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Explaining the many dimensions of Food Security worldwide: a global, innovative approach

Nome e Cognome del dottorando
Elena Grimaccia

firma

Docente Guida:
Prof. Luca Salvatici

firma

Coordinatore:
Prof. Luca Salvatici

firma

Dottorato in Economia

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EXPLAINING THE MANY DIMENSIONS OF FOOD SECURITY WORLDWIDE: A GLOBAL, INNOVATIVE APPROACH

Dottorando: Elena Grimaccia

Docente guida: Prof. Luca Salvatici

Comitato di tesi:

Prof. Filomena Maggino, Dr. Alessia Naccarato, Dr. Petro Gennari

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Abstract

The research project has a profoundly innovative character with the study of a scale of measurement of food insecurity related to individuals and analysed worldwide.

After reviewing the extensive literature on the different theoretical approaches and measurement methods of a complex phenomenon such as food insecurity, I proceeded to the validation of a scale of measurement of food insecurity at the individual level - the Food Insecurity Experience Scale (FIES) of FAO, verifying its reliability and validity through the Exploratory Factor Analysis and - for the first time - through a Confirmatory Factor Analysis and the use of Simultaneous Equation Models.

The data related to FIES, surveyed for the first time globally in 2014, has been analysed to identify the determinants of individual food insecurity, taking into account also the levels of development of the countries considered, as well as their geographical location.

In addition to the originality in the thematic and methodologic approach, the thesis could also be useful for monitoring policies, as macro-indicators of food insecurity based on FIES have been included among the targets of the Sustainable Development Goals.

Il progetto di ricerca ha carattere profondamente innovativo con lo studio di una scala di misurazione della food insecurity *riferito ai singoli individui e analizzato a livello mondiale.*

Dopo la revisione dell'ampia letteratura sui diversi approcci teorici e le metodologie di misurazione di un fenomeno complesso come l'insicurezza alimentare, ho provveduto alla validazione di una scala di misura della food insecurity *a livello individuale – la* Food Insecurity Experience Scale *(FIES) della FAO, verificandone l'attendibilità e la validità tramite l'*Exploratory Factor Analysis *e – per la prima volta – tramite una* Confirmatory Factor Analysis *e l'uso di* Simultaneous Equation Models.

I dati relativi alla FIES, rilevati per la prima volta a livello globale nel 2014, sono stati analizzati per individuare i fattori determinanti della food insecurity *individuale, tenendo conto nella modellizzazione econometrica anche dei livelli di sviluppo dei Paesi considerati, nonché della loro appartenenza geografica.*

Oltre a presentare innovazioni nell'ambito della ricerca metodologia e tematica, la tesi sarà utile anche per il monitoraggio di policies*, in quanto indicatori macro di insicurezza alimentare basati sulla FIES sono stati inseriti tra i target dei* Sustainable Development Goals.

JEL Codes Q18, F63, C35, C38.

Keywords Food insecurity; Sustainable development; Self-reported scale; Confirmatory Factor Analysis; Simultaneous Equation Models; Ordered logistic regression.

To Leonardo and Filippo.

Introduction

Food insecurity remains a barrier to sustainable development and creates a trap from which people cannot easily escape: hunger and malnutrition mean less productive individuals, who are more prone to disease and thus often unable to earn more and improve their livelihoods. A world with zero hunger can positively impact our economies and other dimensions of sustainable development such as education, health and gender equality (UN 2018).

On 25 September 2015, the United Nations Assembly adopted, in its resolution 70/1, the post-2015 development agenda: "Transforming our world: the 2030 Agenda for Sustainable Development". In the document of definition of the Sustainable Development Goals, UN defines food insecurity as one of the most relevant development challenges that nowadays low-income countries have to cope with (UN 2015b). In the 2030 Agenda, food security is a very ambitious, stand-alone goal: Goal 2. "End hunger, achieve food security and improve nutrition and promote sustainable agriculture". SDG2 include 5 multidimensional targets, which cover aspects related to: food access, nutrition, agricultural productivity, sustainable food systems, genetic diversity, investment, trade and market information.

Food insecurity, poverty, malnutrition, income inequality and lack of decent employment opportunities reinforce each other in a vicious cycle by eroding human capital and decreasing labour productivity, thereby perpetuating poverty and social inequalities across generations (FAO 2010). The lack of an adequate diet, both in terms of calorie intake and of essential nutrients, can erode the population's health and working capacity and thus food insecurity can lead to labour productivity diminution and amplification of the economic problems of different countries (Ghattas 2014).

Although we see strong relationships between income and hunger indicators, and between poverty and the likelihood of food insufficiency, a one-to-one correspondence between measures of food insecurity and measures of poverty does not exist (Rose 1999). Economic growth alone is not a sufficient condition to ensure food security, while there is extensive space for public action in promoting food security through, for instance, expenditure on women's education, health, and expansion of households' entitlements to food.

In this context, studying the common determinants of food insecurity with a common and reliable tool across the globe is needed to help drawing more effective policies for the most vulnerable groups of population.

The importance of a measure of food insecurity centred on individuals rather than only on countries or regions was recognised starting from the work of Sen in the Eighties (Sen 1981, 1983). In World Food Summit in 1996, an innovative definition of food security was developed: “Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 1996). This definition has been refined in “The State of Food Insecurity 2001”: “Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO 2002).

The financial, economic and food crisis in 2008 resurfaced the need of data on food insecurity at individual and household level, having many studies demonstrated that households that were more vulnerable before the financial crisis saw a worsened effect in terms of food insecurity with the crisis (Vilar-Compte et al. 2015, Bloem 2010), increasing also disparities among men and women, poor and not poor households, people in education or not (d’Errico et al. 2018, FAO 2010), or that smaller household performed much better than households with more members (Lokosang et al. 2016).

Even if measures of food insecurity at individual and household level existed, a common metric able to measure food insecurity based on personal experience at the global level was not available to be studied and used for policies. Data comparable worldwide where drawn by macroeconomic measures at the national level, and the monitoring of food insecurity was carried out at country level, thus not permitting to analyse the characteristics of food insecure people and to determine the economic and social personal factors related to individual food insecurity. Measures at household or individual level were developed and used at local level, starting from the Nineties in the US, and then in Latin America, but an instrument able to collect the direct experience of individuals across the globe was missing.

In this framework, the Food Insecurity Experience Scale (FIES) presents a notable innovation, and its validation and analysis carried out in this thesis is an original contribution to the research devoted to food security and its economic and social determinants.

FIES is an experience-based scale developed to measure food insecurity at the individual level. It captures in particular the access dimension of food insecurity and it has been built by the Food and Agriculture Organization of the United Nations (FAO) to collect comparable

data on individual food insecurity worldwide, asking directly to respondents their experiences, anxieties and perception of food insecurity.

FIES provides a direct measure of the problems that individuals and households experience in having access to food, providing an assessment of the severity of food insecurity. The measures based on FIES are able to estimate food insecurity also when the frequency of the phenomenon is very close to zero, differently from indicators based on macro-data (e.g. Prevalence of Undernourishment) that are not estimated for developed Countries.

Other characteristics of the FIES are that: it can be used both at household and individual level, allowing the analysis of inequalities in access to food for several personal characteristics (e.g. gender, education, household composition, income); it is based on a short questionnaire (eight questions) that can be easily included in all surveys of households or individuals; it is a quick and cheap tool that allows timely intervention.

Experience-based food insecurity scales like the FIES represent, thus, a simple, timely and less costly method for measuring the access dimension of food insecurity based on data collected at the household or individual level.

Direct measures of experienced food insecurity can be used to potentially identify vulnerable populations before malnutrition becomes manifest, they allow disaggregation at sub-national levels and across different population groups, making it possible to identify more specifically who the food insecure are and their geographic distribution. The ease of application, analysis, and interpretation facilitates better communication of results to decision makers, leaders of civil society, and the general public.

It is worth underlining that FIES does not provide specific information on actual food consumption, diet quality and food expenditures like household expenditure surveys and individual food intake surveys.

Because of its characteristics, this innovative method to detect food insecurity has been listed among the indicators for the monitoring of the UN Sustainable Development Goals. requested that the Goals and targets identified in the 2030 Agenda have to be followed up and reviewed using a set of global indicators. In particular, the ambitious Goal 2 “zero hunger: end hunger, achieve food security and improved nutrition and promote sustainable agriculture“ and target 2.1 ”by 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and

sufficient food all year round" have to be monitored by Indicator 2.1.2: Prevalence of moderate or severe food insecurity in the population, based on the FIES (resolution 70/1, the UN General Assembly). Food Insecurity Experience Scale (FIES) them has become a new global standard to measure food insecurity

FAO has identified FIES as the tool with the greatest potential for becoming a global standard capable of providing comparable information on food insecurity experience in different population groups, both at individual and at household level (Ballard et al. 2013).

The originality of the FIES resides, first of all, in the individual-level information that allows a substantially innovative detailed analysis.

Second, the experience-base information follows a "new deal" in the measurement approach of economic and social phenomena, not only food insecurity, as emphasised in the thesis: subjective poverty, economic "sentiment" and happiness are all issues at the top of the research topic in the last decade.

This is one of the very first studies to utilise the FIES data, and -at our knowledge - one of the most complete.

The precautions used in the empirical analysis are among the most advanced: an analysis of the reliability and validity of the scale has been conducted before the application of the model, while afterwards an analysis of the robustness of the results is presented.

The results estimated in the models add further insight to the study of the food insecurity: gender disparities, strong impact of education against hunger, role of income, are all determinants of which I give acknowledgement in the thesis.

In this framework, the present thesis addresses the following three principal questions:

- What is the role of experience-based tools to measure food insecurity in the wide literature on food security measures?
- Is the Food Insecurity Experience Scale able to measure access to food of individuals across the world?
- Which are the determinants of individual food insecurity at the global level? Do these determinants vary across different geographical areas? And at different levels of development? Understanding economic and social factors related to food insecurity and achieve a better knowledge of the groups of most food insecure people can contribute to designing effective policies (Smith 2017).

In order to answer to these questions, the thesis is organised in four Chapters.

The first Chapter, after a brief overview of the main theoretical approaches to the definition of food security, provides a review of different methods to measure the phenomenon, with a particular attention to experienced-based scales and FIES. Its original contribution lies in systematically reviewing the large body of empirical literature that has been developed in the last decades, in order to capture the theoretical and epistemological background of self-experienced food security. The many different definitions of food security, that have been long debated, are still not univocal. In fact, macro-measures, such as the FAO Prevalence of Undernourishment, monitor national and regional trends in undernutrition, based on estimates on the availability of food at the macro level, but do not identify individual and familial factors, nor the characteristics of the most vulnerable population groups. Anthropometric measures, such as child weight-for-age (measure of underweight) and height-for-age (measure of stunting), provide invaluable information regarding the nutritional status of individuals, but are costly and require a relatively sophisticated level of expertise to collect and analyse the data, not permitting to develop policies if not too late. Measures based on household surveys employ indirect methods to estimate food intake, because acquisition of food products during a reference period is not equivalent to actual consumption of the purchased products during the same period, and results do not consider food purchased outside the home, nor self-produced goods. Information are often not available for the distribution of food among the household members, and there is not – for the moment – a common instrument comparable across the globe.

There has been substantial research devoted to developing, refining and validating different approaches for measuring the state of food insecurity at the global level. The development of measures of whether people are experiencing food insecurity because of limited access to food, and if so at what level of severity, constitutes an important addition to the suite of commonly used food security measures.

Food insecurity experience-based measures have been defined “third generational indicators’’, after the availability approach and the income-consumption measures (Barrett 2002). These more direct measures are intended to capture the household’s or individual’s reported experience of the problem through responses to validated survey items that are transformed into a scale and are able to measure access to food (Coates et al. 2006).

The use of self-reported indicators to measure food insecurity in a comparable way in different Countries has been widely debated, considering that the individual perception of hunger can differ for different individuals, due to their history of nutrition, because of their different psychometric characteristics. The measurement of food insecurity at the individual and household level aims to measure this access component and is based on the idea that the experience of food insecurity causes predictable reactions and responses that can be captured and quantified through a survey and summarized on a scale (Coates 2006).

Through the critical review of the immense literature on the definition and measurement of food security, the Chapter shows how the use of direct measures of individual food insecurity could be included in the Sen's entitlement approach and, more generally, in the more recent framework of the measures of multidimensional phenomena.

The Food Insecurity Experience Scale, developed by the Voices of the Hungry project (VOH) of FAO, is an experience-based food insecurity scale module, derived from widely-used scales: the US Household Food Security Survey Module (HFSSM), the Household Food Insecurity Access Scale (HFIAS) (Coates et al. 2007), and the Latin American and Caribbean Food Security Scale (Spanish acronym ELCSA), as described in Ballard (2013).

Being the information included in the dataset one of the original elements of the present study, an entire Chapter is devoted to illustrating the characteristics of the dataset. FIES is indeed the first ever experience-based scale surveyed in order to generate comparable disaggregated data on food security at worldwide level. The aim of the second Chapter is, then, to present in detail all the original elements of the information included in the analysis: the methodological characteristics of the FIES, from its development from other experience-based scales, to the definition of the items; the survey methodology to collect data on FIES; and the principal correlates are presented.

Starting from 2014, the FIES has been incorporated into the Gallup World Poll and it has been surveyed in almost 150 countries and territories all over the world, with a sample of more than 150 thousand individuals. This survey provides, for the first time, cross-country comparable estimates of food insecurity on a global scale. Although the FIES is not the first individual experience-based scale in the field of food security, it is the first one surveyed into such a large number of countries in a standardized manner, together with meaningful covariates, such as the level of education, the composition and number of children in the household, the location of the dwellings and other economic, demographic and social

variables. Therefore, an extended analysis of the methodologies used to collect data and of the dataset obtained is presented.

The third Chapter looks into the FIES consistency, reliability and validity. The reliability and validity of FIES has been analysed with the Rasch model by Nord (2012), its content validity has been assessed with an analysis of the correlations with other significant macro indicators (FAO 2015), and its validity has been studied in 2018 by Ghattas for South Africa.

However, in this Chapter an original study, both for its methods and for its extension, is presented. The construction and validation of the FIES aims to detect with accuracy individuals that present a critical level of food insecurity, thus allowing to understand the applicability of this innovative scale. Diverse aspects of reliability and validity have been analysed. Moreover, both an exploratory factor analysis and three different confirmatory factor analysis, following diverse hypothesis, have been carried out. The analysis has allowed to find out a possible alternative way to collect data on individual food insecurity.

The fourth Chapter presents a micro-econometric analysis of food insecurity, based on information on the individuals' experience, measured by FIES, together with other personal and household characteristics, considered important in the literature. The objective of this part of the thesis is to assess which factors can determine individual food insecurity.

Looking into the variables that influence food security at individual level, such as education, household income, household composition (couples, lone parents, with or without children), age, using the Food Insecurity Experience Scale, it is possible to identify the population groups most affected from food insecurity and through comparisons of food insecurity in various economic and demographic subpopulations in countries around the world.

The result is to identify determinants of food insecurity that can reflect the effectiveness of each country’s policies and can help to define policies to fight hunger, both in developed and developing countries. The analysis is carried out at individual level to expand our understanding of individual perception and personal and familiar characteristics associated to food security. In particular, the study enhances the understanding of social, gender, age specific vulnerability to food insecurity.

Food insecurity presents marked differences depending on the level of development of the country under consideration. To take into account these relations, countries have been

grouped together using a cluster analysis, based on the indicators forming the UN Human Development Index.

The model used allows to identify the economic, social and demographic characteristics related to food insecurity at global level and for each group of countries, giving further and original evidence to the existing literature. The study is also very useful to further validate the FIES methodology: if respondent characteristics relate to food insecurity in similar ways around the world, the findings will provide further evidence for the validity and effectiveness of the FIES as a valid measure of food insecurity.

The comparisons of food insecurity in different economic and demographic subpopulations across countries allow a better understanding of the complex phenomenon and support policy aimed at improving the well-being of population and ending hunger.

Chapter 1

Innovative approaches in the conceptualization and measurement of food security

1.1. Introduction

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life. (2009 Declaration of the World Summit on Food Security)

Poverty, inequality and food insecurity are the most crucial and persistent problems facing humanity nowadays. Their mitigations are at the heart of any meaningful development effort.

On 25 September 2015, the United Nations Assembly adopted, in its resolution 70/1, the post-2015 development agenda: "Transforming our world: the 2030 Agenda for Sustainable Development". In the 2030 Agenda, Member States referred to "the global indicator framework, to be developed by the Inter-Agency and Expert Group on Sustainable Development Goal Indicators" to "be agreed by the Statistical Commission by March 2016 and adopted thereafter by the Economic and Social Council and the General Assembly, in line with existing mandates".

In the document of definition of the Sustainable Development Goals (SDGs), UN defines food insecurity as one of the most relevant development challenges that nowadays low-income countries have to cope with (UN 2015).

In the 2030 Agenda for Sustainable Development, food security is a very ambitious, stand-alone goal, "Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture". SDG2 includes 5 multidimensional targets, which cover aspects related to: food access, nutrition, agricultural productivity, sustainable food systems, genetic diversity, investment, trade and market information.

SD Goal 2.1 states: "By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round", while SD Goal 2.2 asserts: "By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in

children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons".

The relationship between food security and other areas of policies is very complex to analyse. For instance, extreme poverty and high inequality are linked with conflicts and political instability because it creates incentives for people to engage in activities outside the market (e.g. illegal drug trafficking, crime) that contribute to political and social instability. Such instability generates disruptions in the current economy and uncertainty about the future, thereby discouraging the accumulation of wealth, savings and investment (Alesina and Perotti 1996). Moreover, according to FAO (2016) food security presents further fragility towards the effects of climate change: beyond 2030, the negative impacts of climate change on the productivity of crops, livestock, fisheries and forestry will become increasingly severe in all regions, and productivity declines would have serious implications for food security because food supply shortfalls would lead to major increases in food prices, while increased climate variability would accentuate price volatility. Since the areas most affected would be those with already high rates of hunger and poverty, food price increases would directly affect millions of low-income people (FAO 2016).

Food insecurity, poverty, malnutrition, income inequality and lack of decent employment opportunities reinforce each other in a vicious cycle by eroding human capital and decreasing labour productivity, thereby perpetuating poverty and social inequalities across generations.

The lack of an adequate diet, both in terms of calorie intake and of essential nutrients, can erode the population's health and working capacity and thus food insecurity can lead to labour productivity diminution and amplification of the economic problems of different countries. (Ghattas 2014).

Although we see strong relationships between income and hunger indicators, and between poverty and the likelihood of food insufficiency, a one-to-one correspondence between measures of food insecurity and measures of poverty does not exist (Rose 1999).

Economic growth alone is not a sufficient condition to ensure food security, while there is extensive space for public action in promoting food security through, for instance, expenditure on women's education, health, and expansion of households' entitlements to food. This result is particularly relevant as it empirically tests the hypothesis advanced by Burchi and De Muro (2012) on the "capability to be food secure" as the result of the interaction between the capability of "being free from hunger" obtained through the access to

food, and the ones of being in “good health” and “being educated”. The “capability to be food secure” not only results from the complex interaction among various human development dimensions, but is also influenced by the environment understood as institutional, social and economic factors.

There has been substantial research devoted to developing, refining and validating different approaches for measuring the state of food insecurity. The development of measures of whether people are experiencing food insecurity because of limited access to food, and if so at what level of severity, constitutes an important addition to the suite of commonly used food security measures.

FAO has identified the Food Insecurity Experience Scale (FIES) as the tool with the greatest potential for becoming a global standard capable of providing comparable information on food insecurity experience in different population groups, both at individual and at household level. The FIES is an experience-based scale developed to measure food insecurity at the individual level. It captures in particular the access dimension of food insecurity and it has been developed by FAO to collect comparable data worldwide.

The theoretical background of FIES will be described in this Chapter at Section 6, while the methodological issues related to FIES and its survey will be illustrated in Chapter 2.

In this first Chapter, I provide a review of different approaches in the definition and measure of Food Security (FS). The aim is to place the FIES within the vast literature on the definition and measurement of food insecurity. The aim of this part of the thesis is not to provide an exhaustive review of all the definitions and operational approaches to the measure of food insecurity, but to collocate critically the experience-based measures of food insecurity in the interesting debate on the theoretical approach to the measure of multidimensional phenomena, such as food insecurity.

After a brief overview of the main theoretical approaches, the study focuses on measures at the micro level, related to individuals or households, and in particular on the measures of food insecurity based on the personal experiences reported by the respondents.

In Section 4 advantages and disadvantages of experience-based approaches compared to more established definitions are presented, while in Section 5 the principal techniques for the measure of food security are described.

In Section 6 the main features of FIES are reported, while in Section 7 the macro application of FIES data, used to monitoring experience-based food insecurity at country level for the SGD2 is synthetized.

1.2. Conceptual framework: definitions of food security

Food security is a very complex, multi-faced, and comprehensive concept, which has evolved along time (Maxwell 1996). Some authors mention the existence of about 200 definitions for concept of FS (Clay, 2002). Accurate measurement and policy targeting, therefore remains a challenge due to the many dimensions involved (Aliber, 2009a).

Here I provide an overview of the main theories for the definition of food insecurity, among a very extensive literature, with the aim of briefly illustrate the main different approaches and their evolution. Key references for a more exhaustive review of the definition and methods of measuring food insecurity are: Maxwell and Smith (1992), Hoddinott (1999), Habicht, et al. (2004), Hart (2009), Burchi and De Muro (2012, 2015), Pangaribowo et al. (2013), Jones et al. (2013), Leroy et al. (2015) for the Access dimension, Lele et al. (2016). An overview of the operational definition and measure methodologies in provided in Section 1.5.

The oldest approach to food security is the "food availability" approach, and it is still the most influential, according to Burchi and De Muro (2015). It dates back to Thomas Malthus' work "An Essay on the Principle of Population" (1789), that has been very influential for the study of population, food, and political economy, and it is still known as the Malthusian approach. The approach is focused on the equilibrium between population and food: in order to maintain this equilibrium, the rate of growth of food (and other natural resources) availability should be not lower than the rate of growth of population. This approach had a huge visibility in MIT project of the Club of Rome (Meadows et al 1972). Considering this approach, the units of analysis have usually been countries, or the world, and it focused on the agricultural sector (Burchi and De Muro, 2015).

During the Seventies, the study of FS moved from food availability at macro-level to income at micro-level (Reutlinger and Selowsky 1976, ILO 1977, Griffin 1978). In this income-based approach, food insecurity is implicitly assumed as a sub-category of poverty (often referred to as "food poverty"). For instance, Reutlinger and Selowky (1979) underline the urgency for deliberate policies and programs, especially among nutritionally vulnerable groups.

As noted in Griffin and Khan (1978) in the International Labour Organization (ILO) study, "there certainly is no evidence that the world is moving toward a Malthusian trap. When the poor starve, it is not mainly because there is no food but because they do not have the wherewithal to acquire food. In other words, the problem of world hunger cannot be solved merely by attempting to increase production. The solution requires better distribution and more productive employment both to increase incentives to expand output and create effective demand for greater food output" (ILO, 1977).

In 1983, FAO expanded its definition of food security: from the definition of 1974, based on food supply ("Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices"), the concept of FS was extended to include access by vulnerable people to available supplies, so that food security refers to a condition that "ensure that all people at all times have both physical and economic access to the basic food that they need" (FAO, 1983). Food insecurity results when people have insufficient physical availability of food, limited economic and social access to adequate food and/or inadequate food utilization (FAO, 1983).

The definition of FS based on food consumption, that include food consumed or acquired by households in terms of quantities and monetary values, uses data collected in National Household Surveys, including expenditure and quantities of food items acquired or consumed during the reporting household survey period from the different food sources in sufficient details to allow for the estimation of food dietary energy and nutrient consumption. Both quantity and monetary data collected are useful to estimate average food prices for different products by different groups of households suitably for calculating price elasticities of demand.

Using this definition of food security, based on income or consumption at household level, it is not possible to clearly measure food security for individuals, because of different distribution of the amount of food among the household members (Burchi and De Muro 2015). Moreover, it does not take into account subsistence production, that not only contributes directly to these households' food security as a supply of food, but also enables households to divert income to meet other requirements (Aliber and Hart, 2009).

The concept of a "basic needs" development strategy was born in the middle of the Seventies. This idea originated in the psychology literature of the 1940s and more specifically in an article by Albert Maslow in the Psychological Review of July 1943 in which he distinguished

a hierarchy of five needs starting with physiological and ending with self-actualization needs. The ILO report for the 1976 World Employment Conference defined basic needs in terms of food, clothing, housing, education, and public services: "the satisfaction of basic needs means meeting the minimum requirements of a family for personal consumption: food, shelter, clothing; it implies access to essential services, such as safe drinking-water, sanitation, transport, health and education; it implies that each person available for and willing to work should have an adequately remunerated job. It should further imply the satisfaction of needs of a more qualitative nature: a healthy, humane and satisfying environment, and popular participation in the making of decisions that affect the lives and livelihood of the people and individual freedoms" (ILO 1976). Employment was both a means and an end, and participation in decision making was also included (Maxwell and Smith 1992; Maxwell 1996).

The "basic needs" approach focuses directly on whether people eat enough food, and contributed to make a further step in shifting the analysis from the macro level to the micro level (Burchi and De Muro 2015). This is the main approach behind the view of food security as "Consumption of less than 80% of World Health Organization (WHO) average required daily caloric intake" (Reardon and Matlon 1989) and as "The ability … to satisfy adequately food consumption needs for a normal healthy life at all times" (Sarris 1989). Within the "basic needs" framework, there are two different approaches to measure food security. The first method is based on the direct observation of food consumption, but obtaining detailed data on food security status—such as 24- hour recall data on caloric intakes—can be time consuming and expensive and require a high level of technical skill both in data collection and analysis. The second method assess food security by asking people the number of meals eaten per day or the frequency of consumption of certain types of food, as in the dietary diversity approach, defined as the number of unique foods consumed over a given period of time (Hoddinott and Yisehac 2002). These approaches consider directly food, rather than the income necessary to buy it. In this way, no information on current prices per unit are needed. Moreover, by concentrating on what is actually eaten, the first approach implicitly estimates the food produced at home rather than purchased in the market. Observing directly the individual intake of food is particularly important because of gender bias: by observing directly the food intake of women, we do not assume that they receive the same amount of food as men (Burchi and De Muro 2016).

A more holistic way of looking at food security is the “entitlement approach” of Amartya Sen. In his 1981 paper, Sen presents an alternative approach to famines, moving the attention from the availability of food, measured by the average food supply per head, towards the people's ability to command food through legal means available in the society (including the use of production possibilities, trade opportunities, entitlements vis-à-vis the state, etc.). The approach is explained, focusing on exchange entitlement mappings, fluctuations in which can lead to big shifts in the intergroup distribution of food command. Sen explains that “the entitlement of a person stands for the set of different alternative commodity bundles that the person can acquire through the use of the various legal channels of acquirement open to someone in his position” (1986). Given this definition, famines are due to the failures to assure entitlements to large groups of population.Burchi and De Muro (2012) underline that the entitlement approach contribution is visible in two important food security definitions: “All people at all times have both physical and economic access to the basic food they need” (FAO 1983), and “Access by all people at all times to enough food for an active, healthy life” (World Bank 1986).

Having enough food per capita at national level is a necessary but not sufficient condition for food security: there is plenty of evidence of the presence of large food insecurity and under nutrition in countries with sufficient food per capita. The distance from the income-based approach is smaller, being income an important means to gain access to food: “In dealing with starvation and hunger, the focus on incomes – though defective – is not entirely disastrous. And, of course, it is a good deal better than the focus on total food output and population size. The weighting system of real income and cost-of living pays sufficient attention to food in a poor community to make real income a moderately good ‘proxy’ for entitlement to food in most cases” (Sen 1983).

Starting from the 1981 work of Sen, Chambers and Conway elaborated the concept of Sustainable Livelihoods (SL). The SL framework has many communalities with the basic needs approach and the entitlement approach. Like the former, it focuses on “gaining a living” (Chambers and Conway 1991), that is “the necessities of life”,

The SL concepts have been also widely used for food security measurement, especially in humanitarian emergencies (Maxwell 1995; Maxwell et al. 1999, 2013) and famines (Howe and Devereux 2004; Devereux 2006).

The entitlement approach was overcome from Sen himself after a decade (Dreze and Sen 1989), applying the capability approach to food security. From the perspective of the capability approach, poverty and food insecurity are surely the worst forms of unfreedom conceivable, especially in a world characterized by unequal levels of wealth in human history (Sen 1999). Hence, if the ultimate end of development relates to the removal of the substantive unfreedoms that constrain the flourishing of human beings and their actual possibility to live the life they have reason to value, the reduction of poverty and food insecurity becomes one of the key priorities in the development agenda. At the microeconomic level, it is possible to observe that "the capability to be food secure" (Burchi and De Muro 2012) is the result of the joint and complex action of macroeconomic and social constraints, functional limitations and other contextual characteristics of the household environment. An important development of the approach is stability: the capability to be food secure should have a long-time perspective (Burchi and De Muro 2015).

In 1996, the World Food Summit (WFS) adopted a still more complex definition of food security assessing that "Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life".

1.3. The 1996 World Food Summit definition and the four dimensions of Food Insecurity: availability, access, utilization, and stability over time

Based also on the work of Sen, who moved the approach to food security from the macro level to the individual level and the necessity of people, the 1996 World Food Summit definition identified four main dimensions of food security.

