, maize, oranges, palmoil, pork, rice, soybeans, sugar, sunflower seeds, sunflower seed oil, tea, tobacco, wheat	Share of each commodity in the value of eurozone imports from outside the eurozone, using Eurostat's external trade statistics (COMEXT database)
ECB world price index (use-weighted)	Bananas, barley, beef, cocoa, coconut oil, coffee, maize, oranges, palmoil, pork, rice, soybeans, sugar, sunflower seeds, sunflower seed oil, tea, tobacco, wheat	Share of each commodity in the value of demand in the eurozone, taking into account eurozone imports and exports and domestic production, using Eurostat's agriculture statistics, external trade statistics (COMEXT) and by-product manufacturing statistics (PRODCOM) and FAOSTAT
Unprocessed food HICP	Meat, fish, fruit and vegetables	Share of each group in the total expenditure of all households for the goods and services covered by the index

Note: Information on the IMF world price index from IMF (2015a) and IMF (2015b). Information on the ECB world price indices from ECB (2008). Information on the HICP weighting scheme from ECB (2015).

Appendix A2. Results

Table A2.1. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test statistics

	Unprocessed food HICP				Unemployment rate				Exchange rate				Wages				Economic growth			
	ADF		PP		ADF		PP		ADF		PP		ADF		PP		ADF		PP	
	cp _t	Δcp _t	cp _t	Δcp _t	u _t	Δu _t	u _t	Δu _t	e _t	Δe _t	e _t	Δe _t	w _t	Δw _t	w _t	Δw _t	g _t	Δg _t	g _t	Δg _t
Austria	-0.39	-10.66**	-0.57	-10.68**	-1.60	-9.01**	-1.94	-8.89**	-1.17	-8.92**	-1.31	-8.74**	-7.26**	-12.16**	-6.71**	-16.12**	-0.20	-14.38**	-0.07	-14.91**
Belgium	-1.47	-15.17**	-1.43	-15.18**	-1.32	-6.53**	-1.79	-6.14**	-1.17	-8.92**	-1.31	-8.74**	-3.73**	-12.36**	-3.43*	-12.89**	-0.38	-17.04**	-0.37	-18.42**
Bulgaria	-1.34	-7.46**	-1.76	-7.42**	-0.61	-3.94**	-0.85	-3.67**	-1.53	-8.65**	-1.61	-8.47**	-0.14	-16.39**	0.03	-17.00**	-0.93	-13.05**	-0.92	-13.25**
Croatia	-1.72	-6.94**	-1.90	-6.77**	0.42	-4.82**	-0.40	-4.97**	-1.34	-9.40**	-1.43	-9.26*	-1.94	-19.95**	-2.08	-30.59**	-1.55	-14.09**	-1.74	-14.23**
Cyprus	-1.16	-12.98**	-0.93	-13.40**	2.25	-8.99**	1.48	-9.04**	-1.17	-8.92**	-1.31	-8.74**	-2.82	-12.38**	-2.63	-12.62**	-1.29	-13.84**	-1.49	-14.35**
Czech	-1.41	-8.81**	-1.96	-8.62**	-1.41	-5.69**	-1.68	-5.62**	-1.24	-9.25**	-1.29	-9.13**	-1.63	-12.54**	-1.60	-12.57**	-2.25	-12.86**	-2.55	-13.19**
Denmark	-0.96	-11.60**	-0.98	-11.58**	-0.20	-7.58**	-0.74	-7.55**	-1.17	-8.95**	-1.31	-8.76**	-1.24	-14.28**	-1.47	-14.90**	-0.92	-14.03**	-0.94	-14.04**
Estonia	-0.63	-9.43**	-0.78	-9.43**	-1.05	-7.66**	-1.37	-7.77**	-1.17	-8.92**	-1.31	-8.74**	-1.65	-16.78**	-1.36	-23.57**	-1.16	-14.06**	-1.33	-14.50**
Finland	-1.01	-13.63**	-1.08	-13.57**	-1.91	-1.82	-1.72	-2.62	-1.17	-8.92**	-1.31	-8.74**	-1.92	-12.38**	-1.86	-12.43**	0.11	-13.91**	0.22	-13.95**
France	-1.44	-10.63**	-1.45	-10.52**	0.12	-5.69**	-0.93	-5.57**	-1.17	-8.92**	-1.31	-8.74**	-1.51	-18.20**	-2.32	-20.30**	-1.50	-16.42**	-1.83	-16.52**
Germany	-0.83	-8.72**	-1.29	-8.69**	2.94*	-2.10	0.92	-2.70	-1.17	-8.92**	-1.31	-8.74**	0.17	-14.19**	0.45	-14.75**	-0.50	-12.71**	-0.30	-12.89**
Greece	-1.84	-8.88**	-2.06	-8.73**	4.34**	-7.73**	2.63	-7.98**	-1.17	-8.92**	-1.31	-8.74**	-5.24**	-12.34**	-5.08**	-12.76**	-1.30	-12.60**	-1.25	-13.63**
Hungary	-0.89	-7.68**	-1.03	-7.43**	1.01	-6.60**	0.33	-6.44**	-1.55	-9.13**	-1.81	-9.00**	-1.80	-13.73**	-1.71	-17.93**	-1.66	-13.03**	-1.84	-13.50**
Ireland	-3.43*	-8.76**	-3.10*	-9.05**	1.01	-5.05**	0.29	-4.91**	-1.17	-8.92**	-1.31	-8.74**	-1.78	-12.79**	-1.81	-12.80**	-2.54	-12.52**	-2.70	-12.95**
Italy	-1.97	-9.10**	-1.79	-9.04**	-0.40	-14.67**	-0.61	-14.58**	-1.17	-8.92**	-1.31	-8.74**	-0.29	-13.57**	-0.26	-13.97**	-1.71	-12.44**	-1.36	-13.45**
Latvia	-0.89	-8.97**	-0.92	-8.70**	-0.91	-12.33**	-1.08	-12.54**	-1.58	-9.34**	-1.90	-9.29**	-0.95	-13.18**	-0.96	-13.24**	-1.02	-12.59**	-0.92	-13.23**

Lithuania	0.32	-8.38**	-0.11	-8.43**	-0.70	-2.99 *	-1.07	-2.99*	-1.75	-9.00**	-1.75	-8.91**	-0.71	-12.79**	-0.69	-12.79**	-2.05	-9.87**	-2.08	-9.99**
Luxemb	-2.16	-13.82**	-2.07	-13.80**	-1.22	-7.39**	-1.18	-7.74**	-1.17	-8.92 **	-1.31	-8.74**	-6.76**	-13.29**	-6.28**	-17.24**	0.50	-12.99**	0.91	-13.32**
Malta	-0.07	-11.16**	0.00	-11.10**	-1.88	-8.51**	-2.06	-8.08**	-1.17	-8.92**	-1.31	-8.74**	-1.58	-12.60**	-1.53	-12.64**	-1.86	-12.36**	-1.87	-12.37**
Netherlands	-1.62	-12.22**	-1.63	-12.22**	0.34	-7.59**	-0.47	-7.95**	-1.17	-8.92**	-1.31	-8.74**	-2.35	-13.40**	-2.60	-13.39**	-2.52	-13.63**	-2.84	-13.67**
Poland	-0.90	-8.11**	-1.02	-7.66 **	-0.18	-3.22*	-0.54	-3.08*	-1.50	-8.39**	-1.79	-8.28**	-0.94	-15.83**	-0.79	-19.96**	-0.23	-12.83**	-0.13	-13.12**
Portugal	-2.69	-11.52**	-2.66	-11.54**	1.10	-5.32**	0.44	-5.06 **	-1.17	-8.92**	-1.31	-8.74**	-9.71**	-13.49**	-9.47**	-18.09**	-1.84	-12.49**	-1.86	-14.52**
Romania	-5.16**	-6.12**	-3.94**	-5.96**	-2.01	-12.18**	-2.39	-12.34**	-3.18*	-7.96**	-3.11*	-7.93**	-3.19**	-14.95**	-4.52**	-15.11**	-2.48	-13.22**	-3.68**	-14.46**
Slovakia	-1.09	-8.55**	-1.48	-8.38 **	-0.92	-4.35**	-1.16	-4.42**	-1.17	-8.92**	-1.31	-8.74**	-1.95	-12.81**	-1.52	-15.73**	-2.42	-12.73**	-2.53	-12.76**
Slovenia	-1.03	-11.55**	-1.10	-11.55**	0.68	-5.38**	-0.41	-5.48**	-1.17	-8.92**	-1.31	-8.74**	-1.78	-21.34**	-1.48	-27.15**	-2.47	-12.98**	-2.62	-13.00**
Spain	-2.64	-11.96**	-2.73	-11.96**	2.92*	-3.96**	1.02	-3.60**	-1.17	-8.92**	-1.31	-8.74**	-2.58	-12.39**	-2.56	-12.42**	-2.30	-13.61**	-3.22*	-14.39**
Sweden	-1.56	-12.51**	-1.55	-12.51**	-1.92	-18.21**	-1.49	-18.49**	-1.04	-8.56**	-1.39	-8.46**	-0.41	-13.20**	-0.10	-14.43**	-1.80	-12.42**	-1.74	-12.46**
UK	0.53	-11.68**	0.63	-11.65**	0.50	-6.80**	-0.11	-6.65**	-1.28	-9.00**	-1.72	-9.09**	-1.64	-17.18**	-1.19	-19.50**	-0.76	-12.74**	-0.72	-12.78**