The WFS recognition of food security as a multidimensional phenomenon represented a significant theoretical advancement, as it broadened the scope of food security analysis and policies from the previous focus on food availability. At the same time, it also brought about a number of additional analytical and methodological issues. Here the main features of the four dimensions are illustrated, while in Section1.4 and 1.5 the main operational definition and methods of analysis are discussed.

The first dimension (Food availability) addresses the supply side of food security and is determined by the level of food production, stock levels and net trade. However, it became obvious that an adequate supply of food at the national or international level does not in itself guarantee household level food security. Therefore, it is useful to understand the aggregate indicators like macroeconomic and demographic factors on food consumption (Suresh 2009).

This idea was supported by the argument that the green revolution in Asia of the 1960s and 1970s, with its package of improved seeds, farm technology, better irrigation and chemical fertilizers, was highly successful at augmenting food supplies, but this was not automatically translated into improvements in food security of all people. This insight highlighted the problem of a lack of effective demand. Even if people have money, if there is no food available in the market, people are at risk of food insecurity.

From the early 1980s, the importance of food access was increasingly recognized as a key determinant of food security. Access to food is influenced by market factors and the price of food as well as an individual's purchasing power, which is related to employment and livelihood opportunities. Sen (1981) and Suresh (2009) argued that the mere presence of food in the economy or in the market does not necessarily entitle a household or a person to consume it. Since it can be affected by different factors like infrastructures like road and market outlets to buy food determine the physical access to food.

Food utilization has become increasingly prominent in food security discussions since the 1990s. Utilization is commonly understood as the way the body makes the most of various nutrients in the food. This food security dimension is determined by people's health status. General hygiene and sanitation, water quality, health care practices and food safety and quality are determinants of good food utilization by the body. Food security was traditionally perceived as consuming sufficient protein and energy (food quantity). The consumption of foods, according to Suresh (2009), both in quantity and in quality that is sufficient to energy and nutrient requirements is a basic measure of food utilization. Food security is not just about quantity of food consumed, but also about quality, and that body must be healthy to enable the nutrients to be absorbed.

Stability over time demands the above three dimensions to be stable over the period of time and not be affected negatively by natural, social, economic or political factors. Therefore, no individual measure suffices to capture all aspects of food security.

According to World Bank (1986), disruption of the stability of food availability, access, and utilization results in either chronic or transitory food insecurity. Chronic food insecurity means that a household runs a continually high risk of inability to meet the food needs of household members. In contrast, transitory food insecurity occurs when a household faces a temporary decline in the security of its entitlement and the risk of failure to meet food needs is of short duration. Transitory food insecurity focuses on intra- and inter-annual variations in household food access.

It has been argued that this category can be further divided into cyclical and temporary food insecurity (Deveraux 2006). Temporary food insecurity occurs for a limited time because of unforeseen and unpredictable circumstances; cyclical or seasonal food insecurity when there is a regular pattern in the periodically of in adequate access to food. This may be due to logistical difficulties or prohibitive costs in storing food or borrowing.

While the governments, through their economic, social and food policies, create the general conditions for their population to be supplied with available foodstuffs and to gain the necessary incomes to procure it (availability and access), food security finally becomes a problem of households and individuals. In this respect, there are frequent situations when even in the richest countries, where food security has no longer been a problem for a long time, there are communities and persons subject to food insecurity or at high nutritional risk (Alexandri 2015).

1.4. “Objective” and “subjective” measures of food security

The use of self-reported indicators to measure food insecurity in a comparable way in different Countries has been widely debated, considering that the individual perception of hunger can differ for different individuals, due to their history of nutrition, because of their different psychometric characteristics. However, the scientific literature is very rich on subjective measures of poverty, and there is a wide range of self-reported food security instruments.

The interest in the comparison of subjective and objective measures is still very high in many branches of science (Gelman and Hennig 2017). As underlined by many scholars, however, a more fruitful way of approaching the issue is “to follow the path of relatedness rather than opposition” (Brulè and Maggino 2017).

Subjective poverty measures contribute towards measures of human poverty that can identify the broader domains of poverty, not merely its symptoms (Anand and Sen 1997; Stiglitz, Sen, and Fitoussi 2009). As argued by Sen (1985, 1999, 2000), income is better understood as denoting the means to better living conditions, but it is not necessarily the better living condition in itself.

However, the use of subjective measures of poverty and food security are still seen with some suspect by some scholars who follow Amartya Sen's approach.

In the past thirty years, the scientific research on subjective measures has been very rich with regards to well-being and poverty, but the measurement of food security has been based until very recently exclusively on a "quantitative" approach.

Radimer et al (1992) introduced their paper by explaining that "[their] research was undertaken with the conviction that it was possible to measure hunger directly". Since then, the term "direct measure" of food security has been widely adopted in the past. However, because it is easily confused, the word 'direct' has been gradually abandoned.

Another term used to indicate measures based on the direct experiences of respondents has been the term 'qualitative'. Widely used by scholars, it is also a misnomer. Unlike most qualitative methods (such as key informant ratings or focus group feedback), which are principally descriptive and cannot be standardized beyond a specified time and place, the results collected via measures of food insecurity related behaviours are quantified and analysed using statistically rigorous methods.

Likewise, the term "perceived" food insecurity is also less than ideal. Indeed, some of the items in the various scales assess perceptions (e.g. Do you or adult members of your household ever eat less than you feel you should because there is not enough money for food?), but an equal number of questions try to get at behaviours (e.g. Adult skipped meals) that are, theoretically, observable although they are captured in the scale through self-report.

The most useful candidate descriptor that applies equally well to any of the questions in the scale and to several conceptually similar types of instruments (including the Coping Strategies Index, CSI) is "experiential" – derived from peoples' experiences. The experiential food insecurity scale can be understood as a measure that quantifies a range of behaviours known to reflect food-related stress.

In the present Chapter, the terminology used to describe the various measures is the one chosen by the scholar in analysis. In the following Chapters, however, the most recent term of "experienced" food insecurity is utilized.

In fact, many experiences of self-reported food insecurity measures have been carried out in the last decade. However, the discussion on the epistemological, theoretical and methodological validity of self-reported measure of food security has been scarce. (see Appendix I).

As reported in Artkinson et al. (World Bank 2017), the use of subjective assessments of personal poverty status should be considered. In order to measure the subjective assessment of poverty, the report suggests the use of the Gallup World Poll (GWP), because it covers most countries of the world every year, including more than two-dozen countries in Africa, with a sample of about 1,000 in each country, and asks identical questions throughout the world. The GWP, created in 2005, is a nationally representative survey of individuals 15 years of age and older conducted annually in nearly 150 countries, areas or territories, administered to collect information on people's opinions and experiences (Gallup 2017). The methodological characteristics of the survey used to collect FIES data are reported in Chapter 2.

Alkire, in the paper "the missing dimensions of Poverty Data" (2007) highlights the importance of "psychological and subjective states of wellbeing, which have clear intrinsic and instrumental value. They are a key component of the other dimensions proposed here, as well as an end result of their attainment".

In 2009, the Stiglitz Sen Fitoussi commission legitimised subjective measures of poverty and well-being as a policy tool. In Recommendation 6 (Quality of life depends on people's objective conditions and capabilities) they stated that "there is a consensus that quality of life depends on people's health and education, their everyday activities (which include the right to a decent job and housing), their participation in the political process, the social and natural environment in which they live, and the factors shaping their personal and economic security. Measuring all these features requires both objective and subjective data." The conclusion was that "The Commission believes that in addition to objective indicators of well-being, subjective measures of the quality-of-life should be considered".

Moreover, in Recommendation 10 it is stated that "Measures of both objective and subjective well-being provide key information about people's quality of life". The 2009 report urges Statistical offices to "incorporate questions to capture people's life evaluations, hedonic

experiences and priorities in their own survey". The eminent scholars underline that "research has shown that it is possible to collect meaningful and reliable data on subjective as well as objective well-being", noting that "subjective well-being encompasses different aspects (cognitive evaluations of one's life, happiness, satisfaction, positive emotions such as joy and pride, and negative emotions such as pain and worry)" and therefore "quantitative measures of these subjective aspects hold the promise of delivering not just a good measure of quality of life per se, but also a better understanding of its determinants, reaching beyond people's income and material conditions". They conclude that "Despite the persistence of many unresolved issues, these subjective measures provide important information about quality of life. Because of this, the types of question that have proved their value within small-scale and unofficial surveys should be included in larger-scale surveys undertaken by official statistical offices".

With respect to the theoretical approach, the 2009 report emphasises that: the fair allocation approach and the capability approach "have obvious differences, but also certain similarities. For example, subjective well-being is sometimes claimed to encompass all capabilities, in so far as these refer to attributes and freedoms that people value (implying that enhancing their capabilities will improve people's subjective states). However, proponents of the capability approach also emphasise that subjective states are not the only things that matter, and that expanding people's opportunities is important in itself, even if this does not show up in greater subjective well-being. Similarly, both the capability and the fair allocation approaches rely on information on the objective attributes of each person, while differing in the ways in which these are weighted and aggregated".

Poverty studies typically measure poverty by comparing "objective" indicators of economic well-being, commonly expenditure or income, with a money-metric poverty threshold. But, as noted in Posel and Rogan: "money-metric measures will misrepresent the extent of poverty if current income or expenditure is not well correlated with the many dimensions of the household's living standards. These measures may also misrepresent the extent of poverty if they are not sensitive to differences in household size and composition and if information on income or expenditure is difficult to collect".

However, Ravallion and Lokshin (2001) underline that there is "scope for debate at virtually every step" in generating these poverty measures. In addition to questions about the appropriate poverty threshold, there is debate about whether economic well-being should be

identified using income or expenditure, how to adjust these indicators for possible underreporting or non-reporting and for differences in costs-of living across different regions or countries, what to include in the measurement of income or expenditure (e.g. where in-kind transfers and subsidized housing are received), and how to compare the economic status of households of different sizes and composition.

One alternative way of measuring poverty is simply to ask people to self-assess whether or not they (or the households in which they live) are poor. While economists and poverty analysts have been somewhat reluctant to embrace this type of subjective data, a growing body of work has identified a number of advantages to using subjective measures of welfare (Posel and Rogan 2016). In particular, self-assessed poverty measures may avoid many of the problems associated with money-metric poverty measures. For example, subjective assessments of poverty do not depend on a pre-determined, expert-derived poverty threshold and they do not require assumptions about how to adjust resources for household size economies in consumption and for the different needs of adults and children (Ravallion and Lokshin 2001). Furthermore, there is also "no obvious reason" why respondents would not be willing to self-assess their poverty status (Ravallion and Lokshin 2001), while respondents may be reluctant to give information on income (Posel and Rogan 2014). In addition, subjective assessments are likely to capture longer-term measures of economic status (such as a household's asset base and accumulated wealth) than current income and expenditure, and they may also reflect anticipated future shocks and opportunities for household members (Posel and Rogan 2014).

Subjective measures of poverty are also likely to incorporate a far wider range of welfare components than can be measured by narrow money-metric indicators (Ravallion and Lokshin 2001; 2002).

Nonetheless, a number of concerns with subjective data have been raised in both the psychology and economics literatures. First of all, Survey respondents can be expected to interpret subjective questions relative to their personal frame of reference, which will depend on latent aspects of their own knowledge and experience (Ravallion et al. 2016). Although respondents may be willing to self-assess their poverty status, they may not provide an authentic self-report, or their self-assessment may reflect their aspirations rather than the real circumstances of their lives, and these aspirations or perceptions may adapt to local circumstances and opportunities (Posel and Rogan 2014). For example, subjective

assessments may be influenced not only by the household's own economic well-being but also by how this is seen to compare with the economic well-being of other households (Lokshin, Umapathi and Paternostro 2006).

However, most studies that analyse subjective poverty do not propose that subjective measures replace money-metric poverty measures.

In fact, several studies have compared subjective and money-metric poverty measures, testing whether there are systematic differences across a range of characteristics, and what these differences could suggest about the measurement of money-metric poverty (Ravallion and Lokshin 2002; Carletto and Zezza 2006; Lokshin, Umapathi and Paternostro 2006).

The results of these studies typically find a partial correlation between the measures. Ravallion and Lokshin (2002) explain these differences with the "wrong weights" that are used when calibrating measures of expenditure or income that adjust for household size, household composition and cost of living differences and they suggest that differences between money-metric and subjective poverty rates may reflect "low dimensionality" in the measurement of objective economic welfare. In assessing their economic status, for example, respondents may take into consideration not only their current expenditure or income, but also their past income, future commitments and opportunities, employment status, education and health, and their access to housing and basic services. These other dimensions incorporate the combination of capabilities and key functionings that are likely to be important in generating an economic livelihood. In particular, education, employment, assets and health have been found consistently to influence the self-assessment of poverty (Ravallion and Lokshin 2002; Carletto and Zezza 2006).

Further explanation for the different results is that measures based on monetary income and consumption do not take into account subsistence activities (Deaton 1997). These activities, aimed at self-producing food used to satisfy the needs of the household, are particularly significative in developing countries, where subsistence activities have a considerable weight in the households' income

Finally, a source of error in the measure of self-perceived living standards is asking respondents for a relative assessment of their welfare. In this way, it is assumed that respondents have relevant information about the welfare of other households and can correctly set themselves in comparison to other households living standards (Pradhan and Ravallion 2000).

Referring to levels of nutrition change Deaton (1997) notes that household surveys nearly always collect data on household consumption (or purchases), not on individual consumption, and so cannot give us direct information about who gets what. In the development literature, much attention has focussed on gender issues, particularly although not exclusively among children, and on the question of whether girls are treated as well as boys. Subjective individual measures will of course overcome this limit.

1.5. Measuring Food Security

Measuring food security is a complex task for a variety of reasons. As illustrated in Section two, the definition of the concept is not univocal. Consequently, there are many operational definitions that refer to different theoretical approaches.

Food security is a concept that has evolved considerably over time and there is a huge literature on household food security indicators. The proliferation of indicators that emerged over recent years, however, leads to perhaps unnecessary complications. Already in 1999, a review of the available indicators listed up to 200 different definitions and 450 indicators (Hoddinott 1999).

In this Section, I show some of the main and more established approach for the measure of food insecurity.

1.5.1 Prevalence of Undernourishment (PoU)

FAO has produced estimates of the Prevalence of Undernourishment (PoU) and of the Number of Undernourished (NoU) since 1974, when a first global and regional assessment was published with the fifth World Food Survey.

The 1996 World Food Summit, hosted by FAO, set the target set at of reducing by one half by the year 2015, the number of undernourished in the world, and established the NoU as the indictor used to monitor progress towards this target. Since 1999, country level estimates of the PoU and NoU, in addition to regional and global aggregates, are published in the State of Food Insecurity report (FAO, IFAD and WFP 2015).

The Prevalence of Undernourishment (PoU*)* is defined as the probability that a randomly selected individual from the reference population is found to consume less than his/her calorie requirement for an active and healthy life (Wanner et al 2014).

The PoU indicator, i.e. the share of population not meeting their minimum dietary energy requirements, is measured by using: (i) data on dietary energy supply retrieved from Food Balance Sheets (FBS); (ii) a log-normal distribution; (iii) a threshold of minimum energy requirements based on the demographic structure (by age and sex class) of the population, according to the following equation:

$$PoU = \int_0^{MDER} f_x(u)\, du \qquad [1.1]$$

The probability density function used to infer the habitual levels of dietary energy consumption in a population, *f(x)*, refers to a typical level of daily energy consumption during a year, where MDER is the minimum dietary energy requirement.

To implement this methodology, it is necessary to:

(i) choose a functional form for the distribution of food consumption *f(x)*;

(ii) identify values for the three parameters: mean food consumption, its variability (CV) and its asymmetry;

(iii) compute the MDER threshold: MDER is calculated as a weighted average of energy requirements according to sex and age class, and is updated each year from UN population ratio data.

As such, *f(x)* does not reflect the possible implications of insufficient food consumption levels that may prevail over shorter periods.

1.5.2. Measures based on Household Budget Surveys and Household Income Expenditure Surveys

Food availability does not ensure access to food, as problems related to the distribution of income at national level can seriously affect the access to food and the food security at household level (Alexandri 2015). As such, food security is ultimately considered as a household or individual issue.

With the aim of measuring and monitoring progress towards Millennium Development Goals targets on halving the number and the proportion of hungry people by the year 2015, several methodological proposals have been made in the last ten years (Sinbrian 2008). Smith (2003) and Smith et al. (2006) proposed a methodology to estimate food deficiency levels through households' food acquisitions. This approach uses nationally representative Household Budget and Expenditure Surveys in order to derive measures of food deprivation as these surveys are a source of multiple, policy- relevant and valid measures, such as (1) household food energy deficiency; (2) dietary diversity, a measure of diet quality; and (3) the percent of expenditures on food, a measure of vulnerability to food deprivation (Smith 2003). The "household food energy deficiency" is calculated as dummy variable (0, 1) indicating whether a household falls below a certain energy intake requirement: a household's energy availability is compared with a requirement that is based on its age and sex composition. Summarized for a population group, the household data give the percent of households or individuals who are energy-deficient. It can be calculated also the depth of energy deficiency (by how many kilocalories a household falls below its requirements), that gives a measure of the severity of food insecurity. It should be emphasized that the food data collected in household expenditure surveys reflect the quantity of food "acquired" by a household rather than that "consumed" by its members, and that no information on the distribution of food among the members of the households cannot be computed.

In 2007, Smith and Subandoro proposed a non-parametric approach for estimating the percentage of people that are food energy deficient using household survey data.

Measures based on household Surveys present many advantages: first, food consumption is directly measured and fewer assumptions about missing data on agricultural production, trade, post-harvest losses and non-food uses are required; second, the reliance on micro data allows for generating disaggregated estimates according to sub-national levels or social groups; third, the high level of disaggregation of food items in many of the surveys allows for a better reflection of what is actually consumed, thus making the conversion of food quantities into calories more precise; fourth, as opposed to the FAO index, the method does not require distributional assumptions related to food access across households and income levels (and this is the reason why these methods are often referred to as non-parametric); fifth, while FAO uses data on the population structure at the country level to derive the cut-off point

related to the population minimum dietary energy requirements, the survey-based approach takes the actual demographic structure of households into account.

However, methods based on household food consumption surveys still present methodological and empirical problems (De Haen *et al.* 2011). Household survey data cannot measure correct levels of dietary food energy consumption: for instance, estimates often neglect food consumption acquired outside the household, whether in the private (from street vendors, restaurants…) or public sectors (as food consumption in the public sector, e.g. in hospitals, schools, prisons…) because the surveys do not always collect these data as their primary purpose is not to measure food security.

Furthermore, issues of cross-country or time comparability of the estimates may arise. Cafiero (2011) noted that the standards for calculating human energy requirements are designed to be applied to groups of individuals of the same sex and age and not to single individuals. As such, the combination of the potentially large imprecision and possibly systemic bias in measuring single household level dietary energy consumption levels, and of the improper usage of the energy requirement norms in classifying households seem to point that the head-count method is far from being a robust method to measure the proportion of households that are actually undernourished in a population.

1.5.3. Anthropometric indicators

Anthropometric measurements are commonly used for the diagnosis of under nutrition throughout the life cycle, i.e. for infants, children, adolescents, adults, pregnant and lactating women, and elderly (Shetty 2003). They measure the outcomes of food and nutritional security at the individual level, while the previous two methods are based on inputs.

Nutritional anthropometry has been defined as "measurements of the variations of the physical dimensions and the gross composition of the human body at different age levels and degrees of nutrition" (Jelliffe, 1966 as cited in Shetty, 2003). Anthropometric measurements are of two types, growth and body composition, and have been widely used for the assessment of the nutritional status of both children and adults. The most common ones focus on the relationship between height and weight of individuals. In particular, the greatest scientific consensus and common application relates to anthropometric measures on body development of children aged 0-5, because for other groups the debate on the cross-country comparability

of reference standards is not settled (De Haen et al. 2011*)*. Recently, WHO proposed a new Nutrition Landscape Information System (NLIS), developed as part of the Landscape Analysis on Readiness to Accelerate Action in Nutrition (WHO 2010).

While many individual sources of publicly-available data exist, it is a challenge to identify, collect and organize those data systematically from various sources

1.5.4. Self-reported food security assessments

Starting from the 1960s, policy makers have been increasingly looking for measurement techniques for food insecurity and hunger that are simple to use and easy to analyse (Kennedy 2003). In particular, they focused their attention to subjective indicators of perceptions of hunger and food insecurity. The major experiences in the field of qualitative measures of food insecurity relate to the work of the United States Department of Agriculture on the "Household Food Security Survey Module (HFSSM)" (Hamilton et al. 1997); the "Household Food Insecurity Access Scale- HFIAS" (Coates et al. 2007) and the "Household Hunger Scale" (Deitchler et al. 2011) developed to assess food insecurity in different cultural contexts; and, recently, the hunger module inserted in the Gallup World Poll indicators, which were recently employed by Heady (2013) as an alternative indicator of the impact of food crises on the poor.

Within the United States, self-reported indicators are able to provide insights into the way in which households experience food insecurity, which is defined mostly on the basis of the access and stability dimensions (Kennedy 2003).

At the beginning of the Nineties, the research conducted by Radimer, Olsen and Campbell (1990) and Radimer et al. (1992) in the USA revealed that the experience of food insecurity is characterized initially by uncertainty and anxiety regarding food access, followed by changes in the quality of the diet as the situation worsens, such as a less balanced, more monotonous diet. With increasing severity, the quantity of food consumed decreases as portion sizes are reduced or meals are skipped (Radimer, Olson and Campbell 1990; Radimer et al. 1992; Radimer 2002).

Based on the above-mentioned study, the U.S. Household Food Security Survey Module (US HFSSM) has been applied annually in the United States since 1995 to monitor the food security situation (Hamilton et al. 1997). It represented a significant change in approach to

food insecurity measurement, compared to traditional ways of assessing it indirectly, either through the determinants (such as food availability) or the consequences (such as anthropometric failures and other signs of malnutrition). An essential criterion was a measure that was qualitative but not subjective (for further examination of the characteristics of subjective indicators see Section 1.4 and Appendix I; for further insight see Brulè and Maggino 2017). Of the approximately 30 food insecurity and hunger indicator questions originally tested, the final "core module" questionnaire contained a total of 18 questions for households with children and 10 questions for households without children (Kennedy 2003), as shown in Appendix II.

As unfold in Section 4.4, Radimer (1992) stated that it was possible to measure food insecurity and hunger “directly” asking people, also following the approached developed by Sen (1983). The term “direct” measure has been abandoned because too broad. The most appropriate descriptor for the scales in analysis is “experiential”, as is to say “derived from peoples’ experiences” (Coates 2004).

The items that compose the US HFSSM, as well as the FIES module, ask people directly about having to compromise the quality and quantity of the food they eat due to limited money or other resources to obtain food. Each item refers to a different situation and is associated with a level of severity according to the theoretical construct of food insecurity underlying the scale.

The Household Food Insecurity (Access) Scale (HFIAS) is a survey instrument developed by the Food and Nutrition Technical Assistance (FANTA) to assess whether households have experienced problems with food access during the last 30 days. The instrument consists of nine occurrence questions and nine frequency questions; these questions ask about the changes households made in their diet or food consumption patterns as a result of limited resources to acquire food. This tool measures the level of food insecurity during the past 30 days as self-reported by the household. These measured results are then assigned a categorical designation (food secure or mildly, moderately, or severely food insecure) or given a numerical value (0-27), with higher numbers representing a greater level of food insecurity.

It is worth noticing that, although the underlying approach of the HFSSM and HFIAS is the same, the intended purpose and range of application for each tool is different. Whereas the HFSSM was developed exclusively for application in the US, the HFIAS was developed to provide a universally-applicable tool that would allow for a cross-culturally equivalent

measure of food insecurity in resource-poor areas in a developing country context (Deitchler et al 2010). While in the HFSSM wording of the questions, selection of answers, and reference period have been adapted to such a social and cultural context, the HFIAS was tested in order to allow more comparability in different cultural environment. However, the number of items (questions) in the scale and the number of possible answers (both binary and ordered modalities) make the instrument difficult to apply in different cultural and social framework, and, therefore, the data collected in different geographical area not completely comparable in a wide range of countries (Deitchler et al. 2011).

The Escala Latinoamerican y Cariben (ELCSA) was conceived out of the combined experiences with food insecurity scales in various countries as well as the growing demand for tools to diagnose and monitor hunger and food insecurity. A formal, interactive process of consultation was initiated in 2007 to promote the development of a single instrument capable of measuring household food insecurity in diverse national and sub-national contexts (Pérez-Escamilla et al. 2004).

Other issues in creating a food security scale are nearly as important as the conceptual themes and items themselves. These include: 1) the recall period and the response options, 2) methods for scoring responses, and 3) the performance of the items as a group (Coates 2004).

It should be noted that the reference period differs for each scale: 12 months for the US HFSSM, 3 months for the ELCSA, and 30 days for the Brazilian Food Insecurity Scale. Response categories vary somewhat as well; the US HFSSM has three additional affirmative response categories to characterize the frequency of occurrence, whereas the response categories for the ELCSA and the Brazilian scale are dichotomous (yes/no) answers (FAO 2013).

According to Kennedy (2003) qualitative indicators provide direct measures of food insecurity, as they incorporate the perceptions of food insecurity and hunger by the people most affected, and are quick to administer and well-understood by policy-makers. Moreover, validation research shows that they are highly correlated with income and consumption expenditure, as well as dietary energy intake (Kennedy 2003).

A critical issue, however, relates to the validation of those measures for cross-country comparisons: hunger is a deeply cultural phenomenon and perceptions may vary according to the cultural, economic, social and educational background of reference (Deitchler et al. 2011; Headey 2011).

Other disadvantages relate to the comparability over time of trends in food insecurity based on these measures, as the underlying concept they capture may change, and on the one of *adaptive preferences* in respondents' perception about their hunger levels (Sen 1985, 2002; Nussbaum 2000), due, for instance, to their income and education status.

Finally, Barrett (2010) pointed out two important issues related to perceptions-based indicators of food insecurity. First, because most food insecurity is seasonal or aperiodic – correlated with episodes of temporary unemployment, ill-health or other adverse events – perceptions-based survey measures consistently find food insecurity rates several times higher than related hunger or insufficient-intake measures (National Research Council 2005). Second, qualitative assessments may not suffice to capture the utilization aspect of food insecurity, such as the one associated with lack of micronutrient in the diet.

Qualitative methods could be extremely rewarding in terms of providing complementary and easy to monitor data for national and global food security monitoring.

1.6. Food Insecurity Experienced Scale

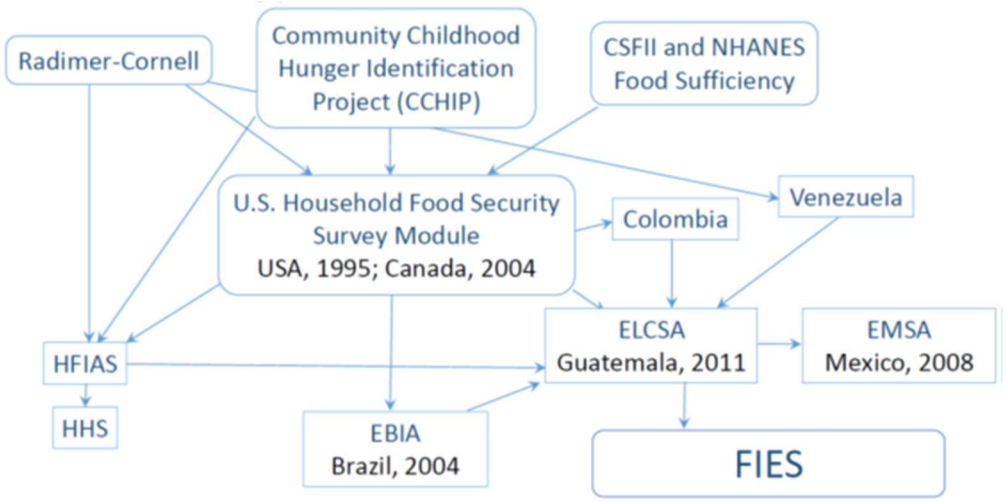
Because of renewed research needs in the knowledge of food insecurity at micro level, in 2013, FAO launched the Voices of the Hungry (VOH) project, with the aim to provide policy relevant and timely information about individual food insecurity, in different area across the globe (FAO 2016). The VOH project has developed an experience-based food insecurity scale module called the Food Insecurity Experience scale (FIES), that is used as a common metric for measuring food insecurity at several levels of severity, across different geographic areas and cultures.

The FIES is an experience-based metric of severity of food insecurity that relies on people's direct responses to a series of questions regarding their access to adequate food.

The FIES is the global version of an experience-based food insecurity scale that originated from a regional initiative in Latin America and the Caribbean and it is based on a short form of the Latin American and Caribbean Food Security Scale (*Escala Latinoamericana y Caribeña de Seguridad Alimentaria*, or ELCSA), with roots in the US HFSSM, as well as the Household Food Insecurity Access Scale (HFIAS) developed by the U.S. Agency for International Development . In the next Chapter, in Section 2.2, a more extensive examination

of the development of experience- based food insecurity scale for individuals and household is presented.

Figure 1.1. FIES genealogy



Source: Cafiero (2017)

FAO started using this method of measurement to provide valid and reliable population estimates of food insecurity in the different countries of the world.

The FIES scale is based on a short questionnaire (eight questions) that can be easily included in all surveys of households or individuals, therefore it is a quick and cheap tool that allows timely intervention.

The specific questions of interest are phrased as follows:

Now I would like to ask you some questions about your food consumption in the last 12 months. During the last 12 MONTHS, was there a time when:

- Q1. You were worried you would run out of food because of a lack of money or other resources?
- Q2. You were unable to eat healthy and nutritious food because of a lack of money or other resources?
- Q3. You ate only a few kinds of foods because of a lack of money or other resources?
- Q4. You had to skip a meal because there was not enough money or other resources to get food?
- Q5. You ate less than you thought you should because of a lack of money or other resources?
- Q6. Your household ran out of food because of a lack of money or other resources?
- Q7. You were hungry but did not eat because there was not enough money or other resources for food?
- Q8. You went without eating for a whole day because of a lack of money or other resources?

A simple yes or no answer is recorded, also in order to avoid as much as possible language differences.

The strengths include a focus on access rather than availability, a recall period (12 months) capable of capturing seasonality and other short-run food price movements, and large cross-country comparability.

The most important debate regarding experience-based food insecurity scales during the history of their development addressed the feasibility of creating an internationally valid instrument using a single scale for the many diverse cultural and socioeconomic contexts in the world. In the case of FIES, there is considerable evidence pointing to the validity and reliability of experienced-based food insecurity scales in diverse contexts, but nevertheless research to refine and improve them is ongoing (Cafiero et al. 2014). In Chapter three, an extensive and original analysis of validity of the FIES is presented.

Starting in 2014, the FIES has been incorporated into the Gallup World Poll questionnaire and the data used to derive estimates of the prevalence of food insecurity at different levels of severity. Surveys are being conducted based on nationally representative samples of 1000 adult individuals, using a three-stage sampling framework, in each of the four pilot countries. The specifications of the survey are described more in details in Sections 2.4 and 2.5.

The linguistically and culturally adapted FIES questions are directed to adult individuals randomly selected at the 3rd stage who reside in sample households randomly selected in the 2nd stage from primary sampling units, which are in turn either randomly selected or selected based on probabilities proportional to population size (1st stage).

Experience-based food insecurity scales, in addition to contemplating aspects related to deprivations in diet quality and quantity, capture also psychosocial aspects associated with anxiety or uncertainty regarding the ability to procure enough food: food insecurity can affect health and well-being in many ways, with potentially negative consequences for mental and social in addition to physical well-being, even in the absence of measurable negative effects on nutritional status.

In synthesis, the Food Insecurity Experience Scale provides a direct measure of the problems that individuals and households experience in having access to food; provides an assessment of the severity of food insecurity (mild, moderate, or severe). This means that the indicator can also be used in developed countries; it can be used both at household and individual level,

allowing the analysis of inequalities in access to food for several personal characteristics (e.g. men and women); it is based on a short questionnaire (eight questions) that can be easily included in all surveys of households or individuals; it is a quick and cheap tool that allows timely intervention.

Experience-based food insecurity scales like the FIES represent, thus, a simple, timely and less costly method for measuring the access dimension of food insecurity based on data collected at the household or individual level.

Being collected at the individual level, direct measures of experienced food insecurity can be used to potentially identify vulnerable populations before malnutrition becomes manifest. The information collected across the world allow disaggregation at sub-national levels and across different population groups, making it possible to identify more specifically who the food insecure are and their geographic distribution. As FIES is concerned, at sub-national level, a sample of one thousand individual in each country allows for analysis distinguishing only by gender (see Chapter 2). In our study, the analysis of different groups of populations is carried out with regard to world regions, with a sample size large enough to have significant results. However, with larger samples, it would be possible to achieve significative results in relation with different characteristics of the population also at country level. The ease of application, analysis, and interpretation facilitates better communication of results to decision makers, leaders of civil society, and the general public.

It is worth underlining that FIES does not provide specific information on actual food consumption, diet quality and food expenditures like household expenditure surveys and individual food intake surveys.

This innovative method to detect food security has been listed as target 2.1.2 of the UN Sustainable Development Goals and will need that countries provide this information for the global monitoring of the GOAL 2 "Zero hunger". In the above-mentioned resolution 70/1 (see Section 1.1), the UN General Assembly requested that the Goals and targets identified in the 2030 Agenda have to be followed up and reviewed using a set of global indicators. In particular, Goal 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and target 2.1 (By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round) have to be monitored by Indicator 2.1.2: Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience

Scale (FIES). Food Insecurity Experience Scale (FIES) them has become a new global standard to measure food insecurity.

1.7. Conclusions

The original contribution this Chapter has been to place food insecurity self-reported measures, and FIES in particular, among the huge literature on food security in order to capture the theoretical and epistemological background of self-experienced food security measure.

Even if measures of food insecurity at individual and household level existed, a common metric able to measure food insecurity based on personal experience at the global level was not available to be studied and used for policies. Data comparable worldwide were drawn by macroeconomic measures at the national level, and the monitoring of food insecurity was carried out at country level, thus not permitting to analyse the characteristics of food insecure people and to determine the economic and social personal factors related to individual food insecurity. Measures at household or individual level were developed and used at local level, starting from the Nineties in the US, and then in Latin America, but an instrument able to collect the direct experience of individuals across the globe was missing.

In this framework, the Food Insecurity Experience Scale (FIES) presents a notable innovation, and its validation and analysis carried out in this thesis is an original contribution to the research devoted to food security and its economic and social determinants.

FIES is an experience-based scale developed to measure food insecurity at the individual level. It captures in particular the access dimension of food insecurity and it has been built by the Food and Agriculture Organization of the United Nations (FAO) to collect comparable data on individual food insecurity worldwide, asking directly to respondents their experiences, anxieties and perception of food insecurity. The indicator based on the FIES has been included in the set for monitoring the Goal 2 of the SDGs: “Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)”.

Another original contribution lies in the critical and systematic review of the literature on subjective and objective measure, contributing to the clarify the conceptualization of the

differences among quantitative, subjective, and direct measure of a complex phenomenon such as food security, in analogy with a similar – but different – situation as poverty.

Chapter 2.

Experience based food insecurity measures: the FAO Food Insecurity Experience Scale

2.1.Introduction: experiential food insecurity measures

Food security exists ‘‘when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meet their dietary needs and food preferences for an active and healthy life” (FAO 2002). Access to food was recognized as one of the pillars of food security. It is this dimension of food security – food access – that experience-based food insecurity scales are designed to measure in populations, based on data collected at the household and individual level (Ballard et al. 2013).

As presented in Chapter 1, the measure of food insecurity has followed different approaches. Macro-measures, such as the FAO Prevalence of Undernourishment, are focused on the availability of food, in order to monitor national and regional trends in undernutrition, based on estimates on the availability of food at the macro level, but do not identify individual and familial factor, nor the characteristics of the most vulnerable population groups. Anthropometric measures, such as child weight-for-age (measure of underweight) and height-for-age (measure of stunting), provide invaluable information regarding the nutritional status of individuals, but are costly and require a relatively sophisticated level of expertise to collect and analyse the data. Measures based on household data household surveys employ indirect methods to estimate food intake, because acquisition of food products during a reference period is not equivalent to actual consumption of the purchased products during the reference period, and results do not consider food purchased outside the home, nor self-produced goods.

Research on the topic of experienced food insecurity dates back to the Sixties, but it had further boost after the food price crisis in 2008, and more recently after the publishing of the 2030 Agenda of the Sustainable Development Goals. The availability of Gallup World Data at global lever further increased the attention of scholars on the study of individual determinants of food insecurity (Smith et al 2017a, Smith et al. 2017b).

According to Kennedy (2003) qualitative indicators provide direct measures of food insecurity, as they incorporate the perceptions of food insecurity and hunger by the people

most affected, and are quick to administer and well-understood by policy-makers. Moreover, validation research shows that they are highly correlated with income and consumption expenditure, as well as dietary energy intake (Kennedy 2003).

A critical issue, however, relates to the validation of those measures for cross-country comparisons: hunger is a deeply cultural phenomenon and perceptions may vary according to the cultural, economic, social and educational background of reference (Deitchler et al. 2011; Headey 2011).

Other possible critical aspects of these measures that are indicated by some scholars refer to the comparability over time because the underlying concept of food insecurity could change overtime, being affected by the adaptive preferences in the perception of respondents about their levels of hunger (Sen 1985, 2002; Nussbaum 2000), due, for instance, to their income and education status. Moreover, qualitative assessments may not suffice to capture the utilization aspect of food insecurity, such as the one associated with lack of micronutrient in the diet (Barrett 2010).

Qualitative methods could be extremely rewarding in terms of providing complementary and easy to monitor data for national and global food security monitoring.

This study will extend our understanding of social and personal vulnerability to food insecurity. The study analyses an innovative measure of food insecurity based on self-stated information: the FAO's Food Insecurity Experience Scale (FIES), will be used to investigate factors related to the level and severity of food insecurity within and across the 147 Countries surveyed in the Gallup World Pool starting from 2014.

FIES is a measure of access to food at the level of individuals or households. It measures severity of food insecurity based on people's responses to questions about constraints on their ability to obtain adequate food. The FIES is based on construct of the experience of food insecurity composed of three domains: uncertainty/anxiety, changes in food quality, and changes in food quantity (Ballard et al. 2014).

The use of self-reported indicators to measure food insecurity in a comparable way in different Countries has been widely debated, considering that the individual perception of hunger can differ for different individuals, due to their history of nutrition, because of their different psychometric characteristics. However, the scientific literature is very rich on

subjective measures of poverty, and there is a wide range of self-reported food security instruments.

The strong relationship between food insecurity and income in confirmed by many empirical studies (Rose 1999), but the correspondence between poverty-level incomes and hunger is not complete. For example, in 1995 in the US 13.1% of those in poverty experienced hunger and half of those experiencing hunger had incomes above the poverty level (Current Population Study). Panel data indicate that those who are often food insufficient are much more likely than food-sufficient households to have experienced recent events that stress household budgets, such as losing a job, gaining a household member or losing food stamps (Rose 1999). Therefore, the two phenomena are linked, but they are not the same (see Chapter 4).

Theoretically, the relationship between poverty and food insecurity, is conceptualised in the capabilities approach: on the one hand, poverty, understood not only as lack of entitlements to food (Sen 1981), but also of basic health and care facilities, education, access to water and sanitation, or voice in face of governments, is a critical determinant of food insecurity (Drèze and Sen 1989; Burchi and De Muro 2012; UNDP 2012). At the same time, food insecurity causes capability poverty in various ways, which can last for generations (UNDP 2012), weakening the health of children and mothers. Therefore, food security fosters the reduction of poverty by decreasing mortality and morbidity, enhancing education and people's capability of employment.

In this Chapter, however, the comparison of the two phenomena is more related to the methodology of measurement, being both poverty and food security two complex events, measurable preferably by multidimensional indicators.

Food security is, according to the World Food Summit definition (see Section 1.3), a multidimensional construct including the availability, access, utilisation, and stability of food (FAO 1996). The WFS recognition of food security as a multidimensional phenomenon represented a significant theoretical advancement, as it broadened the scope of food security analysis and policies from the previous focus on food availability. At the same time, it also brought about additional analytical and methodological issues. These are particularly marked in the field of measurement. Since the dimensions are also complex and multifaceted phenomena, one has to identify which among the possible (and available) indicators are better suited to capture the concept to be measured in the context of reference. These indicators can

be either qualitative (i.e. self-reported food insecurity) or quantitative (i.e. number of meals in a day).

Monitoring may lead to misleading results that can in turn affect the way in which policies are formulated. For instance, if the focus of the metrics is exclusively on patterns of caloric consumption, the results of the evaluative exercise may point to an apparent status of stability in food security outcomes. However, it may be the case that, in order to preserve the caloric content of the diet, people may switch to cheaper calories (such as in the case of Giffen goods), or adopt other behaviours that may lead to adverse consequences in terms of other dimensions of food security, such as utilisation or stability of access (Barrett 2002; Maxwell et al. 2008). In order to capture the behavioural dynamics of food security, the joint adoption of qualitative and quantitative research methods seems promising (e.g. Hossain & Green 2011). These methods could also capture the consequences on subjective well-being of distress due to food insecurity (Kennedy 2003; Wunderlich & Norwood 2006). For this reason, many authors argued the need for integrating food security information systems with some reliable and cross-validated measures of the subjective aspects linked to the feeling of food insecurity (i.e. Kennedy 2003; Deichtler et al. 2011; Headey 2011)

The interest in the comparison of subjective and objective measures is still very high in many branches of science (Gelman and Hennig 2017). As underlined by many scholars, however, a more fruitful way of approaching the issue is "to follow the path of relatedness rather than opposition" (Brulè and Maggino 2017).

In principle, food security is an intrinsically individual concept, as it points to the dietary requirements for maintaining a healthy and active life. Aggregation – both at national and household levels - suppresses variability in food security outcomes, as resources are not distributed equally between and within socio-economic groups in a country, nor in the household, as the distribution of food and care may be highly inequitable across different household members (Pitt and Rosenzweig 1985; Haddad and Kanbur 1990). However, until the early 1980s, food security has been mainly conceptualised and measured at the national level, and only after Sen's contribution on food entitlements, at the household level (Sen 1981).

A common metric that could provide information on individual food insecurity at the global level has so far been lacking. The Food Insecurity Experience Scale (FIES) is the first survey protocol to measure people's direct experiences of food insecurity at the individual level on a

global scale, thus permitting to produce annual comparable estimates of food insecurity around the world.

FIES responds to the challenge issued by Eileen Kennedy (2003): that is, to investigate the development of "a common scale…" that could provide a "…consistent basis for measuring food insecurity and hunger prevalence at well-defined levels or ranges of severity, across varied cultural contexts and levels of economic development".

Though there is certainly a great deal of variation in both the causes and consequences of food security in different countries, there is, regardless, a core of the phenomenon common to all contexts that can be tapped for measurement purposes (Coates 2004)

Many studies have validated experiential food insecurity scales in the United States, Canada, Mexico, and Latin America over the past few decades (Cafiero et al. 2014, Coates, Webb, and Houser 2003; Coates, Wilde, Webb, Rogers, and Houser 2006; Frongillo and Nanama 2006; Nord 2012; Perez-Escamilla et al. 2004).

Experiential measures capture cross-cultural aspects of food insecurity and have proven their validity across global regions (Coates 2013; Perez-Escamilla 2012).

As a micro-level measure, experiential food insecurity measures offer insight into the determinants of food insecurity at the individual level, making it possible to show the characteristics and geographic concentration of the food insecure (Ballard et al. 2013; Nord 2014).

The advantages of collecting data from a survey are many: firstly, food consumption is directly measured at the household level, and fewer assumptions about missing data on agricultural production, trade, post-harvest losses and non-food uses are required; second, the reliance on micro data allows for generating disaggregated estimates according to sub-national levels or social groups; third, while macro data are based on hypothesis on the population structure at the country level, the survey-based approach takes the actual demographic structure of households into account.

However, there may be many features related to the survey methodology that could make data affected by bias. These elements may relate to a series of issues related to the data collection: definitions of the variables, data collection methods, sample design, missing data. Therefore, the methodological issues related to the survey of FIES data are fundamental to evaluate the quality of the measure. The present Chapter will deal with all the operational methodologies

necessary to obtain reliable and robust data: design, implementation and processing of survey data. Of particular interest is the construction of the instrument of measure, that is to say the FIES survey module.

The remainder of this Chapter is thus organized as follows. Section 2 illustrate the long history of the development and evolution of experience—based food insecurity scales. Then, in Section 3, a detailed analysis of the items usually utilized to collect data on food insecurity is presented. In Section 4, the specifications of the FIES Survey Module used for the actual collection of data and the reasons are explained. This leads to the presentation of the Survey in Section 5: the sample methodology, the data collection method, the analysis of FIES items is presented. Section 6 introduces the data in terms of distribution of the principal explaining variables and analyse the missing values. Finally, Section 7 concludes by pointing to strands for further research. In the appendix further statistics are provided.

2.2. Development of FIES

As described in Chapter 1 (Sections 5 and 6), the FIES is the global version of an experience-based food insecurity scale, that originated from the U.S. Household Food Security Survey Module (U.S. HFSSM). This experiential measure of food insecurity captures the Radimer et al. (1990) latent construct of food insecurity (Bickel et al. 2000; Nord 2002).

So, in this Section, the most famous and significant methods of experiential food insecurity measures are presented, then - in the next Section - are shown the common domains of food insecurity experience scale, while the characteristics of FIES are depicted.

In the early 2000s, several Latin American countries began implementing their own experiential food insecurity measures, eventually culminating in a Latin America and Caribbean food security scale called ELCSA (Escala Latinoamericana y Caribena de Seguridad Alimentaria) (FAO 2012a, FAO 2012b; Perez-Escamilla et al. 2007).

After extensive testing, the U.S. HFSSM and ELCSA have proven reliable ‘‘in diverse socio-cultural contexts” (Ballard et al. 2013).

Following this evidence of reliability, FAO built the FIES, using the methodology of the U.S. HFSSM and ELCSA and adjusted the scale to be applied globally. The FAO Voices of the Hungry project (VOH) has developed an experience-based food insecurity scale module called the Food Insecurity Experience scale (FIES). The FIES originated from the initiative in

Latin America and the Caribbean and it is based on a short form of the Latin American and Caribbean Food Security Scale (Escala Latinoamericana y Caribeña de Seguridad Alimentaria, or ELCSA), with roots in the US HFSSM, as well as the Household Food Insecurity Access Scale (HFIAS) developed by the U.S. Agency for International Development (Ballard 2013).

The research conducted by Radimer, Olsen and Campbell (1990) and Radimer et al. (1992) in the USA supported the idea that the experience of insecurity prompts predictable responses that are quantifiable in a way that "food security" itself is not. These behaviours and attitudes relate to insufficient quantity and quality of food, food procured through personally and socially unacceptable means, and feelings of vulnerability to downturns in supply (Kendall, Olson, and Frongillo 1996; Radimer, Olson, and Campbell 1990; Radimer et al. 1992).

The tool used by the USDA to monitor national food security, is the U.S. Core Food Security Module (US CFSM) built on the theoretical groundwork of Radimer and colleagues. The U.S. Core Food Security Module (U.S. CFSM) is a scaled set of 18 items that is designed to capture the full range of severity of the food insecurity problem as it is experienced in the United States. Five different types of experiences and behaviours that distinguish households experiencing different degrees of food insecurity (Hamilton et al. 1997).

The USDA Core Food Security Measure has been inserted since 1995 into the annual Current Population Survey.

The method is based on the idea that the experience of food insecurity (access) causes predictable reactions and responses that can be captured and quantified through a survey and summarized in a scale. Qualitative research with low-income households in the U.S. provided insight that households experience food insecurity due to access limitations in the following ways (Radimer et al. 1990, Radimer et al. 1992; Hamilton 1997):

- Feelings of uncertainty or anxiety over food (situation, resources, or supply);
- Perceptions that food is of insufficient quantity (for adults and children);
- Perceptions that food is of insufficient quality (includes aspects of dietary diversity, nutritional adequacy, preference);
- Reported reductions of food intake (for adults and children);
- Reported consequences of reduced food intake (for adults and children); and
- Feelings of shame for resorting to socially unacceptable means to obtain food resources.

The eighteen-question U.S. Household Food Security Survey Module (US HFSSM) asks respondents to describe behaviours and attitudes that relate to these various aspects, also called 'domains', of the food insecurity experience (Hamilton et al. 1997).

Studies by Tufts and Cornell Universities in Bangladesh and Burkina Faso (Frongillo and Nanama 2006, Coates, Webb, and Houser 2003; Webb, Coates, and Houser 2002, Nord et al 2002), demonstrated that a replicable process similar to the approach used to develop the U.S. Core Food Security Measure (i.e. grounded in people's experience of food insecurity and relying on systematic ethnographic inquiry, item development and testing, cognitive debriefing, and construct validation), resulted in valid food insecurity scales that had predictive capability also in these developing country contexts.

In 2006, the Journal of Nutrition released a supplement that brought together many of the foremost researchers with experience on developing and applying food insecurity scales in widely different parts of the world (http://www.fantaproject.org/publications/hfias.shtml). This seminal publication, which set the stage for a new way of measuring food insecurity internationally, cited three main conceptual developments in food security measurement: "1) a shift from using measures of food availability and utilization to measuring "inadequate access"; 2) a shift from a focus on objective to subjective measures; and 3) a growing emphasis on fundamental measurement as opposed to reliance on distal, proxy measures" (Webb et al. 2006).

The Journal of Nutrition, for the first time, defined food insecurity scales as "experiential" or "experience-based" measures that directly ask people about their experiences or behaviours in relation to food when money or other means to obtain food are limited (Ballard et al. 2013).

The Food and Nutrition Technical Assistance (FANTA) Project - funded by the US Agency for International Development (USAID) - developed the Household Food Insecurity Access Scale (HFIAS), a household food insecurity measurement instrument designed to be used cross-culturally. The HFIAS is an adaptation of the Household Food Security Survey Module (HFSSM), used by the United States Department of Agriculture (USDA) and other United States (US) agencies to measure the access component of food insecurity in the US (Deitchler et al 2010).

The scale is based on a household's experience of problems regarding access to food and represents three aspects or domains of food insecurity found to be universal across cultures (Coates 2004, Coates et al. 2007). The domains represented in this scale are: first, feelings of

uncertainty or anxiety about the household food supplies; secondly, perceptions that household food is of insufficient quality (including variety and food type preference); and finally, insufficient food intake and its physical consequences (Knueppel 2009).

The generic occurrence questions, grouped by domain, are:

First domain: Anxiety and uncertainty about the household food supply:
Q1. Did you worry that your household would not have enough food?
Second domain: Insufficient Quality (includes variety and preferences of the type of food):
Q2. Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?
Q3. Did you or any household member have to eat a limited variety of foods due to a lack of resources?
Q4. Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
Third domain: Insufficient food intake and its physical consequences:
Q5. Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?
Q6. Did you or any household member have to eat fewer meals in a day because there was not enough food?
Q7. Was there ever no food to eat of any kind in your household because of a lack of resources to get food?
Q8. Did you or any household member go to sleep at night hungry because there was not enough food?
Q9. Did you or any household member go a whole day and night without eating anything because there was not enough food?

Each of the questions is asked with a recall period of four weeks (30 days).

The respondent is first asked an occurrence question – that is, whether the condition in the question happened at all in the past four weeks (yes or no). If the respondent answers "yes" to an occurrence question, a frequency-of-occurrence question is asked to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often (more than ten times) in the past four weeks.

HFIAS was developed to provide a universally-applicable tool that would allow for a cross-culturally equivalent measure of food insecurity in resource-poor areas in a developing country context. Due to these differences in intended scope, the HFIAS was made to be

distinct from the HFSSM in several ways, including the number of items comprising the scale and the wording for these items, the recall period used, and the inclusion of frequency questions in the HFIAS to account for how often a condition was experienced (never, rarely, sometimes or often) in the scale score (Deitchler et al 2010).

2.3.Food insecurity items analysis

The measurement scale depicted above present many similarities: even if they have been developed for different cultures, the three domains of food insecurity identified by Coates for the FANTA project– with particular regard to access to food - appear to be universal across different countries and cultures (Coates et al. 2006). In her 2006 paper, Jennifer Coates examines 22 different scales, finding out commonalities in the experience and expression of food insecurity across cultures. The paper recommended that questions related to these domains be used as the basis of future food insecurity (access) scale measures (Coates, 2006). In order to thoroughly assess the relevance of particular themes and items, the sample of 21 applications is augmented with additional insights from ethnographic literature.

2.3.1 Worry about getting enough food

The theme about being "*Worry about getting enough food" corresponds* to what Radimer et al. (1990; 1992) described as the psychological aspect of individual hunger and food insecurity.

In the sample of instrument taken into account by Coates (2004), eight of the twenty-two food insecurity measurement scales contained questions about food-related anxiety generally phrased as either how often the respondent "worries about food running out", "worries that the food won't last" or fears that they "don't know where it will come from", but only two sought to assess the *severity* of the anxiety through questions pertaining to 1) the number of worrying episodes (e.g. did you worry more than once in the last month?"), 2) the length of time before the predicted food problem that the worrying began (e.g. do you worry you will lack food for next week? Next month?) and 3) the frequency of stress consequences such as insomnia.

In five of the eight studies, the "food worries" questions were affirmed more often than any other behaviour, while in two of the remaining studies they were the second most prevalent. Only in the Haiti study did "worries about food" come fourth, after questions about reducing a

staple food (beans) due to hardship. In every instance the prevalence of food worries was high (even in fourth place, the question in Haiti elicited an 88.2% rate of response), and for this reason some doubt arises on the possibility that these questions could succeed on their own at distinguishing the food insecure from the food secure in countries where food stress is the norm.

Scale items assessing worry and anxiety over future food supply are central to the concept that experiential food security scales seek to measure; these are the questions that most closely approximate perceived vulnerability, or, food insecurity itself. Exposure to risk coupled with uncertainty about the future and the ability to manage it is likely to prompt the types of behaviours captured through other questions in the scale. In other words, whether or not any adversity is actually experienced, merely the fear that supplies will be disrupted can provoke food intake reductions and a savings response (Barrett 2002).

This comparison of anxiety-related items across several different scales suggests that worrying about food is quite common in different cultures. As such, a universal "worry" question should be possible, though it may not do an adequate job on its own of distinguishing between the mildly and severely insecure. This type of question may also be useful in combination with other items representing the severity of the anxiety and its consequences.

2.3.2 Food was inadequate in quality or quantity

The definition of food insecurity has rightfully evolved beyond caloric sufficiency to include dietary quality since a diet rich in a variety of macro and micronutrients is essential for good health.

Most of the scales analysed by Coates (2004) ask either about households or individuals eating less food or lower quality food than they would like or than they felt was healthy or nutritious. Items pertaining to quantity were typically phrased using the wording "enough" food or "eating until satisfied". Items on quality had more variation, and were worded as "less preferred foods", "less variety", "relying on a limited number of foods", "eating the same foods day after day", eating "balanced meals" or eating "properly" or "as I should".

Items regarding quantity of food appeared to be similar across the sample, while not every scale adopted the same generic 'quality' items. In Bangladesh, for example, the prototype questionnaire asked about the consumption of specific luxury foods that were not eaten by the

more insecure households (e.g. “How often in the past 12 months did your family eat big fish?”) or less-preferred foods that were never or rarely consumed by the food secure (“How often did you have to eat wheat when you preferred rice?”). Similarly, in Burkina Faso the ‘quality’ theme was assessed using questions about the consumption of foods out of reach of the most insecure, including meat, milk and fish (Frongillo and Nanama 2006).

Finally, some of the items summarized under the theme “perceptions of inadequate quantity and quality” could be grouped a number of different ways. In several of these cases, identifying specific ‘less desired’, or inferior foods, was complicated. For example, not only diets in Bangladesh are quite varied, almost every menu item or variant that was considered seemed to be a desired food by someone, somewhere else.

Communicating ideas of nutritional “balance,” like the question about “eating balanced meals” in the U.S. CFSM, can be very challenging in the context of widespread energy deficiency or lack of nutrition education.

Directly translating the U.S. CFSM question relating to “balanced meals” has also prompted much confusion when applied to different languages and cultures. Derrickson et al (2002) demonstrated through cognitive debriefing that the word “balance” was construed in a vague way by about half the Hawaiians in the sample as meaning “a few food groups”. The other fifty percent thought it either meant something other than a variety of food groups or did not understand it at all.

Harrison and colleagues, in their (2003) study of the interpretation of the U.S. CFSM by Hispanics living in the United States, discovered that only the focus group participants from Puerto Rico interpreted the item to mean “nutritious food or meals”. In fact, some members of the focus groups interpreted the “balanced meal” item quite literally to mean how well the food was distributed across the plate to prevent spillage. A variety of suggestions have been proffered to improve the comprehension of the question, including substituting the word “healthy” for “balanced” (Studdert, Frongillo, and Valois 2001).

Based on the questions reviewed from the different scales, issues of not eating the *types* of foods desired is relevant across cultures even where the first priority is obtaining *enough* food. This seems to be one thematic area where the underlying concept of “less preferred” or “distress” food is common to all, but the actual foods that distinguish the food secure from the insecure have to be identified for each separate context (since asking generally about whether the respondent ate a “less preferred food” may not be readily understood).

2.3.3 Reduced food intake, or consequences of reduced food intake

Every experiential food insecurity scale examined in Coates paper contained questions pertaining to either the "household" or "the adults" or the individual respondent reducing their food intake, and many of the questions asked explicitly whether those reductions happened in order to protect the food consumption of the children.

Four different types of items are common to these twenty scales, each representing a different level of severity of the same phenomenon. They relate to: 1) eating less in a meal or cutting the size of the meal, 2) reducing the number of meals consumed in a day, 3) going an entire day or days without eating anything, 4) "complained of hunger", "went to bed hungry", or "felt hungry but didn't eat", and 5) lost weight.

In the CCHIP measure, the U.S. CFSM and the experiential food insecurity scale applied in India, two of these levels are combined into one question, "Do you or adult members of your household ever cut the size of meals or skip meals because there is not enough money for food?" One question in the Coping Strategies Index from Western Kenya and one candidate item for the Bangladesh food insecurity scale asked about feeding working members of the household at the expense of non-working members.