IMF WP				ECB import-weighted WP				ECB use-weighted WP				Oil price			
ADF		PP		ADF		PP		ADF		PP		ADF		PP	
wp _t	Δwp _t	wp _t	Δwp _t	wp _t	Δwp _t	wp _t	Δwp _t	wp _t	Δwp _t	wp _t	Δwp _t	o _t	Δo _t	o _t	Δo _t
-0.42	-7.73**	-0.78	-7.72**	-0.25	-8.31**	-0.62	-8.34**	-0.21	-8.56**	-0.53	-8.52**	-1.03	-10.25**	-1.21	-10.27**

Note: The ADF and the PP unit root tests were performed both in the natural logs of levels and the logs of the first differences (Δ) of each variable. ADF and PP unit root tests' critical values: $^{**}(\text{Pr} \leq 0.01) = -3.491$, $^*(\text{Pr} \leq 0.05) = -2.886$

Table A2.2. Engle-Granger cointegration test statistics with the three world price indices.

	IMF wp-cp		ECB's import-weighted wp-cp		ECB's use-weighted wp-cp	
	Modified ADF	PP	Modified ADF	PP	Modified ADF	PP
Austria	-4.247***	-3.749**	-4.184***	-4.169***	-4.218***	-4.276***
Belgium	-3.848**	-4.125***	-4.884***	-5.118***	-3.781**	-4.154***
Bulgaria	-5.215***	-3.601**	-4.476***	-3.662**	-4.378***	-3.772**
Croatia	-3.436**	-3.480**	-3.099*	-3.313*	-3.102*	-3.302*
Cyprus	-5.072***	-5.323***	-5.044***	-5.333***	-3.905**	-3.993***
Czech R.	-3.218*	-2.883	-3.265*	-3.123*	-3.486**	-3.135*
Denmark	-3.447**	-3.451**	-3.461**	-3.615**	-3.496**	-3.189*
Estonia	-3.496**	-3.390**	-3.826**	-3.688**	-3.648**	-3.526**
Finland	-3.438**	-3.650**	-3.037	-3.490**	-3.211*	-3.687**
France	-5.510***	-5.101***	-5.484***	-4.995***	-5.146***	-4.841***
Germany	-3.809**	-3.459**	-3.915**	-3.621**	-4.112***	-3.813**
Greece	-4.707***	-4.092***	-4.825***	-4.434***	-4.664***	-4.246***
Hungary	-3.833**	-3.815**	-3.708**	-3.600**	-4.019***	-3.446**
Ireland						
Italy	-3.689**	-3.392**	-3.586**	-3.402**	-3.441**	-3.457**
Latvia	-3.701**	-3.449**	-3.361*	-2.977	-3.102*	-2.920
Lithuania	-2.223	-1.985	-2.113	-2.021	-2.075	-2.061
Luxembourg	-3.610**	-3.482**	-3.600**	-3.797**	-3.451**	-3.583**
Malta	-3.474**	-3.973***	-3.397**	-3.449**	-3.532**	-3.693**
Netherlands	-3.508**	-3.558**	-3.695**	-3.750**	-3.649**	-3.800**
Poland	-4.730***	-3.852**	-4.417***	-4.227***	-4.946***	-3.993***
Portugal	-3.732**	-3.438**	-3.968***	-3.656**	-3.656**	-3.733**
Romania						
Slovakia	-4.823***	-3.836**	-4.302***	-3.451**	-4.296***	-3.798**
Slovenia	-4.332***	-4.170***	-4.458***	-4.359***	-4.366***	-4.327***
Spain	-3.432**	-3.510**	-3.534**	-3.420**	-2.861	-2.730
Sweden	-3.448**	-3.413**	-3.565**	-3.520**	-3.316*	-3.382**
UK	-2.403	-2.146	-2.450	-2.381	-2.450	-2.381

Note: wp stands for world agricultural commodity price index. cp stands for unprocessed food HICP. The table only includes MSs with non-stationary unprocessed food HICP. Critical values for the Engle-Granger cointegration tests: ***($\Pr \leq 0.01$) = -3.968, **($\Pr \leq 0.05$) = -3.376, *($\Pr \leq 0.10$) = -3.072. Lag chosen based on cointegration relationship and significance of parameters

Table A2.3. Price transmission elasticities for each MS with the IMF's world price index

MS	Δwp_t	Δe_t	Δu_t	Δo_t	Δw_t	Δg_t	Constant	ECT_{t-1}	WP_t	Median lag length	No. Obs
Austria	+		+	+	+	+	0.010*** (0.002)	-0.154*** (0.045)	0.252*** (0.018)	4.1	146
Belgium	+	+	+	+	+	+	-0.002 (0.002)	-0.131*** (0.032)	0.259*** (0.020)	4.9	147
Bulgaria	+	+	+	+	+	+	0.004 (0.004)	-0.081** (0.033)	0.560*** (0.051)	8.2	134
Croatia	+	+	+	+	+	+	0.001 (0.001)	-0.107*** (0.031)	0.254*** (0.030)	6.1	90
Cyprus	+			+	+	+	0.004** (0.002)	-0.228*** (0.046)	0.609*** (0.027)	2.7	139
Denmark	+			+	+	+	0.001 (0.001)	-0.153*** (0.024)	0.195*** (0.015)	4.2	147
Estonia	+	+	+		+	+	-0.007*** (0.002)	-0.037** (0.018)	0.467*** (0.037)	18.4	146
Finland	+	+	+	+	+	+	0.000 (0.001)	-0.079* (0.045)	0.239*** (0.027)		146
France	+	+	+	+	+	+	-0.050* (0.026)	-0.134*** (0.027)	0.231*** (0.015)	4.8	139
Germany	+	+	+	+	+	+	0.005*** (0.001)	-0.080*** (0.029)	0.174*** (0.023)	8.3	146
Greece	+	+	+	+	+	+	0.021 (0.110)	-0.094** (0.041)	0.257*** (0.038)	7.0	138
Hungary	+	+		+	+	+	0.005*** (0.001)	-0.037* (0.021)	0.777*** (0.041)		142
Italy	+	+	+	+		+	-0.001 (0.001)	-0.046*** (0.013)	0.256*** (0.024)	14.7	143
Latvia	+	+	+	+		+	0.005*** (0.001)	-0.049*** (0.016)	0.782*** (0.044)	13.8	143
Luxemb	+	+	+	+	+		0.002*** (0.000)	-0.041*** (0.010)	0.263*** (0.021)	16.6	147
Malta	+	+	+	+	+	+	-0.091* (0.000)	-0.105*** (0.010)	0.440*** (0.021)	6.2	147