Underlying the use of questions pertaining to "adults reducing food intake" in the U.S. CFSM and elsewhere is the assumption that, under budget pressure, adults will sacrifice in order to protect the food consumption of their children. In U.S. households where there are no children, the presence of adult hunger is the most severe manifestation of a hypothesized 'food security continuum'. However, the results of this item comparison and accompanying ethnographic insights in a variety of countries suggest that adults in the household are not necessarily a cohesive group uniformly making sacrifices on behalf of their children. Certainly, there is no evidence to suggest that mothers are filling themselves while their children go hungry. But, in situations where the next family meal depends on the ability of the income-earner to work, the trade-offs may not be so straightforward. For example, some families in Bangladesh suggested that "the son who pulls the rickshaw", or "those who go outside to work get the most" (Coates, Webb, and Houser 2003; Webb, Coates, and Houser 2002). As cited in Coates 2004, in China, (Wei et al 2002) and Myanmar (Twih and Yhoung-Aree 2002) researchers found that a 'contributions rule' appeared to be more predictive of the intra-household resources allocation than nutritional need.

2.4. FIES Survey Module in the Gallup World Poll

FAO started using this method of measurement to provide valid and reliable population estimates of food insecurity in the different countries of the world and implemented the Food Insecurity Experience Scale. FIES is derived from two of these widely-used experience-based food security scales: the US Household Food Security Survey Module and the Latin American and Caribbean Food Security Scale (Spanish acronym ELCSA), as described in Ballard (2013).

FIES has been simplified in order to make the scale comparable at international level. In particular, information has been collected at individual level rather than at household level, the number of item responses have been reduced to eight, response categories are only "Yes" or "No", rather than ordinal variables. The simple yes or no answer is recorded, also in order to avoid as much as possible language differences.

The questions (items) that compose the FIES module ask respondents whether anytime during a certain reference period they have worried about their ability to obtain enough food, their household has run out of food, or if they have been forced to compromise the quality or quantity of the food they ate due to limited availability of money or other resources to obtain food. (Ballard et al. 2013). The reference period is of 12 months to ensure comparability of surveys conducted in different months (ibidem).

The FIES questions self-reported behaviours and experiences related to food, capturing difficulties in accessing food. Each item refers to a different situation and is associated with a level of severity according to the theoretical construct of food insecurity underlying the scale. The characteristics of the scale (limited number of questions, binary responses, long period of reference) maximize the comparability across countries.

The specific questions of interest are phrased as follows:

Now I would like to ask you some questions about your food consumption in the last 12 months. During the last 12 MONTHS, was there a time when:

Q.1. You were worried you would run out of food because of a lack of money or other resources?
Q.2. You were unable to eat healthy and nutritious food because of a lack of money or other resources?
Q.3. You ate only a few kinds of foods because of a lack of money or other resources?
Q.4. You had to skip a meal because there was not enough money or other resources to get food?
Q.5. You ate less than you thought you should because of a lack of money or other resources?
Q.6. Your household ran out of food because of a lack of money or other resources?
Q.7. You were hungry but did not eat because there was not enough money or other resources for food?
Q.8. You went without eating for a whole day because of a lack of money or other resources?

FIES questions have been linguistically and culturally adapted, and are directed to adult individuals randomly selected. The strengths of this method include a focus on access rather than availability, a recall period (12 months) capable of capturing seasonality and other short-run food price movements, and large cross-country comparability.

Experience-based food insecurity scales, in addition to contemplating aspects related to deprivations in diet quality and quantity, capture also psychosocial aspects associated with anxiety or uncertainty regarding the ability to procure enough food: food insecurity can affect health and well-being in many ways, with potentially negative consequences for mental and social in addition to physical well-being, even in the absence of measurable negative effects on nutritional status.

2.4.1 Analysis of FIES items

Q1: Worry about food (You were worried you would run out of food because of a lack of money or other resources?)

This question asks the respondent to report their personal experience with uncertainty and anxiety about acquiring food during the previous 12 months.

Q2: Healthy food (You were unable to eat healthy and nutritious food because of a lack of money or other resources?)

This question asks about quality of food. The respondent should state if he/she has not able to eat healthy and nutritious food because of lack of money or other resources to get food of good quality.

Q3 Few kinds of foods (You ate only a few kinds of foods because of a lack of money or other resources)

This question asks about dietary choices related to variety – i.e., whether the household had to eat an undesired monotonous diet (little diversity in the different types of foods consumed). The interviewer should read the description of what a monotonous diet might be.

Q4. Eat fewer meals in a day (You had to skip a meal because there was not enough money or other resources to get food?)

This question is about quantity of food eaten, because of lack of income. It asks whether, due to lack of food, the respondent had to eat fewer meals than the number typically eaten in the food secure households in their area. The respondent has to state if he/she did not eat breakfast, lunch or dinner [or skipped a meal] because there was not enough money or other resources to get food.

Q5: Eat less food (You ate less than you thought you should because of a lack of money or other resources)

This question asks whether the respondent felt that the amount of food (any kind of food, not just the staple food) in any meal during the past four weeks was smaller than he/she felt they needed due to a lack of resources. The respondent should answer according to his or her perception of what constitutes enough food for his/her needs.

Q6: No food of any kind in the household (Your household ran out of food because of a lack of money or other resources?)

This question asks about a situation in which the household has no food to eat of any kind in the home. This describes a situation where food was not available to household members through the households' usual means (e.g., through purchase, from the garden or field, from storage, etc.). The respondent needs to answer on behalf of all household members.

Q7: Feeling hungry (You were hungry but did not eat because there was not enough money or other resources for food?)

This question asks whether the respondent felt hungry because of lack of food due to income or other resources reasons.

Q8: Whole day without eating (You went without eating for a whole day because of a lack of money or other resources?)

This question asks whether the respondent did not eat from the time they awoke in the morning to the time they awoke the next morning due to lack of food.

2.5. Survey methodology and data collection

2.5.1. Gallup World Poll survey methodology

The analyses in this thesis use data from the 2014 wave of the Gallup World Poll (GWP), including FAO's FIES data.

The Gallup World Poll (GWP), created in 2005, is a survey of individuals 15 years of age and older conducted annually in nearly 150 countries, areas or territories. The survey is administered to a representative sample of individuals in each country, area or territory to collect information on people's opinions and experiences (Gallup 2017).

The Gallup World Poll tracks the most important issues worldwide, such as food access, employment, and well-being. Since creating the World Poll in 2005, Gallup has conducted studies in more than 160 countries that include 99% of the world's adult population.

Because the GWP is conducted by a private organization and its collaborators, much of the description of the formal survey characteristics relies on Gallup materials.

Since 2005, the GWP has conducted an annual survey of individuals age 15 years and older in over 147 countries. The GWP collects information on individual's income, educational attainment, opinions, experiences, demographic characteristics.

Data are surveyed in 147 countries all over the world, and they provide the first nationally representative data on the food access dimension of food security at the individual level for a very large number of countries (FAO 2016).

In 2013, the Voices of the Hungry project at FAO conducted linguistic adaptations of the FIES-SM in national languages of Angola, Ethiopia, Malawi and Niger, using a methodology that included consultations with country level specialists and officials and focus group discussions (Gallup 2013; Manyamba 2013; Massaoud and Nicoló 2013, as cited in FAO 2016).

FAO used this information to prepare a document to guide GWP's questionnaire translation procedure. Gallup employs multiple independent professional translators to develop versions of the questionnaire in the major conversational languages and dialects of each country. Translations are checked by independent back-translation to the source language.

This same approach is used by Gallup for translation of the FIES-SM. In a few cases where VoH had contact with local experts fluent in a language, translations were assessed by those

experts and the GWP generally included their suggested improvements in the final questionnaire.

2.5.2 Sampling strategy and data collection method

The GWP samples are intended to be nationally representative of the male and female resident population aged 15 years and older in each country.

The study adopted a three-stage sampling procedure to select the sample (Gallup 2017). The linguistically and culturally adapted FIES questions are directed to adult individuals randomly selected at the 3rd stage who reside in sample households randomly selected in the 2nd stage from primary sampling units, which are in turn either randomly selected or selected based on probabilities proportional to population size (1st stage). Surveys are being conducted on nationally representative samples of 1000 adult individuals, representative of the male and female resident population aged 15 and over (in very large countries such as India and China, sample sizes increase up to 5000 individuals). Therefore, sample sizes of 1,000 are most common, although larger samples are taken for some countries such as India (3,000 individuals) and China (5,000 individuals).

The entire country is included except in exceptional cases where safety is a concern or travel to a remote area is exceedingly difficult.

Telephone interviews are conducted for medium- and high-income countries with at least 80% telephone coverage. In countries where telephone interviewing is employed, Gallup uses a random-digit-dial (RDD) method or a nationally representative list of phone numbers. Telephone methodology is typical in the U.S., Canada, Western Europe, Japan, Australia, etc. Gallup purchases telephone samples from various sample providers located in each region, including Sample Answers and Sample Solutions.

In the developing world, including much of Latin America, the former Soviet Union countries, nearly all of Asia, the Middle East, and Africa, Gallup uses an area frame design for face-to-face interviewing in randomly selected households.

Face-to-face interviews are approximately one hour, while telephone interviews are about 30 minutes.

Face-to-face Survey Design foreseen a first stage of sampling that involves the identification of 100-135 Primary Sampling Units (PSU) that are clusters of households. These clusters are stratified by population size or geographic units.

At the second Stage, random route procedures are used to select sampled households. Unless an outright refusal occurs, interviewers make up to three attempts to survey the sampled household. To increase the probability of contact and completion, attempts are made at different times of the day, and where possible, on different days. If an interviewer cannot obtain an interview at the initial sampled household, he or she uses a simple substitution method.

At the third stage, respondents are randomly selected within the selected households. Interviewers list all eligible household members and their ages or birthdays. The respondent is selected by means of the Kish grid. The interviewer does not inform the person who answers the door of the selection criteria until after the respondent has been identified. In a few Middle East and Asian countries where cultural restrictions dictate gender matching, respondents are randomly selected using the Kish grid from among all eligible adults of the matching gender.

In countries where telephone interviewing is employed, random-digit-dial (RDD) or a nationally representative list of phone numbers is used. In select countries where mobile phone penetration is high, a dual sampling frame is used. Random respondent selection is achieved by using either the latest birthday or Kish grid method. At least three attempts are made to reach a person in each household, spread over different days and times of day.

Interviewers complete extensive training sessions with qualified trainers using Gallup's standardized manual. They are trained to follow the sample selection protocol and rules for conducting interviews. Following data collection, the data are reviewed for quality and consistency.

With some exceptions, all samples are probability based and nationally representative of the resident population aged 15 and older. The coverage area is the entire country including rural areas, and the sampling frame represents the entire civilian, non-institutionalized adult population of the country. Exceptions include areas where the safety of the interviewing staff is threatened and scarcely populated islands in some countries.

Household size and oversamples are accounted for by base sampling weights. Poststratification weights are provided to allow projection of results to the national population.

Where adequate population statistics are available, post-stratification weights are adjusted so that survey sample totals match as close as possible national totals for gender, age, education and socioeconomic status. Gallup weights World Poll samples to correct for unequal selection probability, nonresponse, and double coverage of landline and mobile phone users when using both cell phone and landline frames.

The Food Insecurity Experience Scale Survey Module (FIES-SM) was included as a client module in the GWP for the first time in 2014 as part of the FAO ‘s Voices of the Hungry (VoH) project.

The FIES-SM was designed to measure the prevalence and severity of food insecurity experienced by individuals.

As illustrated in the previous Sections, information about the adequacy of an individual’s access to food is assessed using a series of questions about whether they experienced the behaviours and conditions that indicate food insecurity over the past 12 months.

The FIES-SM is flexible with regard to recall period (“during the previous one month”, “three months”, or “12 months”) and unit of reference (individual, e.g. “you were…” or household, e.g. “you, or others in your household, were…”).

In the version that has been applied globally through the GWP, questions are framed with reference to individuals and have a reference period of 12 months (presented above in Section 2.4). This is because the GWP is conducted in different months in different countries and a shorter recall period might result in lack of comparability across surveyed countries due to the possible interaction of seasonality of food insecurity and season of data collection.

In general, shorter recall periods may be expected to provide more reliable data, as recall errors are reduced. Periods as short as the previous 30 days may be more appropriate, depending on the objectives of the specific survey, especially if the survey can be repeated during the year.

Within the context of the GWP, which is a survey of adult individuals weighted to represent the national populations aged 15 or more,6 the questions in the FIES are - with one exception7 - referenced to the individual respondent. The insertion of one question referring

to a household situation is consistent with an individually framed questionnaire. As the experience of running out of food in the house may be thought of as affecting all of the household members it is also an individual experience.

2.6. Analysis of the Data

2.6.1. Questions and measures

The FIES questions are constructed to have yes or no answers to minimize translation errors. The questionnaire is translated into the major conversational languages of each country. The translation process starts with an English, French, or Spanish version, depending on the region. One of two translation methods may be used. The first method foreseen that two independent translations are completed, and an independent third party, with some knowledge of survey research methods, adjudicates the differences. A professional translator translates the final version back into the source language. In the second method, a translator translates into the target language, and an independent translator back-translates to the source language, and finally an independent third party with knowledge of survey methods reviews and revises the translation as necessary.

2.6.1.1 Dependent variable

The individual's responses to the questions in the FIES-SM determine the food insecurity experienced at the individual level. Provided that the FIES data conform to the Rasch measurement model's (Christensen et al. 2013) assumptions, as shown in the following Section 2.7, an individual's food security status can be determined by summing the number of affirmed responses to the questions (number of behaviours or experiences reported). We obtain our dependent variable: a "FIES score" of the symptoms of food insecurity, ranging from 0 (no symptoms) to 8 (all symptoms). In this way, the dependent variable indicates whether the interviewee stated none, one or more symptoms of food insecurity.

The analysis of reliability and validity of FIES presented in Chapter 3 allow us to conclude that the raw score of a respondent (as said, the number of affirmative responses to the set of items) is a sufficient statistic for, and an ordinal indicator of, the severity of food insecurity he or she has experienced.

Indeed, considering FIES's characteristics, the raw score can be analysed as an ordinal variable, with values from 0 (no symptoms of food insecurity) to 8 (all symptoms of insecurity). Therefore, individuals are classified as experiencing food security if they report a raw score of zero.

A further requirement, in the case of assessments of food insecurity in terms of levels of severity, is to identify a threshold that differentiates between adequacy and deprivation. Raw-score-based classifications are typical of other experiential food security scales, such as the US HFFSM and the ELCSA. Individuals could also be classified by severity of food insecurity: people are considered as experiencing mild food insecurity if they report a raw score of at least one; moderate food insecurity if their reported raw score is greater than the FIES-GSS threshold for moderate food insecurity, but less than the country-specific FIES-GSS threshold for severe food insecurity (typically a raw score of 7); severe food insecurity if they report a raw score greater than the FIES-GSS threshold for severe food insecurity (Nord, 2014).

Being the choice of a threshold an element of "subjectivity" in the analysis, because the estimate of the values at which determine different "levels" of food can be conducted according to many different methodologies, I will rely on the raw-score (that I call FIES score). For some of the descriptive analyses presented in Chapter 4, I utilize FIES as a binary measure of the individual's food security, presenting only the share of individuals who have experienced (within the past 12 months) no symptoms of food insecurity.

2.6.1.2. Independent variables

The primary explanatory variables for the analyses are common food insecurity determinants collected in the GWP that include individual-, household-, and socio-economic characteristics.

Most of the variables are standard covariates in food insecurity analyses (please for further details see Section 4.2.2).

Factors related to food insecurity can be classified in three areas: (i) householder's characteristics; (ii) household characteristics; (iii) factors related to economic status.

Householder's characteristics included sex, age, education level - middle school or less (#9 years of schooling), high school (10–12 years of schooling), college or higher (13 years of schooling or more), marital status.

The household characteristics included the number of children in the household, location (rural, urban)

Factors related to household economic status included household income, categorized into two groups: extreme poverty or not (Kirang et al. 2011).

2.6.2. Empirical analysis of the dataset

In 2014, the GWP interviewed 154,206 individuals living in 149 countries. Individuals with missing values on the food insecurity items were excluded from the analyses, resulting in a sample of 152,206 individuals in 147 countries. Individuals were dropped from the sample because they failed to provide valid information on one or more of the items of the FIES scale, thus eliminating the missing data on the variable of interest.

Through the analysis of the economic and socio-demographic characteristics of the sample we achieve the double objective of analyse the quality of our data, confirming that the distribution of the sample reflects that of the entire population, and give us also the possibility of acquire further knowledge about the phenomena that will be analysed much more in detail in Chapter 4 of the thesis.

The sample present a higher percentage of women, in total and in all the world regions, except in Africa (Table 2.1). This distribution is coherent with the gender distribution from UN population division (2017). Incidentally, it is worth noticing the gender distribution of population resents also of its age distribution, because, in the younger population, males are more present than in the older population.

Table 2.1. Distribution of respondents by gender and World Regions – Year 2014

World Regions	Male	Female	Total
Africa	50.4	49.6	100
America	43.5	56.5	100
Asia	47.9	52.1	100
Europe	43.6	56.4	100
Oceania	40.8	59.2	100
Total	46.7	53.3	100

Source: FIES data

Indeed, the natural sex ratio at birth worldwide is commonly thought to be 107 boys to 100 girls, while the sex ratio for the entire world population is 102 males to 100 females (UNPD 2017). Female life expectancy at birth is higher than for men, and therefore the sex rate decreases at older ages.

As expected, the population in Africa is younger than in other world regions, while in Europe we have the higher percentage of older population among the continents.

Even if the sample is not stratified by age and it is not foreseen any poststratification, the age distribution of the sample is coherent with the age distribution calculated by USPD (2017) for the different World Regions.

Table 2.2. Distribution of respondents by age class and World Regions – Year 2014

	Age class				
World Regions	15-24 years	25-44 years	45-64 years	65 and more	Total
Africa	28.8	46.7	18.9	5.6	100
America	20.2	36.2	28.7	15.0	100
Asia	18.9	42.1	28.6	10.5	100
Europe	11.1	32.5	34.6	21.8	100
Oceania	7.3	19.1	39.2	34.4	100
Total	19.54	39.65	27.72	13.09	100

Source: FIES data

With regard to the distribution of the sample according to the extreme poverty line (fixed at 1.25 dollars per day), the data show a huge percentage of poor people in Africa (40% of the population, the same percentage available on the World Bank, Development Research Group. http://iresearch.worldbank.org/PovcalNet/index.htm).

According to FIES data the percentage of extreme poor population is 10 per cent in America and Asia, while much lower percentage are foreseen in Europe and Oceania.

Even if this indicator is very rough in measuring poverty, it gives anyway a valid indication of the phenomenon globally.

Table 2.3. Distribution of respondents by poverty and World Regions (% of population at 1.25$ a day)

	Poverty		
World Regions	Extremely poor	Not extremely poor	Total
Africa	40.3	59.7	100
America	10.3	89.7	100
Asia	10.8	89.2	100
Europe	1.4	98.6	100
Oceania	0.6	99.4	100
Total	15.9	84.1	100

Source: FIES data

The collection of data on education is very difficult, because of the differences in the educational systems across the globe. Gallup harmonized the education variable considering Elementary (or primary) education for people having completed elementary education or less (up to eight years of basic education), "Secondary" education for those who have completed some secondary education up to three years of tertiary education (nine to 15 years of education), while the "Tertiary" level of education is attributed to those who completed four years of education beyond "high school" and/or received a four-year college degree (16 or more years of education).

According to the data in our sample, in Africa, the percentage of people having achieved a Tertiary degree of education is lowest, and results only the 5 per cent of population, while in Oceania the percentage is 34.6 per cent.

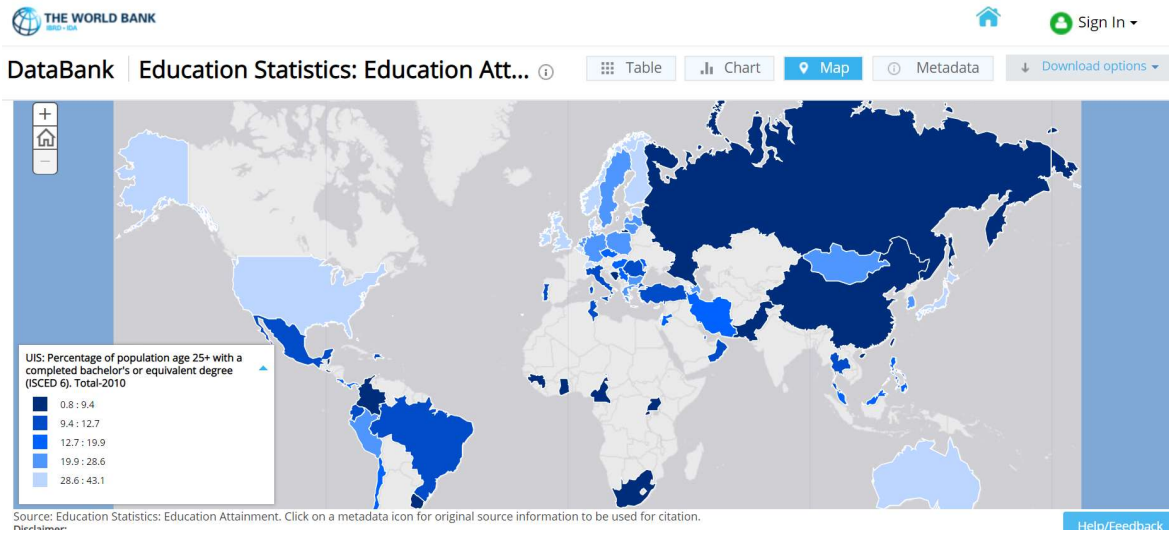
Table 2.4. Distribution of respondents by educational attainment and World Regions (% of population at 1.25$ a day)

	Education			
World Regions	Primary	Secondary	Tertiary	Total
Africa	54.9	40.1	5.0	100
America	34.6	51.5	13.9	100
Asia	34.1	47.8	18.1	100
Europe	15.1	58.9	26.0	100
Oceania	8.0	57.4	34.6	100
Total	34.4	49.3	16.3	100

Source: FIES data

Data on educational attainments across the globe are very difficult to find, but according to the indicators available on the World Bank site, it is possible to verify that our dataset does not present significant bias in terms of distribution by level of education at world Region level (Figure 2.1).

Figure 2.1 Percentage of population 25 or more years old with a completed bachelor's or equivalent degree (ISCED 6) - 2010



Source: World Bank Education Statistics: Education Attainment. Downloaded on the 14th of October 2018 from http://databank.worldbank.org/data/source/education-statistics:-education-attainment

2.6.3. Dealing with missing data

The main problem of partial nonresponse is that estimates of variables in the population may be biased. This problem occurs when nonresponses are not at random, but related to some characteristics of the population itself. If values are missing completely at random, the data sample is still representative of the population. But if the values are missing systematically, analysis may be biased. Missing values in a data set are missing completely at random (MCAR) if the events that lead to any particular data-item being missing are independent both of observable variables and of unobservable parameters of interest, and occur entirely at random. When data are MCAR, the analysis performed on the observed data is unbiased; however, missing data are rarely MCAR. Missing at random (MAR) occurs when missing observations can be fully accounted for by variables where there is complete information. MAR is an assumption that is impossible to verify statistically without taking into account additional assumptions.

So, in terms of probabilities, given R the variable that indicates the missing observation, $Pr(R|Y)=Pr(R|Y_{obs},Y_{mis})$.

In a MCAR condition, $Pr(R|Y)=Pr(R)$, while in a MAR situation $Pr(R|Y)=Pr(R|Y_{obs})$. Finally, in a "not missing a random" case, $P(R|Y)=P(R|Y_{obs},Y_{mis})$ and cannot be simplified any further.

According to Bethlehem (2011), estimates based on observed data must be assumed to be biased unless very convincing evidence to the contrary is provided. Understanding the reasons why data are missing is important to correctly handle the remaining data.

In order to verify the MCAR situation, a first step of analysis of missing data has been to identify patterns of missing data, in relation with the observed variables.

In order to be able of verify that the distribution of missing data is randomly distributed, or that there in not a systematic error in collecting data on our variable of interest (FIES-score), it is due to verify that such distribution in the same in any specification of the covariates.

To do this, we analyse the distribution on the variable FIES-score with the principal covariates in the dataset. The variable FIES-score is built as the sum of the affirmative responses to the eight questions of the FIES survey module. In this way, we can verify how partial non-response of the sum of FIES items deal with the covariates.

For instance, there is not any difference in the pattern of missing data for men and women (table 2.5).

Table 2.5. Percentage of missing observations of the variable FIES-score by gender

FIES score	Men	Women	Total
Valid data	97,12	97,12	97,12
Missing data	2,88	2,88	2,88
	100,00	100,00	100,00

Source: FIES data

The distribution of missing data for the variable FIES score does not change at all together with the gender covariate. This result means that the partial no response are not related with gender.

Also, in relation with the location of the household there is not a very strong change in the percentage of missing values, even if there are higher percentages of missing value in the rural areas (table 2.6).

Table 2.6. Percentage of missing observations of the variable FIES- score by location of residence (variable Raw_score)

FIES score	Rural	Village	City	Suburb
Valid data	96,65	97,20	97,24	98,19
Missing data	3,34	2,80	2,76	1,76
	100,00	100,00	100,00	100,00

Source: FIES data

In the world sample as a whole, the presence of missing data ranges from zero per cent to 18.3 per cent in Somalia and 17.7 per cent in Haiti[1], both countries with ongoing severe political and social crisis (see Appendix III).

2.7. Estimating comparable prevalence rates at country level according to the Rasch model.

Food security outcomes can be analysed at different levels of aggregation (e.g. global, national, subnational, household, individual).

As foreseen in the 2030 UN Sustainable Development Agenda, the analysis of food security at country level has to be carried out using the prevalence rate, computed on FIES data.

[1] Haiti has experienced political instability for most of its history. A massive magnitude 7.0 earthquake struck Haiti in January 2010 with an epicenter about 25 km (15 mi) west of the capital, Port-au-Prince. Estimates are that over 300,000 people were killed and some 1.5 million left homeless. The earthquake was assessed as the worst in this region over the last 200 years. In October 2016, Hurricane Matthew struck southwestern Haiti causing widespread and devastating destruction, with an estimated 2.1 million people affected. Population in 2016 is estimated in 10.8 million people. Haiti's economy suffered a severe setback in January 2010 when a 7.0 magnitude earthquake destroyed much of its capital city, Port-au-Prince, and neighboring areas. Currently the poorest country in the Western Hemisphere, with 80% of the population living under the poverty line and 54% in abject poverty, the earthquake further inflicted $7.8 billion in damage and caused the country's GDP to contract. In 2011, GDP growth rose to 5.5% as the Haitian economy began recovering from the earthquake. However, growth slowed in 2015 to 2% as political uncertainty, drought conditions, and the depreciation of the national currency took a toll on investment and economic growth.(Source: CIA the world factbook https://www.cia.gov/library/publications/the-world-factbook/geos/ha.html)

"Prevalence" is a concept of medical statistics and refers to the proportion of people in a population who have a particular "disease" (or health problem, such as food insecurity) at a specified point in time, or over a specified period of time.

In particular, with regard to Food insecurity measured by FIES, the prevalence rate is calculated on the basis of the Food Insecurity Experience Scale, recorded as part of the sample Gallup surveys in approximately 150 countries around the world.

The Gallup World Poll (GWP) surveys on a representative sample of the population the difficulties experienced by respondents in satisfying their need for food, creating an interesting indicator of the access dimension as part of the food security monitoring (see Chapter 2, Section 3).

The VoH project aims to use the FIES to estimate the prevalence of food insecurity of individuals at different levels of severity across countries and regions of the world. In particular, the VoH methodology measures the severity of food insecurity (lack of economic access to adequate food), based on conditions and behaviours reported in response to the 8-question survey module of FIES.

As explained below in this Section, data collected individually were used to calculate a measure of the severity of food insecurity at the individual level, and subsequently the individual measures have been calibrated to build a common scale of worldwide reference, and then allowing the comparability of the scale between countries.

When responses of a person are listed according to item difficulty, from lowest to highest, the most likely pattern is a Guttman pattern; i.e. {1,1,...,1,0,0,0,...,0}. A set of items having binary answers (e.g., YES or NO) forms a Guttman scale if they can be ranked in some order so that, for a rational respondent, the response pattern can be captured by a single index on that ordered scale (Abdi Herv' 2010). In other words, on a Guttman scale, items are arranged in such an order that an individual who agrees with a particular item also agrees with items of lower rank-order. Agreement with any one item implies agreement with the lower-order items.

Another way to assess the suitability of a set of survey items with binary answers is the Item Response Theory (IRT). IRT is a family of probabilistic models aimed at verifying that the items are presented in an ordinal scale. If the IRT model assumptions are verified, then the raw score of a respondent (the number of affirmative responses to the set of items) is a

sufficient statistic for, and an ordinal indicator of, the severity of food insecurity that the individual has experienced. Raw score-based classifications are typically used with the US HFFSM, the ELCSA and other similar scales to monitor the food security situation in a given population over time.

For a more general discussion of Item Response Theory and its methods please see Section 3.3.3.

To assess the suitability of FIES, a Rasch-model-based scale was estimated for each country, and data were assessed for consistency with model assumptions (Nord 2014), the Rasch model being an Item Response Theory model with single-parameter logistic options (see equation 2.1).

In the VoH application of the Rash model to the FIES data, the severity experienced by each respondent and the severity of each item have been estimated (Nord et al 2016). Respondent severity parameters and measurement error (uncertainty) are calculated as the maximum likelihood values given the item severity parameters, while the severity of an item is defined as the severity experienced by respondents who are equally likely to affirm or deny the item.

Response data are assessed and combined to create a measure using statistical methods based on Item Response Theory, in which the severity of food insecurity experienced by an individual or household is modelled as a latent trait

In the Rasch model, the probability of a specified response (e.g. binary answer) is modelled as a function of person and item parameters. Specifically, in the original Rasch model, the probability of a positive response is modelled as a logistic function of the difference between the person and item parameter.

In the Rasch model, the probability that a respondent will report a given experience is a logistic function of the distance between the respondent's and the item's positions on the severity scale

$$Prob\left(x_{h,i} = 1 \middle| \beta_i, \theta_h\right) = \frac{e^{\beta i - \theta h}}{1 + e^{\beta i - \theta h}} \qquad [2.1]$$

where $x_{h,i}$ is the response given by respondent *h* to item *i*, coded as 1 for "yes" and 0 for "no".

The relative severity associated with each of the experiences (the parameters βi in the formula above) can be inferred from the frequency with which they are reported by a large sample of respondents.

Rasch models have very strong points. First, the probabilistic nature of the model, in contrast with deterministic models like the Guttman scale, takes into account that human responses are subject to fluctuations. Second, the assumptions of the Rasch model can be tested statistically. Third, a Rasch scale is a psychometrically proven interval scale, thus it permits to know better what you are measuring. Fourth, the estimates of the person and item parameters are sample-free. This means that they will hold for every sample and not merely the sample under consideration. A final strong point is the availability of information about the various items [and persons]" (van Alphen, 1994).

In the VoH project, measures were made comparable across countries by first calculating a global standard scale based on item severity parameters of almost all countries; second, specifying thresholds for moderate and severe food insecurity on the global scale, and third, adjusting each country's scale to the global standard based on item severity parameters in order to transform the global thresholds to that country's scale (Nord et al. 2016). To ensure the measured severity of food insecurity is comparable across countries, FAO equated the food insecurity scales for each country to a FIES Global Standard Scale (FIES-GSS). FAO's equating procedure for the FIES-GSS maintains cross-country comparability by creating food insecurity thresholds that allow researchers to partition the continuum of food insecurity into meaningful and comparable ranges of food insecurity (Nord 2012, Ballard et al. 2013, FAO 2016). Thus, the measured severity of food insecurity, food insecurity thresholds, and the food insecurity prevalence rates are all equivalent and comparable across countries. The equating procedures ensure that each of the food security items function similarly across countries.

The threshold for moderate food insecurity—the level of severity beyond which respondents would be classified as having moderate or severe food insecurity—was specified at the severity of the item "ateless" on the global standard scale. The threshold for severe food insecurity was specified at the severity of the item "whlday" on the global standard scale (Nord et al. 2016).

Finally, two prevalence rates were calculated for each country: the percentage of the population with moderate-or-severe food insecurity and the proportion with severe food

insecurity. These calculations are based on the assumption that within each raw score, the true severity of food insecurity is normally distributed with mean at the value of the respondent parameter for that raw score and standard deviation equal to the estimated measurement standard error (uncertainty) of severity associated with that raw score.

Preliminary analysis of the prevalence rate based on FIES show significant and high correlation in the expected direction with most accepted indicators of development (Nord 2012, Ballard et al. 2013, FAO 2016).

Expansion of this type of analysis to other potential outcomes of food insecurity and addition of carefully selected covariates may shed light on differences in the aspects of food insecurity captured by the FIES and the PoU, as well as the mechanisms that link food insecurity to various outcomes. In Chapter 3 of this thesis, an innovative study on the reliability and validity of FIES is presented, while in Chapter 4, an extensive micro econometric analysis, with different methodologies and applications, of FIES and selected covariates is carried out. The analysis at country level of the PoU is not among the goals of this work, but can be object of future research.

2.8. Conclusions

The Food Insecurity Experience Scale provides a direct measure of the problems that individuals and households experience in having access to food. The indicator can be used both in developed and developing countries; it can be used at household and individual level, allowing the analysis of inequalities in access to food for several personal characteristics (e.g. men and women); it is based on a short questionnaire (eight questions) that can be easily included in all surveys of households or individuals; it is a quick and cheap tool that allows timely intervention.

Experience-based food insecurity scales like the FIES represent, thus, a simple, timely and less costly method for measuring the access dimension of food insecurity based on data collected at the household or individual level.

Direct measures of experienced food insecurity can be used to potentially identify vulnerable populations before malnutrition becomes manifest, they allow disaggregation at sub-national levels and across different population groups, making it possible to identify more specifically who the food insecure are and their geographic distribution. The ease of application, analysis,

and interpretation facilitates better communication of results to decision makers, leaders of civil society, and the general public.

It is worth underlining that they do not provide specific information on actual food consumption, diet quality and food expenditures like household expenditure surveys and individual food intake surveys.

FAO developed the Food Insecurity Experience Scale (FIES), building it upon previous research on U.S. and Latin American experiential measures, and, starting in 2014, the FIES has been incorporated into the Gallup World Poll questionnaire, providing for the first time, cross-country comparable estimates of individual food insecurity on a global scale. The collected data have been used to derive estimates of the prevalence of food insecurity at country-level estimates.

This innovative method to detect food security has been listed as target 2.1.2 of the UN Sustainable Development Goals and will need that countries provide this information for the global monitoring of the Goal 2 "Zero hunger (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and target 2.1 (By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round) have to be monitored by Indicator 2.1.2: Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES). Food Insecurity Experience Scale (FIES) them has become a new global standard to measure food insecurity

The characteristics of the dataset, its variables and the sample are part of the innovation offered by this thesis. Therefore, it seemed appropriate to describe profusely the FIES survey module, the methodological approach followed in the sampling and the characteristics of the sample in terms of economic, social and demographic covariates.

Chapter 3

Validation of the Food Insecurity Experience Scale

3.1 Introduction

The procedure of development of Food Insecurity Experience Scale (FIES) has been mentioned in Chapter 2. Now it is necessary to examine whether the constructed scale will give the same results at different occasions. It is, then, compulsory to evaluate the reliability of FIES. The purpose of the present Chapter is indeed to test the internal consistency and convergent and construct validity of the FIES.

In general, measurement involves assigning scores to individuals so that they represent some characteristic of the individuals. To assess that one individual food insecurity is measured by the scores obtained by FIES, it is necessary to conduct ad hoc analysis using the measure to confirm that the scores are based on the latent construct that the scholars wants to measure. This is an extremely important point. Using the collected data on FIES, it is possible to *demonstrate* that this measurement instrument works, not only to *assume* that it represents food insecurity.

In the construction of a measurement instrument like FIES, there are two attributes generally regarded as the most important: reliability and validity. Most measurement specialist agree that, once an adequate degree of reliability has been obtained, validity is the most important attribute of a test (Brenner 1962).

The FIES scale has already been evaluated by experts in the field (Wambogo et al. 2018, Nord 2016, Ballard et al. 2013) and through an analysis of external validity based on macro measure (FAO 2016), but further research is needed. In particular, it is needed to assess the reliability and validity of FIES as a measure of individual food security using methodologies based on the micro data collected.

More in detail, reliability refers to the consistency of a measure (Maggino 2006). In particular, internal consistency is the consistency of people's responses across the items on a multiple-item measure. In general, all the items on such measures are supposed to reflect the same underlying construct, so people's scores on those items should be correlated with each other. If people's responses to the different items are not correlated with each other, then it

would no longer make sense to claim that they are all measuring the same underlying construct. This is as true for behavioural and physiological measures as for self-report measures.

Validity is the degree to which any measurement approach or instrument succeeds in describing or quantifying what it is designed to measure

The validation of FIES aims to precisely detect individuals that present a critical level of food insecurity. It will be also useful to construct a synthetic indicator of food insecurity.

Internal consistency can only be assessed by collecting and analysing data (see Section 3.3). The scale scores are analysed with descriptive statistics in Section 3.3.1 Internal consistency of the scale is assessed using Cronbach's alfa (see Section 3.3.2), that is the most established index of internal consistency in literature. An analysis of split-half correlation is presented also in Section 3.3.2. This approach involves splitting the items into two sets, such as the first and second halves of the items or the even- and odd-numbered items. Then a score is computed for each set of items, and the relationship between the two sets of scores is examined. The Spearman-Brown coefficient is used to calculate the reliability when the number of items in a questionnaire is changed. Both indexes – the Spearman Brown coefficient and the Cronbach's alfa have been calculated for the whole sample, dividing the sample in two parts, according to the odd-even and split-half methods, and for the single items, in order to assess the reliability of the FIES measure. The corresponding results are presented in Section 3.3.2.

In Section 3.3.3., the eight items composing the FIES measure have been analysed in term of cumulability to evaluate if the cumulative distribution of the items really represents an increasing severity of individual food insecurity. The eight items of the FIES form a metric aimed to measure the severity of experienced food insecurity along a unidimensional scale: at the bases of the construction of the scale there is therefore a cumulative scale model, that has been verified by an application of the Item Response Theory model.

In Section 3.3.4, examination of the 8-items questionnaire by exploratory factor analysis (EFA) allowed the analysis of dimensionality. The construct validity verifies if the measure is consistent with the theoretical concept being measured. The most useful and established method consists in analysing the factorial evidence, that is to say the clustering of items according to the theory-based grouping of items. The construct validity was assessed using rotated principal component factor analysis with a varimax rotation.

In Section 3.3.5, as suggested by Coates (2006), a confirmatory approach has been used to evaluate the scale appropriateness of potentially generic questionnaire items. Using different Simultaneous Equations Models (SEMs), has been possible to assess the relevance across cultures of each of the domains. In the past two decades, many studies on the comparability of experience-based food insecurity measures have been conducted, but this study - to my knowledge - is the first to use Confirmatory Factor Analysis (CFA), based on the SEM methodology.

Finally, content validity has been evaluated by a micro econometric analysis of FIES in relation with extreme-poverty.

3.2. The scale

As more diffusely described in the previous chapter, the Food Insecurity Experience Scale, developed by the Voices of the Hungry project (VoH) at FAO, is an experience-based food insecurity scale module, derived from widely-used experience-based food security scales, such as the US Household Food Security Survey Module (HFSSM), the Household Food Insecurity Access Scale (HFIAS) (Coates et al. 2007), and the Latin American and Caribbean Food Security Scale (Spanish acronym ELCSA), as described in Ballard (2013), both adapted version of the Cornel and Radimer measuring tool, which was initially developed to be used in the USA.

In particular, the measurement of experience-based food insecurity at the individual level aims at measuring the access component, and it is based on the idea that the experience of food insecurity causes predictable reactions and responses that can be captured and quantified through a survey and summarized on a scale (see Chapter 2). Access to food means that ”individuals have adequate incomes or other resources to purchase or obtain levels of appropriate foods needed to maintain consumption of an adequate diet/nutrition level and are able to obtain these foods in socially acceptable ways” (US Agency for International Development (1992) Policy Determination 19, Definition of Food Security. Washington, DC: USAID.).

The development of the FIES, its methodological characteristics and the survey design have been presented in Chapter 2 (Section 2, 4 and 5 respectively).

In extreme synthesis, the FIES provides a direct measure of the problems that individuals and households experience in having access to food. It has been simplified in order to make the scale comparable at international level: it is based on a short questionnaire (eight questions); information has been collected at individual level rather than at household level; response categories are only "Yes" or "No", rather than ordinal variables; a reference period of 12 months to ensure comparability of surveys conducted in different months (see Chapter 2).

Data on FIES have been collected in 147 Countries, on a sample of more than 150 thousand individual, aged 15 and more. The characteristics of the sample have been illustrated in Section 2.6.

Here, I proceed to the verification of the reliability and validity of the FIES.

3.3. Evaluation of the scale

3.3.1. Exploratory analysis results: responses to items on the Food Insecurity Experience Scale

Analysing the frequency distributions of the eight items, it is possible to make the first evaluations of the scale. Responses to the FIES items were generally consistent with expectations: more respondents reported affirmatively to the items indicating less severe food insecurity, such as being worried about not having enough food, than to items indicating more severe food insecurity, such as going a whole day without eating (table 3.1).

Table 3.1. Affirmative responses to items on the FIES

Questions	Items	Affirmative responses (% yes)					
During the last 12 MONTHS, was there a time when		Total	Africa	Asia	Americas	Europe	Oceania
Q1. You were worried you would run out of food because of a lack of money or other resources?	WORRIED	33.3	55.8	39.4	26.9	16.3	7.9
Q2. You were unable to eat healthy and nutritious food because of a lack of money or other resources?	HEALTHY	31.4	53.5	35.5	24.8	15.8	8.8
Q3. You ate only a few kinds of foods because of a lack of money or other resources?	FEWFOOD	32.9	56.4	36.8	26.0	16.3	11.4
Q4. You had to skip a meal because there was not enough money or other resources to get food?	SKIPPED	21.6	44.8	23.6	14.5	6.3	5.1
Q5. You ate less than you thought you should because of a lack of money or other resources?	ATELESS	26.2	51.7	28.9	18.3	9.1	7.3
Q6. Your household ran out of food because of a lack of money or other resources?	RUNOUT	20.7	40.2	23.7	15.1	6.6	4.7
Q7. You were hungry but did not eat because there was not enough money or other resources for food?	HUNGRY	18.1	38.7	22.4	10.8	4.5	4.1
Q8. You went without eating for a whole day because of a lack of money or other resources?	WHLDAY	12.2	28.0	12.7	6.8	2.8	2.3

Source: author's elaborations on FIES data

As shown in table 3.1, affirmative responses to the eight items ranged from 33.3% at the first question (worried you run out of food) to 12.2% (went without eating for a whole day).

Furthermore, it is possible to note that the items present a higher percentage of affirmative responses in the Regions where there is a higher concentration of less developed countries.

In table 3.2, the Spearman measure of correlation is presented. The measure evaluates monotonic relationships for ordinal variables. According to this measure, items are highly correlated but none of them overlaps completely (table 3.2). This result is a first indication that the items are really measuring the same concept, but the information collected considers different aspects of the latent construct.

Table 3.2. Matrix of correlations *(Spearman coefficient)*

	WORRIED	HEALTHY	FEWFOOD	SKIPPED	ATELESS	RUNOUT	HUNGRY	WHLDAY
WORRIED	1							
HEALTHY	0.700	1						
FEWFOOD	0.684	0.745	1					
SKIPPED	0.586	0.603	0.618	1				
ATELESS	0.643	0.654	0.687	0.711	1			
RUNOUT	0.587	0.595	0.601	0.687	0.685	1		
HUNGRY	0.553	0.567	0.569	0.703	0.676	0.724	1	
WHLDAY	0.437	0.450	0.441	0.580	0.526	0.598	0.659	1

Source: author's elaborations on FIES data

Using the Phi coefficient of association for binary variables, we obtain similar results.

Table 3.2a. Matrix of correlations *(Phi coefficient)*

	WORRIED	HEALTHY	FEWFOOD	SKIPPED	ATELESS	RUNOUT	HUNGRY	WHLDAY
WORRIED	1.000							
HEALTHY	0.696	1.000						
FEWFOOD	0.680	0.742	1.000					
SKIPPED	0.582	0.599	0.614	1.000				
ATELESS	0.639	0.651	0.683	0.708	1.000			
RUNOUT	0.583	0.592	0.597	0.684	0.682	1.000		
HUNGRY	0.548	0.564	0.565	0.699	0.673	0.721	1.000	
WHLDAY	0.432	0.446	0.436	0.576	0.523	0.595	0.655	1.000

Source: author's elaborations on FIES data

3.3.2 Reliability and internal consistency

Reliability is the overall consistency of a measure (Maggino 2006). A measure is said to have a high reliability if it produces similar results in other occasions under similar conditions.

First of all, the reliability of the FIES was evaluated using Cronbach's coefficient α, which estimates how much each item functions as a parallel, though correlated, test of the underlying construct (Cronbach 1951, Santos 1999).

The Cronbach's alpha can be written as the rate of the variance due to the answers of people and the total variance in the measurements:

$$Cronbach's\ alpha = \frac{\sigma_p^2}{\sigma_p^2 + \sigma_{residuals}^2/k} \qquad [3.1]$$

where σ_p^2 is the variance due to the differences between persons, $\sigma_{residuals}^2$ is the error variance and k is the number of items.

Therefore, as the estimate of reliability increases, the fraction of a test score that is attributable to error will decrease (Nunnally 1994).

Note that formula 3.1 also illustrates why Cronbach's alpha becomes higher when the number of items increases: the error variance is divided by the number of items.

It has been proposed that alpha can be viewed as the expected correlation of two tests that measure the same construct. By using this definition, it is implicitly assumed that the average correlation of a set of items is an accurate estimate of the average correlation of all items that pertain to a certain construct. The theoretical value of alpha varies from 0 to 1, since it is the ratio of two variances and the variance in the denominator is always at least as large as the variance in the numerator. Therefore, Cronbach's alpha ranges from 0 (items completely uncorrelated, all variance is random) to 1 (each item yields identical information), with the convention of 0.70 indicating a minimally reliable scale. However, depending on the estimation procedure used, estimates of alpha can take on any value less than or equal to 1, including negative values, although only positive values make sense. Higher values of alpha are more desirable.

The Cronbach's alpha is the most common and established measure of reliability. Alpha is an important concept in the evaluation of assessments and questionnaires. It is mandatory that researchers should estimate this quantity to add validity and accuracy to the interpretation of their data (Tavakol and Dennick 2011).

Nevertheless, alpha should be compared with other indexes of validity. In our case, the Cronbach alpha is only the first of many different measures of reliability and validity of the scale to be presented and analysed.

For the FIES, Cronbach's alpha (on 8 variables, 147825 cases) is 0.927. We can deduce that the internal consistency is excellent. Therefore, the eight items measure the same latent construct.

The definition of food insecurity adopted here assumes that this characteristic is one-dimensional; consequently, the scale assumes the hypothesis that the total score is monotonously linked with the measured dimension (Maggino 2007). To verify this assumption, it is necessary to analyse the internal consistency of the group of identified items.

Split-half correlation involves splitting the items into two sets, such as the first and second halves of the items or the even- and odd-numbered items. Then a score for correlation is computed for each set of items, and the relationship between the two sets of scores is examined.

Spearman-Brown Split Half Reliability Coefficient is also called the Spearman-Brown Prophecy Coefficient. The Spearman-Brown Prophecy Coefficient is used to estimate full test reliability based on split-half reliability measures.

So, while the Pearson correlation of split forms estimates the half-test reliability, the Spearman-Brown "Prophecy Formula" predicts what the full test reliability would be, based on the half test correlation. This coefficient will be higher than the half-test reliability coefficient.

Rulon / Guttman Split Half Reliability coefficient is an adaptation of the Spearman-Brown coefficient, but one which does not require equal variances between the two split forms. The best will be that in which each half contains highly inter-correlated items.

Less than perfect reliability will lead to less than perfect correlations. For FIES, the values of the coefficient are rather satisfactory, all over 0.8 (table 3.3).

Table 3.3. Coefficients of internal consistency

Internal consistency coefficients	Methods	
	1st half-2nd half	ODD-EVEN
Split-half correlation	0.805	0.882
Spearman-Brown Coefficient	0.892	0.937
Guttman (Rulon) Coefficient	0.886	0.934
Coefficient Alpha - all items	0.927	0.927
Coefficient Alpha – 1	0.884	0.873
Coefficient Alpha – 2	0.876	0.845

Source: author's elaborations on FIES data

All the above coefficients have been calculated dividing the items in two parts, according to two different methods: 1st half-2nd half (first column) and odd-even (second column). The different coefficients of correlation are computed splitting the items into two sets. The first method takes into account the order of the items, comparing the first half of the scale with the second half, while the second method does not consider the sequence of the questions, considering odd and even positions of the items.

Comparing the results obtained with the two methods (first-second half and odd-even), it is possible to evaluate the consequences of the order in which questions are posed. In the case of FIES, it is possible to observe that the order of the items is not perfect, because the coefficients present different results in the two methods. For the alpha coefficient, for example, the first method scores higher values, thus indicating different response of the subjects to the two groups of questions.

In other words, the fact that the coefficients calculated according to the first-half/second half method present different values than the coefficient calculated with the odd-even method indicates that there is not perfect cumulability of the scale.

In order to evaluate the contribution of the single item to the scale, it is useful to analyse also the coefficients computed for each question (table 3.4).

Item internal consistency reliability for this study was measured in a variety of ways: correlations between an item and the remaining items in the measure (called corrected item-scale correlations R), Item reliability (that is the product of the standard deviation of the item scores and a correlational discrimination index), correlation among the remaining items excluding the item, Cronbach's alpha for the measure if the single item is removed. The criteria used are summarized in table 3.4.

Being all the above measures of correlation, the higher the value, the higher the reliability of the item. Analysing the results in table 3.4, it is possible to conclude that the internal reliability among items is high. For all the item, the reliability measure with R, decreases excluding the single item.

Table 3.4. Item reliability statistics

Item	Mean	Standard deviation	Item total R	Item reliability Index	Excluding item R	Excluding item Alpha
WORRIED	0.331	0.471	0.810	0.381	0.736	0.919
HEALTHY	0.312	0.463	0.828	0.384	0.762	0.917
FEWFOOD	0.327	0.469	0.834	0.391	0.769	0.916
SKIPPED	0.215	0.411	0.836	0.344	0.782	0.915
ATELESS	0.261	0.439	0.859	0.377	0.807	0.913
RUNOUT	0.206	0.404	0.832	0.337	0.778	0.915
HUNGRY	0.181	0.385	0.823	0.317	0.769	0.916
WHLDAY	0.121	0.326	0.694	0.226	0.624	0.926

Source: author's elaborations on GWP_FIES data

Only the item "Whlday" (meaning the interviewee remain without eating for a whole day because lack of money or other resources) presents a lower level of similarity, with a lower value of the total R, while alpha's value increases without the item. This means that the "whlday" variable presents a lower level of similarity, compared with the remaining questions.

3.3.3 Cumulability by an Item Response Theory probabilistic model

The eight items of the FIES form a metric aimed to measure the severity of experienced food insecurity along a unidimensional scale: all individuals who have selected a more "difficult" item, should have chosen also the previous, "simpler" items. In this way, the eight items should be ordered according to a criterion of increasing difficulty: this allows to obtain an evaluation in which the conditions for exceeding an item are "theoretically" required to pass the previous item. At the bases of the construction of the scale there is therefore a cumulative scale model.

The analysis of the internal consistency leads to an evaluation that could be not univocal, because the same scores can be obtained with different response models (profiles). A "profile" is the sequence of answers to a set of items of a scale. The same total score can be, indeed, obtained giving affirmative answers to different items.

Therefore, it is necessary to verify – when a respondent chose an item – if all the "easier" items have also been selected. In this way, it is possible to assume that the items are ordered according to increasing severity of the same latent construct. It is, then, possible to validate the scale through the comparison of the actual distribution of the responses with a theoretical model of perfect scalability. The perfect scalability of a scale is obtained when a respondent selects an affirmative answer to an item only if he has selected affirmative answers to all the

previous ones. In this case, it is possible to conclude that there is perfect scalability of the items, and that the scale is exactly ordered according to the severity of the construct being measured, and that the scores obtained with the cumulative distribution of the answers are correct. Of course, there is an amount of randomness in the possible discrepancy to the perfect scalability, and it is worth accounting for the significance of this discrepancy, verifying if it is really randomly distributed or if there is an error in the order in which the items are presented to the respondent.

It is possible to verify the cumulability of the FIES by the probabilistic approach of the Item Response Theory.

Item Response Theory (IRT) (van der Linden and Hambleton 1997) concerns models and methods where the responses to the items (binary or ordinal variables) of a questionnaire are assumed to depend on non-measurable characteristics of the respondents (latent traits). These models can be applied to measure such a latent variable (measurement models), or to investigate influences of covariates on these latent variables. In this context, we are interested on evaluating the measurability of our scale.

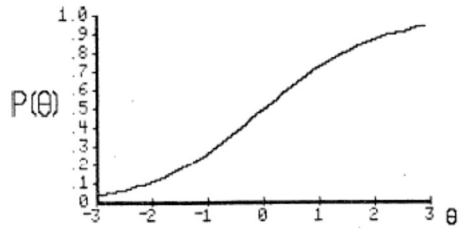
As said above, in most testing work, our main task is to infer the respondents' level of a certain latent trait. In order to do this, we must know something about how his personal situation determines his response to an item. Thus, item response theory starts with a mathematical statement as to how response depends on level of a certain construct (Lord 1980).

This relationship is given by the item response function or item characteristic curve.

Let us denote by θ the trait (e.g. individual food insecurity) to be measured. For a dichotomous item, the item response function is simply the probability P or P(θ) of a correct response to the item. It is very reasonable to assume that P(θ) increases as θ increases, that is to say that the probability that a respondent answers affirmatively to an item indicating a symptom of food insecurity increases with the level of food insecurity (Baker 2001).

Therefore, the item response function is expected to assume the form of a logistic curve, as shown in figure 3.1.

Figure 3.1. A typical item characteristic curve



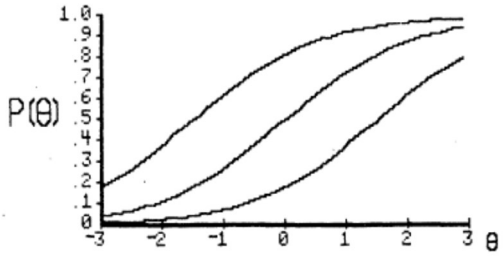
Source: Frank B. Baker. The Basics of Item Response Theory 2001 ERIC Clearinghouse on Assessment and Evaluation

Items can be distinguished according to two principal parameters: difficulty and power of discrimination.

The idea of item difficulty will be examined first. In Figure 3.2, three item characteristic curves are presented on the same graph. All have the same level of discrimination but differ with respect to difficulty. The left-hand curve represents an easier item because the probability of affirmative response is high for respondents with a low level of the latent trait examined and approaches 1 for respondents with a high level of the latent trait.

The centre curve represents an item of medium difficulty because the probability of positive response is low at the lowest levels of the latent trait, around 0.5 in the middle of the food insecurity scale and near 1 at the highest levels. The righthand curve represents a “hard” item. The probability of positive response is low for most of the scale and increases only when the higher levels of food insecurity are reached (figure 3.2).

Figure 3.2. Three item characteristic curves with the same discrimination but different levels of difficulty

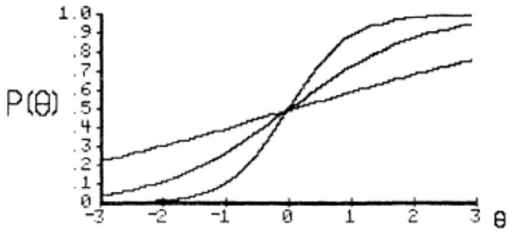


Source: Frank B. Baker. The Basics of Item Response Theory 2001 ERIC Clearinghouse on Assessment and Evaluation

The concept of discrimination is illustrated in Figure 3.3. This figure represents three response functions related to items having the same difficulty level but differing with respect to discrimination. The upper curve has a high level of discrimination since the curve is quite

steep in the middle where the probability of affirmative response changes very rapidly as the level of food insecurity increases. Just a short distance to the left of the middle of the curve, the probability of affirmative response is much less than 0.5, and a short distance to the right the probability is much greater than 0.5. The middle curve represents an item with a moderate level of discrimination. The slope of this curve is much less than the previous one and the probability of affirmative response changes less dramatically than the previous curve as the food insecurity level increases. The third curve represents an item with low discrimination. The curve has a very small slope and the probability of affirmative response changes slowly over the full range of the latent trait. Even at low levels of food insecurity, the probability of affirmative response is reasonably large, and it increases only slightly when high levels are reached.

Figure 3.3. Three item characteristic curves with the same difficulty but with different levels of discrimination



Source: Frank B. Baker. The Basics of Item Response Theory 2001 ERIC Clearinghouse on Assessment and Evaluation

Under item response theory, the standard mathematical model for the item characteristic curve is the cumulative form of the logistic function. It defines a family of curves having the general shape of the item characteristic curves shown above.

The equation for the two-parameter is the following:

$$P(\theta) = \frac{1}{1+e^{-a(\theta-b)}} \qquad [3.2.]$$

where: a is the discrimination parameter, b is the difficulty parameter, θ is the level of the latent trait, and e is the constant 2.718.

The Rasch model considers the discrimination parameter of the two-parameter logistic model as fixed at a value of a = 1.0 for all items; only the difficulty parameter can take on different

values. Because of this, the Rasch model is often referred to as the one-parameter logistic model.

As reported in Baker (2001), Birnbaum (1968) modified the two-parameter logistic model to include a parameter that represents the contribution of guessing the probability of correct response. Unfortunately, in doing so, some of the nice mathematical properties of the logistic function were lost. Nevertheless, the resulting model has become known as the three-parameter logistic model, even though it technically is no longer a logistic model.

For the analysis of FIES, I have applied the logistics version with two parameters (difficulty and discrimination), and the corresponding results are shown in table 3.5 and figure 3.4.

The first three items present a level of difficulty below the average, and the last three items present a level of difficulty well above the average. The ordering is not respected by the two central items: skipped and runout.

Regarding the discrimination capacity, all the items present the same level.