							(0.046)	(0.019)	(0.046)		
Netherlands	+	+		+	+	+	0.000	-0.113***	0.169***	5.8	146
							(0.001)	(0.025)	(0.023)		
Poland	+	+	+	+	+		0.001	-0.101***	0.367***	6.5	119
							(0.002)	(0.037)	(0.034)		
Portugal	+	+		+	+	+	-0.005***	-0.117***	0.113***	5.6	147
							(0.002)	(0.020)	(0.015)		
Slovakia	+		+	+	+		-0.003***	-0.124***	0.186***	5.2	139
							(0.001)	(0.027)	(0.021)		
Slovenia	+	+	+	+	+		-0.004*	-0.139***	0.348***	4.6	146
							(0.002)	(0.025)	(0.029)		
Spain	+			+	+	+	0.001*	-0.033***	0.357***	20.7	147
							(0.000)	(0.008)	(0.035)		
Sweden	+	+	+	+	+	+	-0.001	-0.119***	0.227***	5.5	146
							(0.001)	(0.027)	(0.023)		

Note: WP stands for world agricultural commodity price index, u for unemployment rate, e for exchange rate, o for world oil price index, w for wages and g for economic growth. Newey-West standard errors are shown in parentheses below the parameter estimates. The table only includes MSs in which the consumer price index is I(1) and the residuals of Equation (2) are stationary. + means that, at the 5% level at least, the null hypothesis can be rejected in at least one lag (insignificant lags have been eliminated from the regressions to specify a more parsimonious model). *** p<0.01, ** p<0.05, * p<0.1

Table A2.4. Price transmission elasticities for each MS with the ECB's import-weighted world price index

MS	Δwp_t	Δe_t	Δu_t	Δo_t	Δw_t	Δg_t	Constant	ECT_{t-1}	WP_t	Median lag length	No. Obs
Austria	+		+	+	+	+	0.018*** (0.003)	-0.153*** (0.036)	0.207*** (0.012)	4.2	146
Belgium	+	+	+	+	+	+	-0.005*** (0.002)	-0.224*** (0.040)	0.222*** (0.012)	2.7	139
Bulgaria	+	+	+	+	+	+	0.031 (0.020)	-0.097*** (0.023)	0.457*** (0.046)	6.8	135
Cyprus	+				+	+	0.006*** (0.020)	-0.159*** (0.046)	0.496*** (0.022)	4.0	139
Denmark	+	+		+	+	+	-0.007*** (0.001)	-0.122*** (0.019)	0.161*** (0.015)	5.3	147
Estonia	+		+	+	+	+	-0.006*** (0.001)	-0.064*** (0.020)	0.389*** (0.030)	10.5	150
France	+	+	+	+	+	+	-0.050* (0.028)	-0.098*** (0.025)	0.187*** (0.010)	6.7	139
Germany	+	+	+	+	+	+	0.004*** (0.001)	-0.095*** (0.025)	0.142*** (0.018)	6.9	146
Greece	+	+	+	+	+	+	0.153 (0.112)	-0.049 (0.036)	0.200*** (0.025)		145
Hungary	+	+	+	+	+	+	0.008*** (0.002)	0.010 (0.024)	0.625*** (0.033)		137
Italy	+	+		+		+	0.003*** (0.001)	-0.05*** (0.014)	0.207*** (0.019)	13.5	146
Luxemb	+	+	+		+	+	0.002*** (0.000)	-0.031** (0.012)	0.219*** (0.019)	22.0	147
Malta	+	+	+	+	+	+	-0.103** (0.045)	-0.124*** (0.019)	0.356*** (0.036)	5.2	146
Netherlands	+	+	+	+		+	0.003*** (0.001)	-0.123*** (0.023)	0.139*** (0.016)	5.3	146
Poland	+	+	+	+	+	+	0.006*** (0.001)	0.003** (0.015)	0.286*** (0.026)		123

Portugal	+	+		+	+	+	-0.000 (0.002)	-0.098*** (0.022)	0.102*** (0.018)	6.7	148
Slovakia	+		+	+	+		-0.000 (0.001)	-0.124*** (0.036)	0.168*** (0.019)	5.2	148
Slovenia	+	+	+	+	+	+	-0.005*** (0.002)	-0.139*** (0.028)	0.284*** (0.021)	4.6	146
Spain	+			+	+	+	0.001** (0.001)	-0.026*** (0.008)	0.293*** (0.034)	26.3	147
Sweden	+	+	+	+	+	+	-0.004** (0.002)	-0.093** (0.023)	0.185*** (0.018)	7.1	146

Note: WP stands for world agricultural commodity price index, u for unemployment rate, e for exchange rate, o for world oil price index, w for wages and g for economic growth. Newey-West standard errors are shown in parentheses below the parameter estimates. The table only includes MSs in which the consumer price index is I(1) and the residuals of Equation (2) are stationary. + means that, at the 5% level at least, the null hypothesis can be rejected in at least one lag (insignificant lags have been eliminated to specify a more parsimonious model). *** p<0.01, ** p<0.05, * p<0.1

Table A2.5. Price transmission elasticities for each MS with the ECB's use-weighted world price index

MS	Δwp_t	Δe_t	Δu_t	Δo_t	Δw_t	Δg_t	Constant	ECT_{t-1}	WP_t	Median lag length	No. Obs
Austria	+		+	+	+	+	0.058*** (0.011)	-0.168*** (0.027)	0.236*** (0.012)	3.8	146
Belgium	+	+	+	+	+	+	0.015*** (0.004)	-0.092*** (0.029)	0.238*** (0.018)	7.2	146
Bulgaria	+	+	+	+	+	+	0.003* (0.002)	-0.102*** (0.016)	0.471*** (0.039)	6.4	142
Cyprus	+	+			+	+	0.002 (0.002)	-0.079*** (0.026)	0.506*** (0.033)	8.4	146
Estonia	+	+		+	+	+	-0.006*** (0.002)	-0.047** (0.018)	0.434*** (0.033)	14.4	147
France	+	+	+	+	+	+	0.002* (0.001)	-0.094*** (0.021)	0.217*** (0.016)	7.0	139
Germany	+	+	+	+	+	+	0.134** (0.054)	-0.072*** (0.023)	0.162*** (0.019)	9.3	145
Greece	+	+	+	+	+	+	0.328*** (0.096)	-0.101* (0.057)	0.223*** (0.030)		143
Hungary	+	+		+		+	0.008*** (0.001)	-0.000 (0.012)	0.710*** (0.036)		137
Italy	+	+		+		+	0.003*** (0.000)	-0.047*** (0.008)	0.234*** (0.022)	14.4	146
Luxemb	+	+	+	+	+	+	0.004*** (0.001)	-0.063*** (0.013)	0.248*** (0.023)	10.7	145
Malta		+	+	+	+	+	-0.101** (0.049)	-0.134*** (0.027)	0.407*** (0.037)	4.8	146
Netherlands		+		+	+	+	-0.002 (0.002)	-0.153*** (0.026)	0.157*** (0.018)	4.2	146
Poland	+	+	+	+	+	+	0.005** (0.002)	-0.081** (0.041)	0.344*** (0.028)	8.2	117
Portugal	+	+		+	+	+	-0.013*** (0.003)	-0.111*** (0.019)	0.101*** (0.013)	5.9	146

Slovakia	+		+	+	+	0.000 (0.001)	-0.227*** (0.030)	0.196*** (0.020)	2.7	147
Slovenia	+	+	+		+	+	0.002 (0.002)	-0.118*** (0.024)	0.322*** (0.024)	5.5 146

Note: WP stands for world agricultural commodity price index, u for unemployment rate, e for exchange rate, o for world oil price index, w for wages and g for economic growth. Newey-West standard errors are shown in parentheses below the parameter estimates. The table only includes MSs in which the consumer price index is I(1) and the residuals of Equation (2) are stationary. + means that, at the 5% level at least, the null hypothesis can be rejected in at least one lag (insignificant lags have been eliminated to specify a more parsimonious model). *** p<0.01, ** p<0.05, * p<0.1

Appendix A3. Discussion of results

Own calculations based on Structural Business Statistics (SBS) data from EUROSTAT. The average size of firms engaged predominantly in both the non-specialized in-store retailing of food, beverages and tobacco and specialized in-store food retailing is estimated as the ratio of the turnover (million euros) to the number of enterprises. Non-specialized stores offer a broader range of products at a point of purchase while specialized in-store retailers are generally small retail outlets that do not belong to national or international chains (EUROSTAT, 2009).