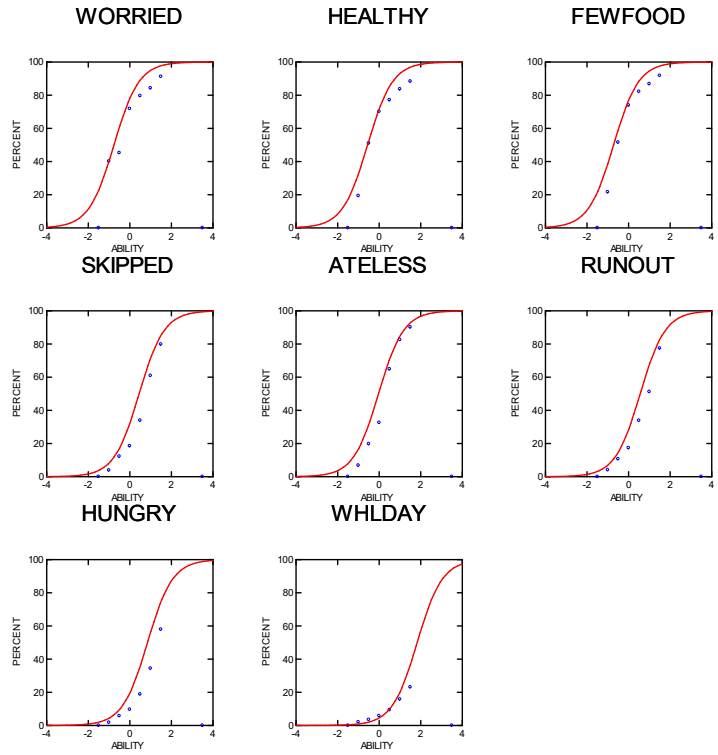
Table 3.5. Item difficulty and discrimination

Item	Label	Item P	Difficulty	Std Err	Discrim	Std Err
1	WORRIED	0.689	-0.762	0.007	0.983	0.009
2	HEALTHY	0.637	-0.560	0.007	0.983	0.009
3	FEWFOOD	0.679	-0.723	0.007	0.983	0.009
4	SKIPPED	0.371	0.449	0.007	0.983	0.008
5	ATELESS	0.495	-0.034	0.006	0.983	0.008
6	RUNOUT	0.344	0.557	0.007	0.983	0.008
7	HUNGRY	0.277	0.851	0.007	0.983	0.008
8	WHLDAY	0.111	1.828	0.009	0.983	0.008
Mean		0.45	0.201	0.007	0.983	0.008
Std Dev		0.197	0.842	0.001	0.0000	0.0000
N cases		8	8	8	8	8

Source: author's elaborations on FIES data

Analysing the item characteristic curves, the items present distribution of the answers that are close to the theoretical, with the exception of "Whlday". The variable – that indicates the most severe symptom of food insecurity – presents a different distribution, with much lower frequencies' values (Figure 3.4).

Figure 3.4 Latent Trait Model Item Plots



Source: author's elaborations on FIES data

3.3.4. Dimensionality verification: Exploratory factor analysis.

The results observed so far confirm the ordinal nature of the measured characteristic. However, some elements that emerged from the analysis above authorize to hypothesize that the FIES, as it has been defined and how it is perceived, is not perfectly one-dimensional. In particular, we could hypothesize the presence of (at least) two components (factors). The Exploratory Factor Analysis (EFA) permits to verify if the components of the FIES present some orthogonality (Maggino, 2005).

EFA is a statistical technique part of the Factor Analysis family of methods. It is called Exploratory because it does not suppose any hypothesis before the application of the analysis. EFA is therefore used when there is little supporting evidence for the factor structure, or when the research goal is to identify the number of common factors and the pattern of factor loadings (Norris and Lecavalier 2010). FA is a family of statistical methods whose goal is to identify the underlying relationships between manifest variables. In general, EFA has been widely used as a technique to develop and evaluate scales and subscale. The purpose of factor

analysis is to identify the fewest possible latent construct needed to reproduce the original data (Gorsuch 1997).

In other words, FA is a collection of methods for explaining the correlations among variables in terms of more fundamental entities called factors or latent construct. According to the FA perspective, variables correlate because they are determined in part by common, but unobserved influences. These influences must be superordinate to the variables that are actually measured because they account for the individual differences in the tests. The goals of factor analysis are to determine the number of fundamental influences underlying a domain of variables, to quantify the extent to which each variable is associated with the factors, and to obtain information about their nature from observing which factors contribute to performance on which variables (Cudeck 2000).

As shown in table 3.6, the application of exploratory factorial analysis seems to confirm our hypothesis: the two factors extracted explain almost the same amount of variance of the total (76.8% of total variance).

Table 3.6. Exploratory factor analysis (varimax)

Rotated Loading Matrix (VARIMAX, Gamma =1.0000)	Factors	
	1	2
HEALTHY	0.843	0.297
FEWFOOD	0.843	0.305
WORRIED	0.819	0.293
ATELESS	0.658	0.555
SKIPPED	0.515	0.683
WHLDAY	0.157	0.865
HUNGRY	0.388	0.806
RUNOUT	0.478	0.718
"Variance" Explained by Rotated Components	3.192	2.954
Percent of Total Variance Explained	39.905	36.921

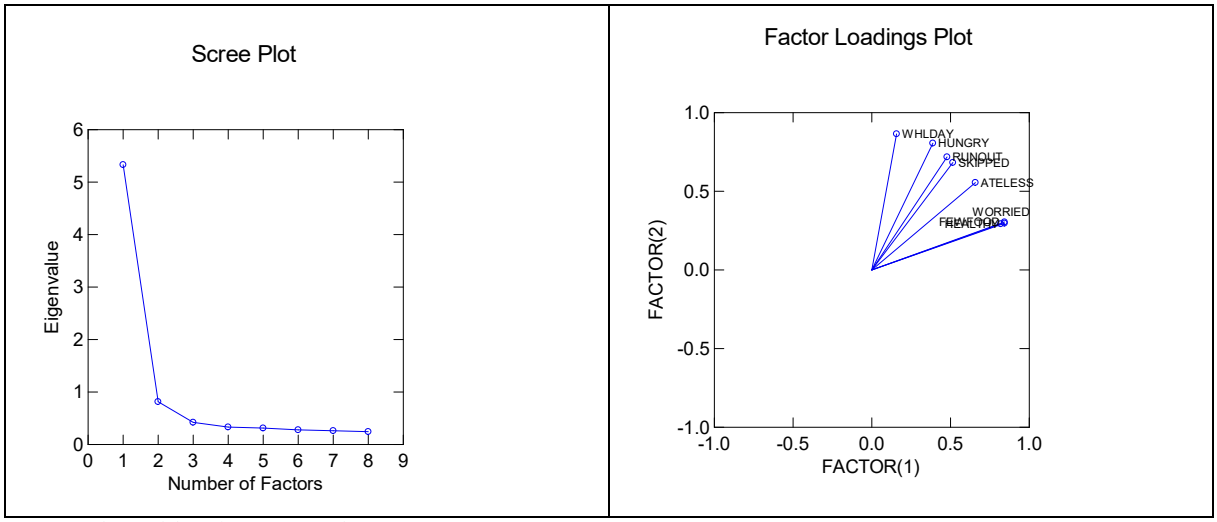
Source: author's elaborations on FIES data

In figure 3.4, the eigenvalues and the factor loadings are represented. The scree plot represents the eigenvalues and it can suggest the number of factors to be retained in the analysis, looking for the natural bend or break point in the data where the curve flattens out. The number of datapoints above the "break" is usually the number of factors to retain (Costello and Osborne 2005).

In our data the bend could be considered at the third or second factor.

The second graph presented in figure 3.5 is the representation on a three-dimensional space of the factor loadings, the weight or score of the original variables on the latent construct.

Figure 3.5. Exploratory factor analysis - Eigenvalues and Factor Loadings (VARIMAX, Gamma =1.0000)



Source: author's elaborations on FIES data

The results of the EFA suggest that the two factors refer to two different aspects of food insecurity: while the first component concerns perceptions and personal evaluations, and it seems more related to subjective aspects of food insecurity (being worried of not have enough food, eat food not nutritious and healthy, or eat less food that desired), the second concerns more "objectives" activities, such as not eat for a whole day, feeling hungry, or run out of food.

The exploratory factor analysis put out a difference from the respondents who have effectively eat less, and those who have perceived a form of food insecurity but have actually eaten.

These results suggest that part of the sample that answered positively to the first part of the scale, of the "perceived" items, did not answer positively to the questions related to experimented food insecurity. This suggests that the FIES was indeed built coherently.

Two variables - "Ateless" and "Skipped" - appear to have smaller influence on the latent factors found in the Exploratory factor analysis presented above. In fact, they present "average" loadings for both the factors. The item "Skipped" presents values very similar -but

smaller- compared to the “Runout” item. The two items refer indeed to similar experiences of lack of food in the household.

In order to verify if the results resented of cultural interferences, such gender differences, I have applied the exploratory factor analysis for women and men separately.

The results presented in the table below indicate that, even with same slight difference, the components of the “food insecurity” construct is the same (table 3.7)

Table 3.7. Exploratory factor analysis (varimax) by gender

Rotated Loading Matrix (VARIMAX)		MALES		FEMALE	
		1	2	1	2
Q1. You were worried you would run out of food because of a lack of money or other resources?	WORRIED	0.819	0.289	0.818	0.295
Q2. You were unable to eat healthy and nutritious food because of a lack of money or other resources?	HEALTHY	0.839	0.299	0.846	0.294
Q3. You ate only a few kinds of foods because of a lack of money or other resources?	FEWFOOD	0.839	0.308	0.846	0.302
Q4. You had to skip a meal because there was not enough money or other resources to get food?	SKIPPED	0.538	0.660	0.497	0.699
Q5. You ate less than you thought you should because of a lack of money or other resources?	ATELESS	0.672	0.538	0.647	0.568
Q6. Your household ran out of food because of a lack of money or other resources?	RUNOUT	0.486	0.712	0.471	0.723
Q7. You were hungry but did not eat because there was not enough money or other resources for food?	HUNGRY	0.404	0.797	0.376	0.812
Q8. You went without eating for a whole day because of a lack of money or other resources?	WHLDAY	0.164	0.867	0.153	0.864
Total variance explained		66.86	9.837	66.466	10.482

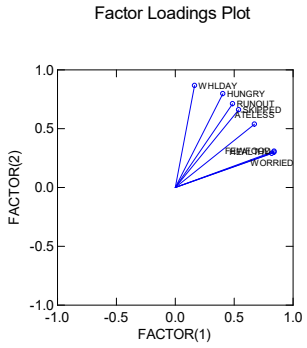
Source: author’s elaborations on FIES data

Like in the previous general example, the variables “Ateless” and “Skipped” present lower influences on the two factors, compared with the other items.

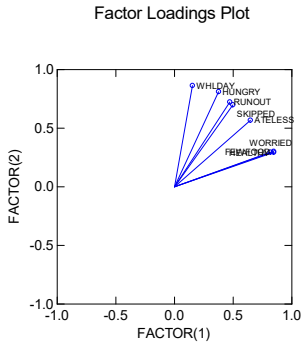
In figure 3.6 the graphs representing the factor loadings separately for the two genders are presented. No significative differences can be appraised.

Figure 3.6. Exploratory factor analysis by gender - Factor Loadings (VARIMAX, Gamma =1.0000)

MALES



FEMALES



Source: author's elaborations on FIES data

Because two important variables remain out of the exploratory analysis, the analysis has been repeated imposing three factors, in order to verify if, in this case, the two items were included. The results are presented in table 3.8. Indeed, the exploratory factor analysis shows a first component identical to the first dimension of the previous model. A second dimension comprises four variables, including the two excluded before (skipped a meal and ate less than whished, besides run out of food and feeling hungry), representing a more "quantitative" experience of food insecurity. The variable "remain a whole day without eating" stand out alone, constituting a third dimension, and explaining 16.7% of total variance. The variable presents a behaviour different from the other variables. This variable is indeed the only one completely "objective", indicating that the respondent spent an entire day without eating, because of lack of money or other resources to obtain food.

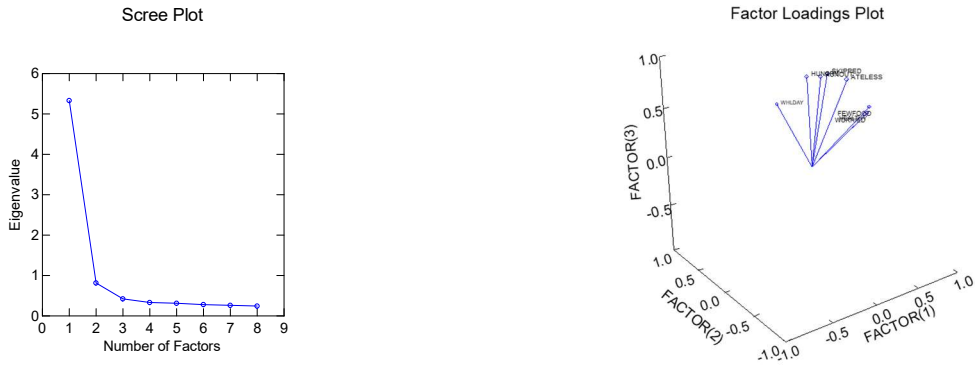
Table 3.8. Factor analysis (3 factors)

Rotated Loading Matrix (VARIMAX, Gamma =1.0000)	Factors		
	1	2	3
WORRIED	0.811	0.211	0.293
HEALTHY	0.832	0.206	0.307
FEWFOOD	0.796	0.132	0.394
SKIPPED	0.362	0.248	0.778
ATELESS	0.512	0.142	0.721
RUNOUT	0.352	0.342	0.728
HUNGRY	0.285	0.476	0.706
WHLDAY	0.215	0.901	0.328
"Variance" Explained by Rotated Components	2.628	1.341	2.599
Percent of Total Variance Explained	32.844	16.767	32.486

Source: author's elaborations on FIES data

As in the case of the two factors EFA, the scree plot indicates that two factors are enough for representing the model (figure 3.7).

Figure 3.7. Exploratory factor analysis with 3 factors- Eigenvalues and Factor Loadings (VARIMAX, Gamma =1.0000)



Source: author's elaborations on FIES data

3.3.5. Confirmatory factor analysis

In the analysis and validation of experience-based scales, Coates (2006) suggests that "in order to be certain, a confirmatory approach is needed to assess the relevance across cultures

of each of the domains and subdomains and to evaluate the appropriateness of potentially generic questionnaire items".

More precisely, Confirmatory factor analysis (CFA) is a type of structural equation modelling that deals specifically with measurement models; that is, the relationships between observed measures or indicators (e.g., test items, test scores, behavioural observation ratings) and latent variables or factors (Brown and Moore 2013).

The solution of a SEM model leads to the simultaneous determination of all the latent dimensions considered in the model. Given that these models provide the simultaneous determination of the relations between the many dimensions of well-being, poverty, or other multidimensional concepts (Fattore and Maggino 2018), SEM go beyond one-way causal relationships usually found in empirical works as they allow for the reciprocal feedback among the different latent dimensions that are constitutive of overall well-being achieved. Moreover, a full structural equation model is an efficient tool to deal with measurement error in both endogenous and exogenous variables. In this framework, the estimation of a system of simultaneous equations allows us to take into account the dependence structure, by estimating the variance and covariance matrix of the error components of the different equations. SEM appears as particularly suitable for the analysis of multidimensional phenomena (Khrishnakumar and Nagar 2008; Khrishnakumar and Ballon 2008), such food insecurity.

In CFA, only few relationships between variables and latent factors are considered, differently from EFA (Ferrara et al. 2018). For this reason, I have based the choice of the CFA models, on the results of EFA and IRT.

In CFA often arises the problem that the observed responses are discrete realizations of a small number of categories, binary in our case. The application of statistical methods that assume continuous distributions could undermine confidence in the validity of the conclusions. However, Flora and Curran (2004) demonstrated that estimation of polychronic (tetrachoric in our case) correlations is robust to modest violations of underlying normality. Similar findings are reported in Brown (2006).

The use of CFA for scale evaluation is quite common, also with categorical data (Fattore and Maggino 2018, Iglesias et al. 2016, S.J. Muncer and B. Speak 2016, Atkinson et al. 2011, only to cite some very recent studies).

The System of equation model for the eight items of the FIES is the following:

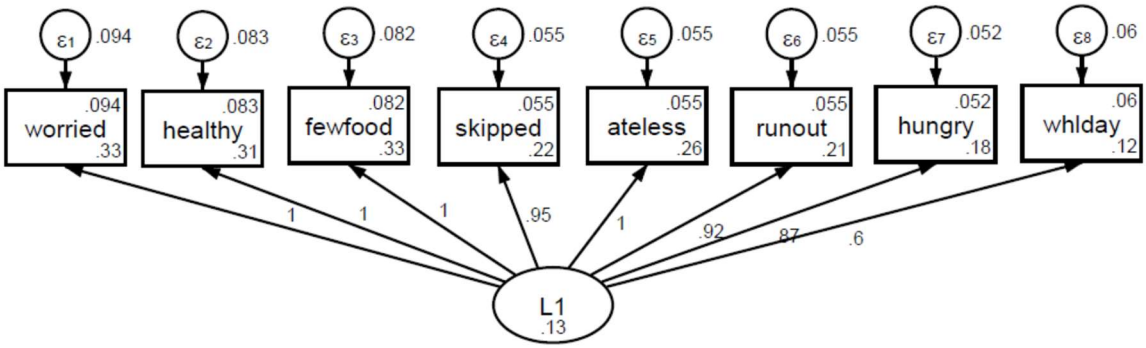
$$\begin{cases} worried = const_w + \beta_w L_1 + \varepsilon_w \\ healthy = const_h + \beta_h L_1 + \varepsilon_h \\ fewfood = const_f + \beta_f L_1 + \varepsilon_f \\ skipped = const_s + \beta_s L_1 + \varepsilon_s \\ ateless = const_a + \beta_a L_1 + \varepsilon_a \\ runout = const_r + \beta_r L_1 + \varepsilon_r \\ hungry = const_h + \beta_h L_1 + \varepsilon_h \\ whlday = const_{wh} + \beta_{wh} L_1 + \varepsilon_{wh} \end{cases} \quad [3.2]$$

where L_1 indicates the latent factor and the dependent variables are the eight items of the scale.

Each equation estimates simultaneously the constant, coefficient and error component related to the single item composing the FIES. All factors have significant coefficients, higher then 0.5, demonstrating that the observed variables sufficiently reflect the construct's latent variable (Tabachnick and Fidell 2007).

Results show that all the items have a positive and significative effect on the Latent variable "food insecurity", but the first three items present a higher value of the coefficient, thus indicating a stronger impact on the latent variable L_1, that in our case is the individual food insecurity (figure 3.8).

Figure 3.8. SEM diagram and coefficients (1 factor model)



Source: author's elaborations on FIES data

The results of this SEM allow us to analyse FIES as the cumulative distribution of the eight items, or in other words as the sum of the affirmative answers to the items, because all the items show a significative impact on the latent variable. In order to complete the evaluation of the scale, an analysis of economic and socio-demographic characteristics of individuals with

FIES should be conducted, to estimate the ability of FIES scale to measure food insecurity in different situations and in groups of people with different characteristics. This micro econometric analysis is presented extensively in Chapter 4. However, here it is useful to present some of the relations obtained in the econometric analysis of FIES, as the latent structure obtained according to the SEM in equation 3.2.

The analysis of the characteristics of individuals in relation with FIES, analysed in different regional areas (see Section 4.3) and at different level of development (see Section 4.5) shows that the drivers related to the FIES score are the level of education, the composition of the household, and that gender has also an impact, mainly in the developing countries. Another important result of the study presented in the next Chapter regards the significance of the extreme poverty factor, whose coefficient shows a significant relation among poverty and individual food insecurity. This allows to confirm the external validity of FIES, compared to a different – more established – measure of extreme poverty.

According to the results presented in figure 3.8, the coefficients present all positive values, with the items "runout" and "hungry" and "whlday" that present quite lower values. Moreover, the results of the exploratory factor analysis (see previous Section) indicate a possible bi-dimensionality of the latent construct. In particular, as shown in Section 3.3.3, the exploratory factor analysis indicates a first dimension more related to personal and perceived aspects of food insecurity, composed by the first three items: "worried", "healthy" and "fewfood" (being worried of running out of food, eat healthy food, and eat sufficient quantity of food), while a second dimension of the latent construct is given by the items "runout", "hungry" and "whlday", related to more quantitative issues of individual food insecurity (run out of food in the household, feeling hungry, staying a whole day without food).

According to the principle of parsimony in statistical modelling (Vandekerckhove 2015), and also in order to reduce the statistical burden on the interviewee (Bethelem et al. 2011), it is worth trying to verify if a lower number of items, describing two sub-scales, can measure individual food insecurity, without losing information.

In order to verify this hypothesis, it is worth conducting a second CFA, considering separately two latent constructs: one related to "qualitative" issues of individual food insecurity ("worried", "healthy" and "fewfood") and another latent construct, composed by "quantitative" items "worried", "healthy" and "fewfood". This setting appears very sensible, rationally representing two dimensions (perception and experience) of food insecurity

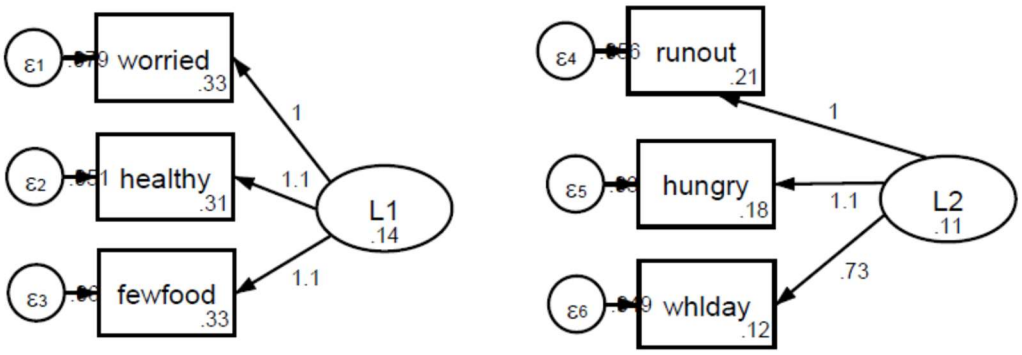
described in the literature (Coates 2006), and at the same time analogous to the results of the EFA.

Therefore, a two factors model was tested using confirmatory factor analysis for two latent variables:

$$\begin{cases} worried = const_w + \beta_w L_1 + \varepsilon_w \\ healthy = const_h + \beta_h L_1 + \varepsilon_h \\ fewfood = const_f + \beta_f L_1 + \varepsilon_f \\ runout = const_r + \beta_r L_2 + \varepsilon_r \\ hungry = const_h + \beta_h L_2 + \varepsilon_h \\ whlday = const_{wh} + \beta_{wh} L_2 + \varepsilon_{wh} \end{cases} \quad [3.3]$$

where L_1 represents the latent factor related to the first sub-scale (perceived aspects of food insecurity) and L_2 is the latent factor for the second sub-scale (actual experiences of food insecurity).

Figure 3.9. SEM diagram and coefficients (2 factors model)



Source: author's elaborations on FIES data

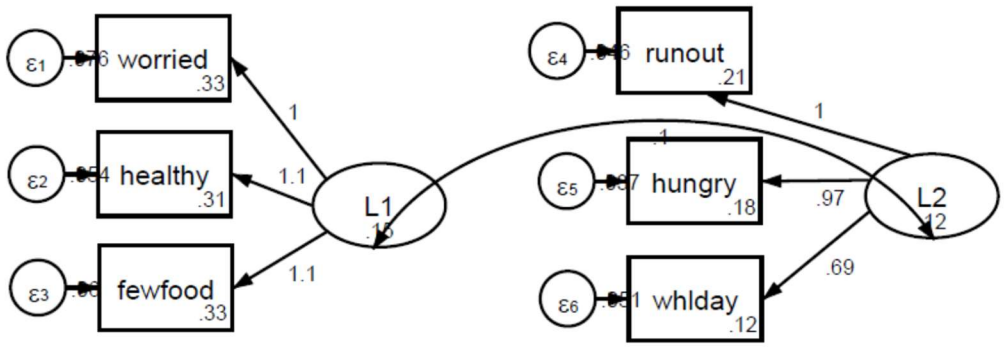
The coefficients β estimated in the model with two factors present higher values compared to the model with only one latent construct (figure 3.9). This latest model's goodness of fit is better than the previous ones (see Appendix VI). In synthesis, the Confirmatory factor analysis suggested that the two subscales model is a better model than the one related to a unique scale.

Therefore, two possible subscales were found, which correspond to a "Perceived food insecurity" subscale and an "Experienced hunger" subscale. The items cannot be considered

as eight independent items, but it appears that two scales are a better instrument than a unidimensional scale.

However, from all the above analysis, it appears that the two latent constructs cannot be considered perfectly independent. Therefore, it is worth taking into account in the model a covariance between the two latent variables (figure 3.10).

Figure 3.10. SEM diagram and coefficients (2 factors model with interaction)



Source: author's elaborations on FIES data

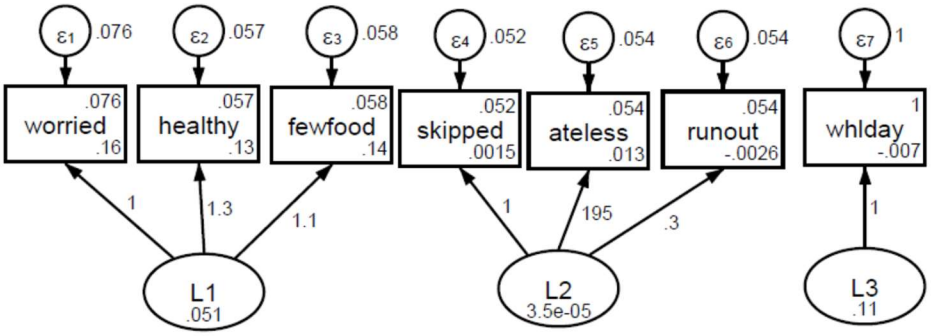
The model above presents the best results: the coefficients are higher and significant, the coefficient of determination is the highest (0.971) while the Standardized root mean squared residual is lowest (0.019).

The covariance between the two latent components is significantly higher than zero.

The empirical results meet the logic that subjective issues related to individual food insecurity are linked with more objective activities.

In order to state the robustness of the two factors model, and considering also the results of the Exploratory Factor Analysis, for the case of three factors, it is interesting to consider also a SEM that takes into account three latent variables (figure 3.11).

Figure 3.11. SEM diagram and coefficients (3 factors model)



In this last model, the statistic proprieties are worst (see Appendix VI).

3.3.6. Analysis of the validity of the FIES

Face Validity answers to the question: "Does the test 'look like' a measure of the construct of interest?". In our case, being the FIES the development of much tested and validated scales, we can consider this kind of validity as already stated.

Content Validity answers the question: "Does the test contain items from the desired 'content domain'?".

Construct Validity answers the question: "Does the test interrelate with other tests as a measure of this construct should?". Construct validity 'begins' with content validity (are these the right types of items) and then adds the question, "does this test relate as it should to other tests of similar constructs?".

More in detail, in their 1955 book, Cronbach and Meehl distinguished four types of validation: predictive validity, concurrent validity, content validity, and construct validity. The first two of these may be considered together as criterion-oriented validation procedures. Once defined the criterion the scholar wishes to predict, he administers the test, and then computes a correlation with an independent criterion measured on the same subjects. If the criterion is obtained after the test is given, he is studying predictive validity. If the test score and criterion score are determined at essentially the same time, he is studying concurrent validity.

Content validity is established by showing that the test items are a sample of a universe in which the investigator is interested. Content validity is ordinarily to be established deductively, by defining a universe of items and sampling systematically within this universe to establish the test (Cronbach and Meehl 1955).

The statistical methods to assess content validity is to study the relation of our instrument/indicator with other tools that measure the same or similar constructs. The methods could be the analysis of correlations or regression coefficients (Maggino 2006).

Construct validity is defined as the ability of an instrument to measure the concept it is supposed to measure (Cook and Campbell 1979, Shadish et al. 2002) or the "degree to which the interpretations of scores resulting from an assessment activity are 'well-grounded or justifiable" (Cook 2014).

All tests of validity are ultimately designed to verify if the measure is consistent with the theoretical concept being measured.

Validity can be assessed through convergent evidence, demonstrating that the measure correlates highly with measures of the same construct, as in this section or that groups known to differ along the construct have significantly different scores on measure (as in Chapter 4). Also factorial evidence can support the theory-based grouping of items (see Section 3.3.4).

The validation process is usually carried out after the reliability verification is complete (Maggino 2007).

Convergent validity refers to the degree to which two measures of constructs that theoretically should be related, are in fact related. It is usually measured by index of correlation. In our case, the measure available at micro level to be analysed together with the FIES score is whether or not the individual is in extreme poverty (less than 1.25 dollars a day), that is an objective situation that could determine difficulties of access to enough food.

The best measure of association between the two constructs (food insecurity and extreme poverty) is the Pearson's chi-square. A chi square (χ^2) statistic is used to investigate whether distributions of categorical variables differ from one another (Pieraccini and Naccarato 2003). A small P-value indicates strong evidence of association (Agresti 2002).

Table 3.9 shows that the two variables (FIES and extreme poverty) do not differ significantly both in the whole sample nor distinguishing the respondents by gender, age, level of education.

Table 3.9: FIES score and extreme poverty by gender, age and Education *(Chi square and significance)*

χ^2 : fies and extreme poverty association by:					
Gender	Male	Female			Total
	9900	12000			22000
	Pr = 0.000	Pr = 0.000			Pr = 0.000
Age class	15-24	25-44	45-64	65 and more	Total
	4400	8500	5900	2700	22000
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000
Education	Primary	Secondary	Tertiary		Total
	16000	1900	1800	2300	22000
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000

Source: author's elaboration on FIES data

The strong relation between the two variables is confirmed by the analysis of the coefficients of an ordered logistic model where the FIES score is the dependent variable and the extreme poverty is the independent variable, supposing that the causal relation is that the lack of money prevents people the access to food.

Table 3.10: FIES score and extreme poverty by gender, age and Education *(Logit coefficient and significance)*

FIES score	Coef.	Robust Standard Error	z	P>|z|
Total	-1.884	0.014	-139.4	0
Male	-1.848	0.020	-93.88	0
Female	-1.918	0.019	-103.1	0
Age class				
15-24 years	-1.676	0.026	-63.61	0
25-44 years	-1.822	0.021	-87.65	0
45-64 years	-2.007	0.029	-69.77	0
65 years and more	-2.165	0.049	-44.62	0
Education				
Primary education	-1.437	0.018	-79.43	0
Secondary education	-1.718	0.023	-74.91	0
Tertiary education	-1.651	0.080	-20.58	0

Source: author's elaboration on FIES data

External validity measure whether causal relationships can be generalized to different measures, persons, settings, and times (Cook 2014). In the following Chapter, an extensive analysis of the factors related to the experience-based individual food insecurity is presented.

The analysis is carried out following the FIES model as a unique scale, and it shows that the FIES-score works very well in representing the phenomenon, presenting the expected relations with variables such as the extreme poverty. In the complete model, presented in Section 4.3, the ordered logit coefficient related to "not being in extreme poverty" is significantly different from zero and presents a negative value (-0.99, in table 4.3).

In FAO (2016), the validity of the prevalence rates of food security – calculated based on FIES data - at the national level is confirmed by the analysis of the Spearman correlation between the prevalence rate and some selected measures of development (Table 3.11).

Table 3.11. Food Insecurity prevalence rate and selected Development index (Spearman's rank correlation) at the national level.

Indicator	Period	N	Food Insecurity prevalence rate	Severe Food Insecurity prevalence rate
Human Development Index	2013	136	-0.818**	-0.737**
Gross National Income per capita	2011-2013	137	-0.783**	-0.690**
Poverty headcount ratio at $1.25 a day	2010-2013	76	0.755**	0.738**
Multidimensional Poverty Index	2009-2013	42	0.642**	0.598**
Under-5 mortality rate	2013	137	0.833**	0.775**
Life expectancy at birth	2013	136	-0.754**	-0.666**
Water source (% with access)	2012	133	-0.777**	-0.703**
Sanitation facilities (% with access)	2012	130	-0.829**	-0.757**
Youth (15-24 years) literacy rate (%)	2015	113	-0.749**	-0.728**
Adult literacy rate (%)	2015	113	-0.697**	-0.721**
Prevalence of undernourishment	2014	135	0.757**	0.695**
Children aged (0-59 months) Stunting	2009-2013	102	0.666**	0.645**
Children aged (0-59 months) Underweight	2009-2013	102	0.596**	0.600**
Children aged (0-59 months) Wasting	2009-2013	101	0.345**	0.377**
Children aged (0-59 months) Overweight	2009-2013	90	-0.354**	-0.363**

Source: FAO – Voices of the Hungry

The correlations show that both the macro measures of Food Insecurity and Severe Food Insecurity present significant and high correlation in the expected direction with most accepted indicators of development (FAO 2016). Although informative, the comparisons presented above may be revealing possible spurious relations.

Therefore, in analysing the relations among FIES and the economic and social factors that could have an impact on food insecurity it would be better to rely on a micro-econometric study, such as the one presented in Chapter 4.

In the previous Section 3.3.5, we have demonstrated that the FIES could be also analysed as two sub-scales, rather than one unique scale. The first group of items ('worried', 'healthy',

'fewfood') form the "perceived" individual food insecurity sub-scale, while the second "actual experienced" sub-scale is formed by the items "runout", "hungry" and "whlday". The results of the confirmatory factor analysis are encouraging, because all the coefficients of the SEM are greater than 0.5 and the goodness of fit is good. In order to have further indications on the validity of these two subscales, an analysis of the relation of the sub-scale with the extreme-poverty has been carried out. In particular, here I present the results of an ordered logistic model on the two subscales (the one related to the "perception" of food insecurity; the other one related to the "actual experience"), in order to verify if also the two scales based on a reduced number of selected items present significant relations with significant covariates related to food insecurity.

Therefore, the dependent variable for the first subscale is "perceived FIES-score", that is computed by summing the affirmative answers to the first three items. The independent variables are the same used in the total FIES-score model (Section 4.3). The model is the following:

$$"perceived\ fies = \alpha c + \beta_1 \text{ gender} + \beta_2 \text{ age} + \beta_3 \text{ location} + \beta_4 \text{ extreme poverty} + \beta_5 \text{ marital status} + \beta_6 \text{ number of children} + \beta_7 \text{ education} + \beta_9 \text{ Region} + \varepsilon$$

The results presented in table 3.12 show indeed that the first sub-scale measuring the perceived individual food insecurity works well in representing the relations with the factors that impact on food security, presenting the expected signs.

Table 3.12 Coefficients and standard errors for the determinants of the "Perceived" Subscale

Perceived	Coef.	Robust Standard Error	z	P>|z|	[95% Conf. Interval]	
Gender (ref. Male)						
Female	0.082709	0.011148	7.42	0	0.060859	0.10456
Age	-0.00385	0.000397	-9.7	0	-0.00463	-0.00307
Education	-0.5187	0.009081	-57.12	0	-0.5365	-0.5009
Marital status (ref Single)						
Married	0.002176	0.015104	0.14	0.885	-0.02743	0.03178
Widow Divorced Separ	0.48326	0.022269	21.7	0	0.439614	0.526906
Other	0.504313	0.023855	21.14	0	0.457558	0.551068
Location (ref. Farm, rural location)						
Small town	-0.15696	0.013799	-11.37	0	-0.18401	-0.12992
Suburb						
Number of children	0.094337	0.003776	24.98	0	0.086937	0.101738
Not being in extreme poverty	-0.89119	0.016013	-55.65	0	-0.92257	-0.8598
Regions FAO (ref: Africa)						
Asia	-0.34146	0.018204	-18.76	0	-0.37714	-0.30578
America	-0.82173	0.01473	-55.78	0	-0.8506	-0.79285
Europe	-1.18183	0.018272	-64.68	0	-1.21764	-1.14602
Oceania	-1.60593	0.067627	-23.75	0	-1.73848	-1.47338
/cut1	-2.07157	0.026923			-2.12434	-2.0188
/cut2	-1.54227	0.026678			-1.59456	-1.48998
/cut3	-0.97612	0.026532			-1.02812	-0.92412

Source: author's on FIES data

The same model has been estimated for the second subscale of the "actual experience FIES-score". This measure is computed by summing the affirmative answers to the last three items of the FIES. The dependent variables are the same used in the total FIES-score model and in the previous model. For the "actual experienced" sub-scale the model is the following:

$$"actual\ experience"\ fies = \alpha c + \beta_1 \text{ gender} + \beta_2 \text{ age} + \beta_3\ location + \beta_4 \text{ extreme poverty} + \beta_5 \text{ marital status} + \beta_6 \text{ number of children} + \beta_7 \text{ education} + \beta_9 \text{ Region} + \varepsilon$$

Also for this model, the results presented in table 3.13 show that the second sub-scale measuring the actually experienced individual food insecurity presented the expected relations with the selected factors.

Table 3.13 Coefficients and standard errors for the determinants of the "Actual" Subscale

Actual	Coef.	Robust Standard Error	z	P>|z|	[95% Conf.	Interval]
Gender (ref. Male)						
Female	-0.0220934	0.0134898	-1.64	0.101	-0.0485329	0.0043461
Age	-0.0058517	0.000488	-11.99	0	-0.0068082	-0.0048951
Education	-0.5053854	0.0115616	-43.71	0	-0.5280457	-0.4827251
Marital status (ref Single)	-0.1264875	0.0182499	-6.93	0	-0.1622568	-0.0907183
Married	0.3491577	0.0265806	13.14	0	0.2970606	0.4012548
Widow Divorced Separ	0.3429988	0.0277391	12.37	0	0.2886311	0.3973664
Other	-0.0532246	0.0164971	-3.23	0.001	-0.0855584	-0.0208908
Location (ref. Farm, rural location)	-0.1538078	0.0185964	-8.27	0	-0.1902561	-0.1173596
Small town	-0.0576098	0.0265172	-2.17	0.03	-0.1095824	-0.0056371
Suburb	0.0847634	0.0871352	0.97	0.331	-0.0860184	0.2555453
Number of children	0.0653176	0.0040677	16.06	0	0.057345	0.0732901
	-0.9847897	0.0173599	-56.73	0	-1.018814	-0.9507649
Not being in extreme poverty	-0.4030504	0.0200537	-20.1	0	-0.4423549	-0.3637459
Regions FAO (ref: Africa)						
Asia	-0.9950852	0.0171796	-57.92	0	-1.028757	-0.9614139
America	-1.583045	0.0239195	-66.18	0	-1.629926	-1.536163
Europe	-1.743433	0.0961889	-18.13	0	-1.93196	-1.554907
Oceania	-0.02209	0.0134898	-1.64	0.101	-0.0485329	0.0043461
/cut1	-1.424791	0.0309091			-1.48537	-1.3642
/cut2	-0.819434	0.0308795			-0.87996	-0.7589
/cut3	-0.0922	0.0310212			-0.1530	-0.0314

Source: author's elaboration on FIES data

These results help us to conclude that shorter and more specific sub-scales could work as well as the unique scale to measure individual food security, and at the same be even more informative, measuring separately two different aspects of individual food security: the perceived and the actually experienced.

3.4. Conclusions

In this Chapter, an original analysis of the validity of FIES has been presented. The diverse aspects of reliability and validity have been analysed. Moreover, both an exploratory factor analysis and three different confirmatory factor analysis, following diverse hypothesis, have been carried out.

The FIES presents a good level of reliability and internal consistency.

Having verified also its cumulability, and its validity, both through an IRT model and a Confirmatory Factor Analysis, we can assess that the measure of food insecurity associated with a respondent can be calculated with the number of positive responses to items.

But cumulability is not perfect, and bi-dimensionality could be detected with an Exploratory Factor Analysis. Moreover, two items could be deleted without losing fundamental information.

Moreover, the analysis carried out have allowed to find out a possible alternative way to collect data on individual food insecurity, identifying two sub-scales, one related to "perceived" food insecurity, and the other related to "actual experienced" episodes of food insecurity.

Finally, the subscale measuring 'Perceived' aspect of food insecurity and the subscale related to 'quantitative' activities could be measured separately.

In conclusion, it has been possible to verify that the two sub-scales can be administered individually or combined into one scale.

In the next Chapter, FIES score as unique scale will be profusely analysed, with the aim of determining the significant factors with an impact on individual food insecurity and to verify if the scale can measure food insecurity in groups of population with different characteristics and in different occasions.

Chapter 4

Economic and social determinants of food insecurity individual experience: a study at the global level

4.1. Introduction

The comparisons of food insecurity in different economic and demographic subpopulations across countries allow a better understanding of the complex phenomenon and support policy aimed at improving the well-being of population and ending hunger.

As described in the previous chapters, even if definitions and measures of food insecurity have been widely debated, both in the political and scientific spheres, for decades, until very recently data referring to a univocal measure of food insecurity was lacking at the global level. Only starting from 2014, FAO Food Insecurity Experience Scale (FIES) has been surveyed in 149 countries all over the world, with a sample of more than 150 thousand individuals.

This Chapter presents an analysis of food insecurity, based on information on the individuals' experience of their own food insecurity, measured by FIES, together with other meaningful personal and household characteristics described in Section 4.2.2.

The objective of this part of the thesis is to assess which factors can determine individual food insecurity.

Food insecurity presents marked differences depending on the level of development of the country under consideration. To take into account these relations, countries have been grouped together using a cluster analysis, based on the indicators forming the UN Human Development Index.

The model allows us to estimate the impact of the economic, social and demographic characteristics related to food insecurity both at global level and for each group of countries, giving further evidence to the existing literature.

Level of education, composition and number of children in the household, location of the dwellings result to have a significant impact on the risk of food insecurity.

Although the FIES is not the first individual experience-based scale in the field of food security, it is the first individual-level measure that has been applied into a large number of

countries in a standardized manner. Therefore, it will be the first tool able to generate comparable disaggregated data on food security at world level. The choice of taking the individual as unit of analysis has been driven by the recognition that households do not necessarily distribute resources equitably and should not be conceived as a unique entity (Brunelli 2014).

4.2. Empirical analysis

4.2.1. Individual food insecurity at the global level

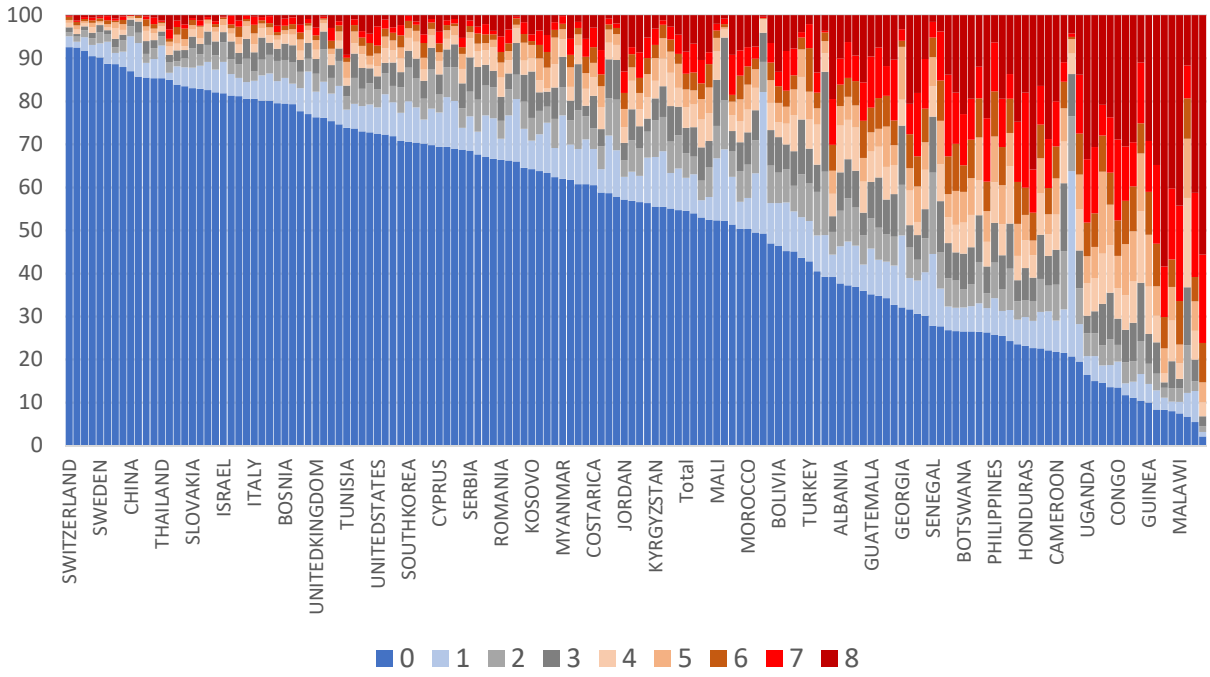
The analysis reported in Chapter 3, as it is to say, the validation of the FIES with the most advanced statistical methods, allows to conclude that - considering FIES's characteristics - the measure of individual food insecurity associated with a respondent can be calculated on the scale based on the number of positive responses to the questions (number of behaviours or experiences reported). We obtain our dependent variable: the raw score associated with the FIES scale (that we can call FIES-score) is a measure of individual food insecurity reporting the number of symptoms of food insecurity, ranging from 0 (no symptoms) to 8 (all symptoms). In this way, the dependent variable indicates whether the interviewee stated none, one or more symptoms of food insecurity.

Therefore, the FIES score can be analysed as an ordinal variable, with values from 0 (no symptoms of food insecurity) to 8 (all symptoms of insecurity). Given that the sequential order of the categories has a precise meaning (severity of the symptoms of food insecurity), it is also appropriate to use an Ordinal (or ordered) logit model for the analysis.

Being the variable FIES-score a count of the number of symptoms of food insecurity for each respondent, a Poisson or a negative binomial regression model could have been used. However, at this stage of the work, only a baseline Poisson model has been applied to the data. The results are very promising, but further research is needed in order to use the best specifications, and to apply the zero inflated version of the model, that would be even better, given the high percentage of population that presents no symptoms of food insecurity.

The distribution of the phenomenon of food insecurity, as measured by the FIES-score, is very much affected by the economic and social condition of countries, as shown in figure 4.1. The indicator captures the phenomenon also in rich and very rich Countries. Food insecurity is more severe in Africa, both using the measure based on FIES data, as well as other in other, more established, metrics and with the theoretical knowledge of the phenomenon.

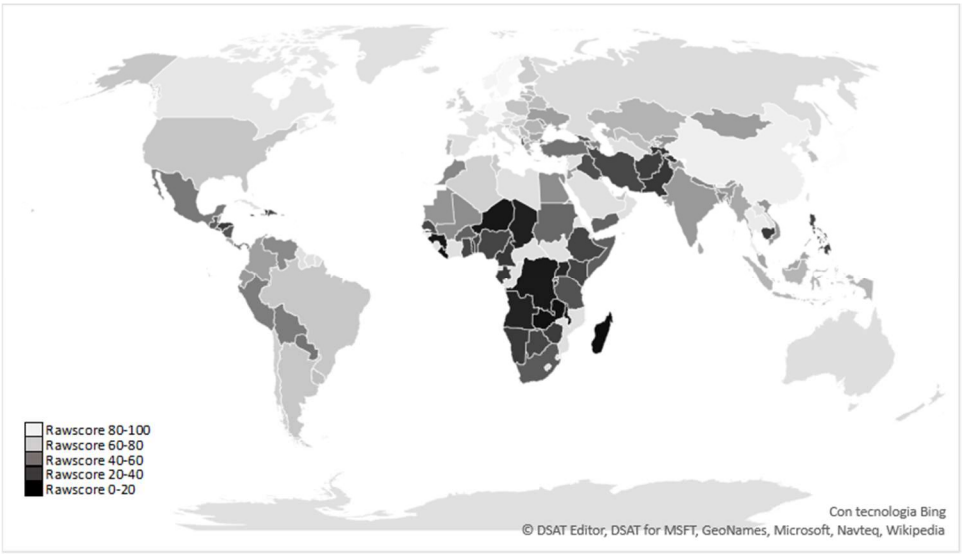
Figure 4.1. Distribution of the FIES score in the world - year 2014



Source: author's elaboration on FIES data

The distribution of the FIES score in the available countries shows that the share of individuals with zero symptoms of food insecurity ranges from 92,5% in Switzerland and Singapore to 2.1% in South Sudan (figure 4.2).

Figure 4.2. Share of population with no symptoms of food insecurity (FIES score=0)



Source: Author's elaboration on FIES data

The food insecurity situation is worst in sub-Saharan Africa, South Eastern and Western Asia. This was most notable in situations of conflict, in particular where the food security impacts of conflict were compounded by droughts of floods, linked in part to El Niño phenomenon and climate-related shocks (FAO 2018). These results are not unexpected, as noted in Section 3.6, and the measure based on FIES data is consistent with other, more established metrics and with the theoretical knowledge of the phenomenon. However, compared to the indicators at the macro level commonly used in the mentioned reports, FIES gives the possibility of analysis at the micro levels, in order to estimate the impact of economic and social factors to the individual food insecurity and to identify the groups of population most vulnerable to the risk of food insecurity.

As illustrated in the previous Chapters of the present thesis, the innovations allowed by FIES in the study of food insecurity consist in the approach of personal experience of food insecurity, and in the possibility of conducting an analysis of individual food insecurity among the first across the globe, giving original evidence on the impact of socio-economic characteristics on food insecurity for different geographical area and level of development.

4.2.2. Food insecurity related factors

In this Section, we examine food insecurity correlated factors. Following the existing literature presented below in this Section and the availability of data, we analyse food insecurity in relation with individual characteristic such as gender, age, education, and household specificity, like the number of children in the family.

World-wide level studies on the determinants of food insecurity are lacking. However, many studies have analysed individual and household food insecurity determinants in specific countries or areas. For example, Asenso-Okyere et al. (2013), study the determinants of food security in selected agro-pastoral communities in south-eastern Ethiopia. Only recently, thanks to the availability of FIES data in the GWP, some results have been available at world level (Smith 2017a; Smith, 2017b).

In literature, one of the most important and frequently reported factor related to food security is gender. Brunelli and Viviani (2014) report the study of Mark Nord on data from the National Health and Nutrition Examination Survey (NHANES), where he proved that American women are more likely to experience food insecurity than American men in households with the same food insecurity and income. Results are similar in the study

conducted by Hadley et al. (2008) that concluded that girls were more likely than boys to report being food insecure, also controlling for their households' food insecurity level. Aurino (2016) shows for India similar results: a wide pro-boy gap emerges in the middle of adolescence with 15-year-old girls less likely to consume the quality food. In South Africa, vulnerability to food insecurity appears to be more pronounced in female headed households, in comparison to male-headed (DOA, 2002). Furthermore, male-headed small-scale farm households are more food secure than female-headed households, and this finding is consistent under subjective and objective measures of food security (Tibesigwa and Visser 2016).

The present analysis shows that women experience food insecurity in a significantly larger share than men: 45.3% of the female population present at least a symptoms of food insecurity, compared with the 43.3% of men. If we consider two of more symptoms, women are food insecure in almost 40% of the population, against 32% among men (see Appendix VII for detailed tables on the empirical analysis of FIES' covariates).

As a first analysis of significance, the values of the chi-square index between FIES and its main covariates are displayed in table 4.1. The table shows also the values of the P-value corresponding to each index, as an indication of significance.

The chi-square index has been chosen because it is the most common and established measure of covariance for categorical data and because it offers a measure of significance (p-value).

The chi-square value is a single number that adds up all the differences between the actual data and the data expected if there was no difference in the distribution according to a covariate: if the distribution of FIES was independent from the distribution of the covariates, the chi-square value would be 0 (zero). The chi-square ranges from zero to infinity, thus not permitting a quantitative comparison of the index between the different covariates.

However, for our aim in this Section, the indications given by the p-values are enough to state the significance of the relations among FIES and the selected covariates. Further in this Chapter, in Section 4.3 and 4.5, the results of more complex and sophisticated analysis on the impact of these factors on food insecurity measured by FIES is presented.

Table 4.1: FIES and related factors *(Chi square and significance)*

χ^2	World	Africa	America	Asia	Europe	Oceania
Gender	71.421	44.969	45.366	41.298	198.400	11.926
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.155
Age class	1900.000	81.981	204.071	179.736	62.255	120.308
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000
Marital status	1200.000	523.301	421.698	443.319	458.370	59.217
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000
Number of children	12000.000	1200.000	908.711	1800.000	170.453	136.342
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000
Education	16000.000	1900.000	1800.000	2300.000	1700.000	41.424
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.123
Poverty	22000.000	4100.000	1200.000	2900.000	525.269	10.728
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.218
Location (rural/urban)	4500.000	1800.000	529.805	770.139	92.015	28.520
	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.000	Pr = 0.643

Source: our elaboration on FIES data

As in previous researches (Strickhouser et al. 2015; Nord 2003), also in our data younger people present higher rates of food insecurity. The share of people younger than 35 years old that are food insecure is around 40 per cent, while among elderly people 30 per cent present symptoms of food insecurity. This result could be related to a lower need of food intake for older people (Smith et al. 2017b).

With regard of determinants related to the households' characteristics, in FIES data, among married individuals, a lower percentage experiences food insecurity, as reported in Smith et al. (2017a), while being Widow, Divorced or Separated constitute a factor of vulnerability toward food insecurity.

The number of children in the household is another factor of interest in the analysis of food insecurity at household level (Asenso-Okiere et al. 2013). Our study shows a significant relation of food insecurity with the numerosity of childhood in the family.

The level of education of the interviewee is an important factor against food insecurity (d'Errico et al. 2018, Nord and Hopwood 2008, Bartfeld et al. 2006): education is a good proxy of social status at it is related to employment. In our analysis, two thirds of people with a lower level of education present at least one symptoms of food insecurity, while the share halves among more educated people.

Income and food security have common determinants, but the two phenomena are conceptually distinct. In fact, while income may determine the household's economic access to food, it by no means guarantees household food security for the later requires availability, utilization, and stability of food at all times (Rose 1999). The indicator we use to measure

extreme poverty (income lower than $1.25 per day) appears to be extremely relevant in the vulnerability to food insecurity. Clearly, among households with very low income, the share of people with no symptoms of food insecurity is only 20%, against a percentage of 62.2% among other families. This result suggests that the two phenomena are associated, but still distinct, because food insecurity can exist even in households which are not extremely poor, while, in some way, one out of five extremely poor households can afford to have enough food. This result extends similar researches that that find out that lower household income is associated with significantly higher rates of food insecurity, like in the United States (Coleman-Jensen et al. 2016).

Even if the relationship is significant everywhere, in some regions it is stronger than in others, due to urban/rural distribution of population, conflict or extreme natural events such as droughts or floods that decrease the availability of food, regardless of the household income (FAO 2018). In Africa, where FAO underlines a very fragile situation due to conflicts and natural disasters, the share of people without any symptom of food insecurity is much lower than everywhere else, regardless being poor or not.

The 2007 and 2008 rise of food prices caused an increase of hunger worldwide, pointing out the fragility of a very large urban population, that have incomes so low that any increase in the price of food put them at very high risk of food insecurity (Cohen and Garrett 2010). In 2014, the FIES data show that, after several years, among urban population the share of people with symptoms of food insecurity is still higher.

Results suggest that the factors identified are indeed strongly associated with individual food insecurity. The geographical differences impact on the gravity of the vulnerability factors but the relations with food insecurity does not change. These relations are cross-cutting across the continents; thus, they are significant regardless of geographical location, which is of great importance in the distribution of the phenomenon.

4.2.3. Representing food insecurity as a dependent variable

As shown above, the dependent variable "FIES" indicates whether the interviewee stated none, one or more symptoms of food insecurity. For multi-country analysis, food insecurity measured by FIES can be measured with different approaches.

According to a first hypothesis, food insecurity may be represented as a binary variable based on a raw score cut-off. From the econometric point of view, it can be analysed as a binary

variable: "0" indicates no self-declared food insecurity symptom, "1" when there are one or more symptoms of food insecurity, and we can therefore consider the individual "food insecure ". In this case, the model to apply is a logit model. Logit regression is a model that estimates the probability that the dependent variable is equal to 1, that is, the event it represents occurs. This approach is conceptually correct, as it can be assumed that the population with at least one symptom of food insecurity may also present the other symptoms with high probability.

Other thresholds could be: FIES raw score equal to 4 or greater versus FIES raw score 0-3, this corresponds approximately to moderately-or-severely food insecure versus secure-or-only-mildly insecure; and FIES raw score 7 or 8 versus raw score 0-6, this corresponds approximately to severely food insecure versus all others. For a more detailed presentation of threshold at the national level, see Section 2.7.

However, considering FIES as binary variable imply losing information on the FIES score. The FIES score can indeed be analysed as an ordinal variable, with values from 0 (no symptoms of food insecurity) to 8 (all symptoms of insecurity). In this case, as the sequential order of the categories has a precise meaning (severity of the symptoms of food insecurity), it is also appropriate to use an Ordinal (or ordered) logit model for the analysis.

The FIES-score is the count of the number of symptoms of food insecurity for each respondent. Therefore, a Poisson or a negative binomial regression model could be applied.

Negative binomial regression is a generalization of Poisson regression which loosens the restrictive assumption that the variance is equal to the mean made by the Poisson model. In our case the mean of the dependent variable (FIES-score) is 1.95, while the Standard Deviation and Variance are 2.76, and 7.6 respectively. Moreover, the FIES-score assumes a value of zeros in more than half of the sample (55.6%), therefore a more complete analysis for the response variable distribution should include a “zero inflated” version for both the Poisson and the negative binomial regression. The presence of large zero counts is precisely one of the main features of the FIES-score variable.

4.3. The model: social and economic factors related to the FIES

As shown in Section 4.2.2, personal and familial characteristics, such as gender, age, and education at the individual level and household income, household composition (couples, lone

parents, with or without children), and location of dwellings are factors that may influence food insecurity at the individual level.

The study analyses food insecurity measured by the FIES, in relationship with such variables. In this way, we improve the understanding of how household and individual factors affect food insecurity across countries. Moreover, comparisons of food insecurity in different economic and demographic subpopulations across the world indicate the groups of populations that may be best targeted by effective policies.

The first approach is to estimate a Logit Model, with a FIES-score recoded as a 0/1 variable, if FIES=0 then y=0 and if FIES>0 then y=1.