The average size of firms engaged in non-specialized in-store retailing⁷ ranges from 0.13 million euros/enterprise in Bulgaria to 12.99 million euros/enterprise in Luxembourg. Bottom two quintiles: Bulgaria, Romania, Poland, Hungary, Greece, Cyprus, Portugal, Lithuania, Slovakia and Latvia. Top quintile: Finland, France, Germany, the Netherlands and Luxembourg. Data on non-specialized in-store retailing from 2011 and for the Czech Republic, Denmark and Malta are not available.

The average size of firms engaged in specialized in-store food retailing¹ ranges from 0.04 million euros/enterprise in Bulgaria to 0.82 million euros/enterprise in Sweden. Bottom two quintiles: Bulgaria, Portugal, Hungary, Romania, Italy, Czech Republic, Greece, Poland, Spain, Latvia and Slovakia. Top quintile: Germany, the Netherlands, Estonia, Austria and Sweden. Data on

⁷ Source: Own calculations based on Structural Business Statistics (SBS) data from EUROSTAT (EUROSTAT, 2015c).

specialized in-store food retailing from 2011, for Malta 2010, and for the Luxembourg and Finland are not available.

Appendix C1. A dynamic model for calorie loss

Dynamic models that take into account these factors and provide more reliable estimates of body weight changes have been developed (Ruff and Zhen, 2015). According to Hall et al. (2011), if we know calorie change, weight and fat mass, changes in fat and lean tissue masses can be approximated by the following equations:

$$\rho_F \frac{dF}{dt} = (1 - p)(I - E); \quad \rho_L \frac{dL}{dt} = p(I - E) \quad (1)$$

where F is fat mass, L is lean tissue mass, I is energy intake rate and E is energy expenditure rate. $\rho_F = 39.5$ MJ/kg and $\rho_L = 7.6$ MJ/kg are parameters that measure the energy per unit change of fat and lean tissue and p is a dimensionless function that partitions between fat and lean tissue among body composition (Hall et al., 2011). Following Hall et al. (2011) and Lin et al. (2011) we estimated the initial fat mass using the Jackson et al. (2002) gender specific equations and the coefficients of the regression that accounts for race, appropriate to Tanzania's population.

$$F_m = \frac{weight}{100} [0.14 * age + 37.35 * \ln BMI - 104.21] \quad (2)$$

$$F_w = \frac{weight}{100} [0.15 * age + 38.67 * \ln BMI - 97.11]$$

The initial lean mass was estimated as the difference between weight and initial fat mass. The total energy expenditure rate was defined by the following equation:

$$E = K + \gamma_L L + \gamma_F F + \delta weight + \beta \Delta I + \eta_F \frac{dF}{dt} + \eta_L \frac{dL}{dt} \quad (3)$$

where the parameters $\gamma_L = 92$ KJ/kg/day and $\gamma_F = 13$ KJ/kg/day are the regression coefficients for the resting metabolic rate to lean tissue mass and fat mass respectively, the parameters $\eta_F = 750$ KJ/kg and $\eta_L = 960$ KJ/kg account for the biochemical efficiencies associated with fat and protein synthesis, the parameter $\beta = 0.24$ accounts for the thermic effect of feeding and other

physiological adaptations that affect energy expenditure when experiencing changes in energy intake (Hall et al., 2011) and δ is physical activity which is a function of the PAL and the ratio of the resting metabolic rate to weight. The PAL was assumed to be 1.7 and the resting metabolic rate was estimated using the Mifflin and St Jeor equations (Mifflin et al., 1990). As already mentioned, once we estimate the weight changes we apply them to the initial body weights observed in the survey for each household member and predict the counterfactual weights after the price shock. The static and dynamic calorie to weight models were performed on a daily basis over a year's time by running the models recursively. Results are reported over 3, 6, 9 and 12 month's period for comparability purposes. Finally, since the dynamic model we apply has been originally developed by Hall et al. (2011) and Lin et al. (2011) for adult subjects, we restrict the analysis to the individuals above eighteen years of age.