Logistic regression is the most common method used to model binary response data. Modelling a binary response variable using normal linear regression introduces substantial bias into the parameter estimates. Similarly to the normal regression, model being based on the Gaussian probability distribution function (pdf), a binary response model is derived from a Bernoulli distribution, which is a subset of the binomial pdf with the binomial denominator taking the value of 1. The Bernoulli probability distribution function may be expressed as:

$$f(y ; \pi) = \pi^{y} (1 - \pi)^{1-y} . \qquad [4.1]$$

Binary logistic regression derives from the canonical form of the Bernoulli distribution. The Bernoulli probability distribution function is a member of the exponential family of probability distributions, so we may structure the Bernoulli distribution into exponential family form: $f(y ; \pi) = \exp\{ \ln(\pi i(1 - \pi i)) y + \ln(1 - \pi i)\}.$ [4.2]

The link function is therefore $\ln(\pi/(1 - \pi))$, and cumulant $-\ln(1 - \pi)$ or $\ln(1/(1 - \pi))$. For the Bernoulli, π is defined as the probability of a success. The first derivative of the cumulant is π, the second derivative, $\pi(1-\pi)$. These two values are, respectively, the mean and variance functions of the Bernoulli probability distribution function. Recalling that the logistic model is the canonical form of the distribution, meaning that it is the form that is directly derived from the probability distribution function, the values expressed in equation 4.2, and the values we gave for the mean and variance, are the values for the logistic model. Estimation of statistical models using the GLM algorithm are based on the log-likelihood function. The likelihood is simply a reparameterization of the probability distribution function which seeks to estimate π, for example, rather than y. The log-likelihood is formed from the likelihood by taking the natural log of the function, allowing summation across observations during the estimation process rather than multiplication. The traditional GLM symbol for the mean, μ, is

typically substituted for π, when GLM is used to estimate a logistic model. In that form, the log-likelihood function for the binary-logistic model is given as:

$L(\mu; y) = = \sum_{i=1}^{n} \{yi \ln(\mu i/(1 - \mu i)) + \ln(1 - \mu i)\}$ [4.3]

The first model to be analysed is the following:

$g(y) = \text{logit(y)} = \alpha + \beta_1 \text{ gender} + \beta_2 \text{ age} + \beta_3 \text{ location} + \beta_4 \text{ poverty} + \beta_5 \text{ marital status} + \beta_6 \text{ number of children} + \beta_7 \text{ education} + \beta_9 \text{ Region} + \varepsilon$ [4.4]

where the logit(y)= $\ln\left(\frac{y}{1-y}\right)$, where *y* is the probability of presence of the characteristic of interest; and the dependent variable y is the binary variable obtained recoding the ordinal variable FIES-score (y=0 if FIES=0; y=1 if FIES>0) and the covariates (defined in Section 4.2.2) are:

- Observable individual characteristics: a dichotomous variable related to gender, age, dummies for marital status, and level of education;

- Household economic and social covariates: urban/rural location (dummies), a dummy for extreme poverty, and the number of children in the household;

- Country specification: a dummy for each World Region has been included, to consider in the model a characterization of the different territorial specificities (world Regions fixed effects).

The results of the model are shown in table 4.2.

Table 4.2: Logit model *(coefficients and significance)*

Binary FIES	Coefficients	Robust Std. Err	z	P>|z|	Confidence Interval 95% [95%	
Gender						
Male	0	(base)				
Female	0.0618	0.01	5.2	0.0000	0.0386	0.0851
Age	-0.0056	0.00	-13.1	0.0000	-0.0064	-0.0048
Education						
Primary	0.0000	(base)				
Secondary	-0.4717	0.01	-34.5	0.0000	-0.4985	-0.4449
Tertiary	-1.0857	0.02	-54.8	0.0000	-1.1245	-1.0468
Poverty						
Extreme poverty	0.0000	(base)				
Not extremely poor	-0.9483	0.02	-48.8	0.0000	-0.9865	-0.9102
Marital status						
Single	0.0000	(base)				
Married	-0.0169	0.02	-1.0	0.2970	-0.0487	0.0149
Separated/ Widow	0.4733	0.02	20.2	0.0000	0.4274	0.5192
Others	0.4380	0.03	16.7	0.0000	0.3866	0.4894
Number of children	0.1328	0.00	28.5	0.0000	0.1236	0.1419
Location of the household						
A rural area or farm	0.0000	(base)				
A small town or village	-0.1741	0.02	-11.4	0.0000	-0.2040	-0.1442
A large city	-0.2301	0.02	-14.3	0.0000	-0.2616	-0.1985
A suburb of a large city	-0.3790	0.02	-16.5	0.0000	-0.4240	-0.3339
World Region						
Africa	0.0000	(base)				
Americas	-0.4337	0.02	-22.4	0.0000	-0.4717	-0.3957
Asia	-0.7632	0.02	-46.9	0.0000	-0.7951	-0.7313
Europe	-1.1767	0.02	-62.4	0.0000	-1.2136	-1.1397
Oceania	-1.5972	0.07	-24.1	0.0000	-1.7273	-1.4671
Constant	1.7912	0.03	64.8	0.0000	1.7370	1.8453
Wald	22926.08					
Prob chi2	0					
Pseudo R2	0.1494					

Source: Author's elaboration on FIES data

The model has some good properties, with significant overall results and a good Rsquare value, considering the complexity of the phenomenon in analysis.

Looking at the determinants of food insecurity (Table 4.2), we find that all the covariates present significant relationships with individual food insecurity: gender, age, the number of children in the household, marital status, education, poverty, location of the dwelling, and living and world region are all associated with experiencing food insecurity.

More in detail, women, people with a lower level of education or extremely poor present a higher probability of being food insecure. An additional child in the household is associated with a 13 percentage points higher probability of experiencing food insecurity, while the older people are, the lower the probability of being food insecure.

In table 4.2a, the odds ratios related to the model [4.4] are presented, where the odds ratios are the ratio between the probability of the presence of the considered characteristic and the absence of the characteristics. Therefore, the probabilities are equal to the corresponding odds divided by one plus the odds.

The transformation from probability to odds is a monotonic transformation, meaning the odds increase as the probability increases or vice versa. Probability ranges from 0 and 1. Odds range from 0 and positive infinity.

Table 4.2a. Logit model *(odds ratios and significance)*

binaryfies	Odds Ratios	Robust Std. Err	z	P>|z|	Confidence Interval 95%	
Gender						
Male	1	(base)				
Female	1.064	0.013	5.2	0.000	1.039	1.089
Age	0.994	0.000	-13.1	0.000	0.994	0.995
Education						
Primary	1.000	(base)				
Secondary	0.624	0.009	-34.5	0.000	0.607	0.641
Tertiary	0.338	0.007	-54.8	0.000	0.325	0.351
Poverty						
Extreme poverty	1.000	(base)				
Not extremely poor	0.387	0.008	-48.8	0.000	0.373	0.402
Marital status						
Single	1.000	(base)				
Married	0.983	0.016	-1.0	0.297	0.952	1.015
Separated/ Widow	1.605	0.038	20.2	0.000	1.533	1.681
Other	1.550	0.041	16.7	0.000	1.472	1.631
Number of children	1.142	0.005	28.5	0.000	1.132	1.152
Location of household						
A rural area or farm	1.000	(base)				
A small town or village	0.840	0.013	-11.4	0.000	0.815	0.866
A large city	0.794	0.013	-14.3	0.000	0.770	0.820
A suburb of a large city	0.685	0.016	-16.5	0.000	0.654	0.716
World Region						
Africa	1.000	(base)				
Americas	0.648	0.013	-22.4	0.000	0.624	0.673
Asia	0.466	0.008	-46.9	0.000	0.452	0.481
Europe	0.308	0.006	-62.4	0.000	0.297	0.320
Oceania	0.202	0.013	-24.1	0.000	0.178	0.231
Constant	5.996	0.166	64.8	0.000	5.680	6.330

Source: Author's elaboration on FIES data

Reading the results of the model in terms of odds ratios, the results are then equivalent of the above, after a monotonal transformation.

Women appear to have a significant low disadvantage, compared with men.

In terms of percentages, we can say that people with a secondary degree have half the probability to be food insecure, compared to people with a primary level of education or less, while with a tertiary level of education the odds ratio is a third.

Logistic models have been expanded to include categorical responses, e.g. proportional odds models and multinomial logistic regression.

Given the nature of the variable, an ordered logistic regression has been applied on the dependent variable (Wooldridge 2002).

The insight is that the nine categories of the FIES score have a meaningful sequential order: a higher value shows a 'higher' level of food insecurity than the previous one (as evaluated in Chapter 3).

In this way, the results will not depend on a hypothesized distribution, as we have an ordinal variable that is considered as such in the model. Logistic regression does not require that the variables present a normal distribution, the error terms (residuals) do not need to be normally distributed, it does not need the hypothesis of a linear relation between dependent and independent variables, and it does not even require homoschedasticity. For our data, the assumptions for the Logistic Regression model are all verified: the cases are independent, and the independent variables are not linear combinations of each other.

Our dependent variable FIES, ranging from 0 (food security) to 8 (maximum number of symptoms of food insecurity) is analysed with respect to the covariates identified in the previous Section and described below. To verify the impact of such variables, we rely on a standard multivariate set-up:

$$g(y) = \text{ologit(y)} = \alpha c + \beta_1 \text{ gender} + \beta_2 \text{ age} + \beta_3\, location + \beta_4 \text{ poverty} + \beta_5 \text{ marital status} + \beta_6 \text{ number of children} + \beta_7 \text{ education} + \beta_9 \text{ Region} + \varepsilon \quad [4.5]$$

Like in the equation 4.4, the dependent variable FIES, measured by the FIES score (score of severity of food insecurity), has been analysed in relationship with:

- Observable individual characteristics: a dichotomous variable related to gender, age, dummies for marital status, and level of education;

- Household economic and social covariates: urban/rural location (dummies), a dummy for extreme poverty, and the number of children in the household;

- Country specification: a dummy for each FAO Region has been included, to consider in the model a characterization of the different territorial specificities.

The parameters c, called thresholds or cut-points, are in increasing order ($c1 < c2 < \ldots$), and $c=1, 2,\ldots,C-1$, where C is the number of categories of the ordinal variable. These cut points reflect the predicted cumulative probabilities, considering the covariates all equal to zero.

4.3.1. Results of the model: determinants of individual food insecurity

The model allows us to determine factors significantly related to food insecurity at the individual level, and also to link these results to the territorial dimension specified by the world Regions, whose characteristics have been described above, and included in the model as dummy variables.

In the analysis, all the explanatory variables identified in Section 3 appear to have a significant relationship with the dependent variable: gender, age, number of children in the household, marital status, location of the dwelling, and poverty are all associated with the probability of experiencing food insecurity. For women and for individuals who are less educated, people living in extremely poor households, or with a higher number of children, the probability of higher food insecurity increases (Table 4.3).

Table 4.3: Ordered Logit model for the FIES score *(Coefficients and standard errors)*

	Coefficients	Robust Standard Error	z	P>|z|	Confidence interval 95%	
Gender						
Male	0	(base)				
Female	0.05	0.01	4.6	0.00	0.03	0.07
Age	0.00	0.00	-12.7	0.00	-0.01	0.00
Education						
Primary	0.00	(base)				
Secondary	-0.49	0.01	-39.2	0.00	-0.52	-0.47
Tertiary	-1.13	0.02	-57.9	0.00	-1.17	-1.09
Poverty						
Extreme poverty	0.00	(base)				
Not extremely poor	-0.99	0.02	-61.9	0.00	-1.02	-0.96
Marital status						
Single	0.00	(base)				
Married	-0.04	0.02	-2.5	0.01	-0.07	-0.01
Separated/ Widow	0.45	0.02	20.4	0.00	0.40	0.49
Others	0.43	0.02	18.3	0.00	0.39	0.48
Number of children	0.09	0.00	24.8	0.00	0.08	0.10
Location of the hh						
A rural area or on a farm	0.00	(base)				
A small town or village	-0.14	0.01	-10.0	0.00	-0.16	-0.11
A large city	-0.21	0.01	-13.9	0.00	-0.24	-0.18
A suburb of a large city	-0.26	0.02	-11.8	0.00	-0.31	-0.22
World Region						
Africa	0.00	(base)				
Americas	-0.46	0.02	-25.3	0.00	-0.49	-0.42
Asia	-0.93	0.01	-63.6	0.00	-0.96	-0.90
Europe	-1.37	0.02	-75.7	0.00	-1.40	-1.33
Oceania	-1.76	0.07	-26.3	0.00	-1.89	-1.63
/cut1	-1.91	0.02			-1.96	-1.86
/cut2	-1.52	0.02			-1.56	-1.47
/cut3	-1.19	0.02			-1.24	-1.15
/cut4	-0.82	0.02			-0.87	-0.78
/cut5	-0.49	0.02			-0.54	-0.45
/cut6	-0.16	0.02			-0.21	-0.12
/cut7	0.18	0.02			0.13	0.22
/cut8	0.78	0.02			0.73	0.83
Wald chi2=						
Prob>chi2=0						
PseudoR2=0.0871						

Estimates were carried out with robust standard errors.

Source: Author's elaboration on FIES data

In particular, considering individual characteristics, gender presents a significant association with food insecurity, and women appear significantly more at risk than men, because the odds of being food insecure are higher for women than for men.

The variable ‘age’ presents an inverse relation with food insecurity: as age increases, the probability of being food insecure decreases.

As in the descriptive results and in the literature, education appears in the model as an important factor against food insecurity. In particular, achieving a Tertiary degree presents the highest coefficient.

As underlined in Section 4.2.2, extreme poverty is a very important risk factor of food insecurity, and this relationship has been discussed also theoretically in Chapter 1 (Rose 1999, Sen 1981).

Referring to household characteristics, living alone implies significantly higher risk of food insecurity than living with a partner. As found by Nord and Hopwood (2008), food insecurity increases together with the number of children in the household. Living in an urban area or in the outskirts of a big city is associated with a higher risk of food insecurity.

Considering as reference category African countries, it emerges that the risk of individual food insecurity in Africa is significantly higher than in other Regions.

In table 4.4, the results of the ordered logistic model are presented in terms of odds ratios. The odds ratios may be interpreted as the probability of being food insecure for a certain group of population, compared with the reference group.

Table 4.4: Ordered Logit model for the FIES score *(Odds ratios and standard errors)*

FIES score	Odds ratios	Robust Standard Error	z	P>|z|	Confidence interval 95%	
gender						
Male	1	(base)				
Female	1.05	0.01	4.6	0.00	1.03	1.07
Age	1.00	0.00	-12.7	0.00	0.99	1.00
Education						
Primary	1.00	(base)				
Secondary	0.61	0.01	-39.2	0.00	0.60	0.63
Tertiary	0.32	0.01	-57.9	0.00	0.31	0.34
Poverty						
Extreme poverty	1.00	(base)				
Not extremely poor	0.37	0.01	-61.9	0.00	0.36	0.38
Marital status						
Single	1.00	(base)				
Married	0.96	0.01	-2.5	0.01	0.93	0.99
Separate/divorced	1.56	0.03	20.4	0.00	1.50	1.63
Widow	1.54	0.04	18.3	0.00	1.47	1.61
Number of children	1.09	0.00	24.8	0.00	1.08	1.10
Location of the hh						
A rural area or on a farm	1.00	(base)				
A small town or village	0.87	0.01	-10.0	0.00	0.85	0.90
A large city	0.81	0.01	-13.9	0.00	0.79	0.84
A suburb of a large city	0.77	0.02	-11.8	0.00	0.74	0.80
World Region						
Africa	1.00	(base)				
Americas	0.63	0.01	-25.3	0.00	0.61	0.65
Asia	0.39	0.01	-63.6	0.00	0.38	0.41
Europe	0.26	0.00	-75.7	0.00	0.25	0.26
Oceania	0.17	0.01	-26.3	0.00	0.15	0.20
/cut1	-1.91	0.02			-1.96	-1.86
/cut2	-1.52	0.02			-1.56	-1.47
/cut3	-1.19	0.02			-1.24	-1.15
/cut4	-0.82	0.02			-0.87	-0.78
/cut5	-0.49	0.02			-0.54	-0.45
/cut6	-0.16	0.02			-0.21	-0.12
/cut7	0.18	0.02			0.13	0.22
/cut8	0.78	0.02			0.73	0.83

Wald chi2=36927.28
Prob>chi2=0
PseudoR2=0.0871

Estimates were carried out with robust standard errors.

Source: Author's elaboration on FIES DATA

4.3.2. Postestimation

We can also analyse predicted probabilities, which are usually more straightforward to interpreter than the coefficients or the odds ratios.

Marginal effects[2] show the change in probability when the predictor or independent variable increases by one unit. For continuous variables this represents the instantaneous change given that the 'unit' may be very small. For binary variables, the change is from 0 to 1, so one 'unit' as it is usually thought.

In ordinal logit models the outcome (dependent) variable has categories in meaningful order. In our data, the FIES score ranges from 0 "No food insecurity" to 8 "maximum food insecurity", so it presents nine categories.

The predicted margins are statistics calculated from predictions of a previously fitted model at fixed values of some covariates and averaging or otherwise integrating over the remaining covariates.

The predicted probability of FIES from the score 0 to the score 8 was calculated for each case, using each case's observed values of gender, education, poverty, number of children, marital status, location of the household, world Region.

The information obtained estimating the marginal effects permit a quantitative comparison, being all reported to the same "measure unit".

The predictive margins shown in table 4.5 give the probability of obtain a certain value of the FIES score.

Table 4.5. Ordered logistic model - Predictive margins (Delta-method**)**

FIES (predict)	Margin	Std. Err	Z.	P>|z|	95% confidence interval	
0	0.554	0.001155	479.8	0	0.552067	0.556596
1	0.075	0.00069	109.28	0	0.074026	0.07673
2	0.058	0.000611	94.32	0	0.056458	0.058855
3	0.059	0.000621	95.75	0	0.058239	0.060673
4	0.047	0.000555	84.4	0	0.045756	0.047932
5	0.041	0.000518	78.81	0	0.039768	0.041797
6	0.036	0.000483	73.76	0	0.034699	0.036593
7	0.048	0.000552	87.77	0	0.047384	0.049548
8	0.081	0.000674	120.84	0	0.080119	0.08276

So, in our sample, we have more than 50% probability of obtaining a FIES score equal to zero (table 4.5). This means that zero is the most common value for the FIES score.

The second highest probability refers to the "all symptoms" score.

[2] In order to estimate the marginal effects, the "margins" command of STATA has been applied. The STATA command can be used with either a categoricar and a continuous variable.

Being the null hypothesis that all the predictions are equal to zero, the value of Z and the corresponding P-values assure us that the estimations are significant.

An alternative is to calculate the predicted probability fixing all the covariates at some value, usually the mean. In this case, the mean of each independent variable has been calculated, and then the predicted probability of FIES scoring from 0 (no symptoms of food insecurity) to 8 (all the symptoms of FI) was calculated using the means already calculated.

This analysis is less interesting because we do not have any particular value of interest corresponding to the average of our variables. However, the table indicate results consistent with the previous one (table 4.6).

Table 4.6. Ordered logistic model - Predictive margins *(At the mean values of the covariates - Delta-method)*

FIES	Margin	Std. Err.	z	P>|z|		95% confidence interval	
0	0.557879	0.001464	380.98		0	0.555009	0.560749
1	0.093886	0.000862	108.89		0	0.092196	0.095576
2	0.069539	0.000744	93.45		0	0.06808	0.070997
3	0.067834	0.000721	94.04		0	0.06642	0.069247
4	0.049603	0.000602	82.45		0	0.048424	0.050782
5	0.039795	0.00052	76.46		0	0.038775	0.040815
6	0.031847	0.000448	71.04		0	0.030969	0.032726
7	0.038473	0.000473	81.41		0	0.037547	0.0394
8	0.051144	0.000527	97.04		0	0.050111	0.052177

In order to improve the interpretation of the model, it is very useful to add the estimation of the prediction according to a factor variable. In this case the predictions are repeated at each level of the variable.

For a variable we are particularly interested in, such as Region, the predicted probability is calculated treating all cases as if region was Africa, and using each case's observed values of gender, education, poverty, number of children, marital status, location of the household.

The measure indicates what would be the probability of FIES being equal to a value from zero to 8 if all the observations come from Africa. The mean of the predictions from step 1 is calculated and the steps are repeated for each value of region (table 4.7).

So, we obtain the probability that FIES assumes one of the scores from 0 (corresponding to the first value of the variable) to 8 (that is the ninth possible value) in the different world Regions.

We can appreciate that the probability for FIES of being zero (corresponding to zero symptoms of food insecurity) is greater in Oceania, slightly less in Europe, and presenting decreasing probabilities in Asia, Americas and Africa.

Table 4.7 Ordered Logistic Model - Predictive Marginal effects by World Region (Delta-method)

FIES	Region	Margins	Std. Err.	z	P>|z|	95% Confidence interval	
0	Africa	0.390	0.003	153.7	0.000	0.385	0.395
0	Americas	0.493	0.003	159.5	0.000	0.486	0.499
0	Asia	0.597	0.002	280.2	0.000	0.593	0.601
0	Europe	0.686	0.003	274.2	0.000	0.681	0.691
0	Oceania	0.761	0.011	71.9	0.000	0.740	0.781
1	Africa	0.087	0.001	109.1	0.000	0.086	0.089
1	Americas	0.087	0.001	108.2	0.000	0.086	0.089
1	Asia	0.081	0.001	106.5	0.000	0.079	0.082
1	Europe	0.071	0.001	100.2	0.000	0.069	0.072
1	Oceania	0.059	0.002	30.2	0.000	0.055	0.063
2	Africa	0.072	0.001	93.6	0.000	0.071	0.074
2	Americas	0.068	0.001	91.3	0.000	0.067	0.070
2	Asia	0.060	0.001	90.9	0.000	0.058	0.061
2	Europe	0.050	0.001	84.2	0.000	0.049	0.051
2	Oceania	0.040	0.002	25.6	0.000	0.037	0.043
3	Africa	0.079	0.001	93.1	0.000	0.078	0.081
3	Americas	0.071	0.001	89.3	0.000	0.069	0.072
3	Asia	0.059	0.001	90.2	0.000	0.058	0.060
3	Europe	0.047	0.001	80.8	0.000	0.046	0.048
3	Oceania	0.036	0.002	22.8	0.000	0.033	0.040
4	Africa	0.065	0.001	80.9	0.000	0.064	0.067
4	Americas	0.056	0.001	77.1	0.000	0.054	0.057
4	Asia	0.044	0.001	78.7	0.000	0.043	0.045
4	Europe	0.034	0.000	70.1	0.000	0.033	0.035
4	Oceania	0.026	0.001	20.6	0.000	0.023	0.028
5	Africa	0.059	0.001	74.8	0.000	0.057	0.060
5	Americas	0.048	0.001	70.4	0.000	0.046	0.049
5	Asia	0.037	0.001	72.5	0.000	0.036	0.037
5	Europe	0.027	0.000	64.1	0.000	0.026	0.028
5	Oceania	0.020	0.001	19.1	0.000	0.018	0.022
6	Africa	0.052	0.001	69.6	0.000	0.051	0.054
6	Americas	0.041	0.001	64.6	0.000	0.040	0.042
6	Asia	0.030	0.000	66.9	0.000	0.029	0.031
6	Europe	0.022	0.000	58.9	0.000	0.021	0.023
6	Oceania	0.016	0.001	18.0	0.000	0.014	0.017
7	Africa	0.072	0.001	79.5	0.000	0.070	0.074
7	Americas	0.054	0.001	69.5	0.000	0.052	0.055
7	Asia	0.038	0.001	73.6	0.000	0.037	0.039
7	Europe	0.027	0.000	61.9	0.000	0.026	0.028
7	Oceania	0.019	0.001	17.1	0.000	0.017	0.021
8	Africa	0.122	0.001	99.5	0.000	0.119	0.124
8	Americas	0.083	0.001	70.7	0.000	0.080	0.085
8	Asia	0.054	0.001	79.6	0.000	0.053	0.056
8	Europe	0.036	0.001	63.1	0.000	0.035	0.038
8	Oceania	0.025	0.002	16.0	0.000	0.022	0.028

Symmetrically, we have the maximum probability of FIES equal to 8 (maximum value of the variable, with all the eight symptoms of food insecurity registered) in Africa, then in the Americas, and less in Asia, with the lowest probabilities in Europe and Oceania.

Another variable we are particularly interested in is gender. The analysis of predicted values can help interpreting our results (table 4.8).

Table 4.8 – Ordered Logistic Model - Predictive Marginal effects by gender (Delta-method)

FIES	Gender	Margin	Std. Err.	Z	P>|z|	95% Confidence interval	
0	Male	0.560	0.002	344.580	0.000	0.556	0.563
0	Female	0.550	0.002	360.810	0.000	0.547	0.553
1	Male	0.075	0.001	108.710	0.000	0.074	0.076
1	Female	0.076	0.001	108.880	0.000	0.074	0.077
2	Male	0.057	0.001	93.430	0.000	0.056	0.058
2	Female	0.058	0.001	93.710	0.000	0.057	0.059
3	Male	0.059	0.001	94.180	0.000	0.058	0.060
3	Female	0.060	0.001	94.680	0.000	0.059	0.061
4	Male	0.046	0.001	82.790	0.000	0.045	0.047
4	Female	0.047	0.001	83.290	0.000	0.046	0.048
5	Male	0.040	0.001	77.050	0.000	0.039	0.041
5	Female	0.041	0.001	77.590	0.000	0.040	0.042
6	Male	0.035	0.000	71.900	0.000	0.034	0.036
6	Female	0.036	0.000	72.460	0.000	0.035	0.037
7	Male	0.048	0.001	83.640	0.000	0.047	0.049
7	Female	0.049	0.001	84.850	0.000	0.048	0.050
8	Male	0.080	0.001	104.030	0.000	0.078	0.081
8	Female	0.083	0.001	109.080	0.000	0.081	0.084

With a good level of significance, we can conclude that males have a higher probability of presenting the score “0” of FIES (food security), while Females have higher probability – compared to male – to present every value from 1 to 8, or, in other words, one or more symptoms of food insecurity.

Another important variable we identified in the model as one of the most important factors impacting on food insecurity is the level of education achieved.

Table 4.9 shows the probability of a certain value of FIES according to the different degree in education. Also according to this analysis, the results show that people with a primary level of education present a higher probability of scoring very high values of FIES and lowest probability of presenting zero symptoms of food insecurity.

Table 4.9 – Ordered Logistic Model - Predictive Marginal effects by level of education (Delta- method)

FIES	Education	Margin	Std. Err.	z	P>|z|	95% Confidence interval	
0	Primary	0.465	0.002	211.6	0	0.461	0.469
0	Secondary	0.570	0.002	342.5	0	0.566	0.573
0	Tertiary	0.694	0.003	232.0	0	0.688	0.700
1	Primary	0.084	0.001	108.4	0	0.083	0.086
1	Secondary	0.079	0.001	108.2	0	0.078	0.081
1	Tertiary	0.066	0.001	93.5	0	0.065	0.068
2	Primary	0.067	0.001	92.5	0	0.065	0.068
2	Secondary	0.060	0.001	93.1	0	0.058	0.061
2	Tertiary	0.047	0.001	79.4	0	0.046	0.048
3	Primary	0.071	0.001	92.6	0	0.069	0.072
3	Secondary	0.060	0.001	93.8	0	0.059	0.062
3	Tertiary	0.045	0.001	75.3	0	0.044	0.046
4	Primary	0.057	0.001	81.2	0	0.055	0.058
4	Secondary	0.046	0.001	82.7	0	0.045	0.047
4	Tertiary	0.033	0.001	65.6	0	0.032	0.034
5	Primary	0.050	0.001	75.7	0	0.049	0.051
5	Secondary	0.039	0.001	76.5	0	0.038	0.041
5	Tertiary	0.027	0.000	59.9	0	0.026	0.028
6	Primary	0.044	0.001	70.7	0	0.043	0.045
6	Secondary	0.034	0.000	71.0	0	0.033	0.035
6	Tertiary	0.022	0.000	55.2	0	0.021	0.023
7	Primary	0.060	0.001	81.6	0	0.059	0.062
7	Secondary	0.044	0.001	81.3	0	0.043	0.045
7	Tertiary	0.027	0.000	56.6	0	0.026	0.028
8	Primary	0.102	0.001	103.7	0	0.100	0.104
8	Secondary	0.068	0.001	94.3	0	0.066	0.069
8	Tertiary	0.038	0.001	55.7	0	0.037	0.040

The value added by the estimation of marginal effects is to quantify the effects of the covariates on FIES. Therefore, summing up the results of the postestimation, it is possible to conclude that for women, the probability that the dependent variable assume the value zero is significantly lower that for men; for people with Tertiary education, the probability of presenting a value of zero is more than double, comparing with those with a Secondary degree of education; that in Europe the probabilities of not being food insecure (FIES score equal to zero) are three time larger than in the Americas and a 50% higher than in Asia.

4.3.3. Analysis of robustness of the model: determinants of individual food insecurity

As each of these results entail substantial normative implications, it is crucial to examine the results in terms of robustness and sensitivity.

In order to ease the comparison across the different specifications of the model, table 4.10 provides a summary overview of the changes in coefficients from the multidimensional baseline specifications (model I) compared with new models, estimated according to different specifications. The table includes the estimates of models with different selections of covariates. In this way, we are able to understand which factors could add valuable information to the model.

First of all, we excluded from the analysis the variable related to geographical areas of residence (model II). In this case, the Rsquare decreases quite a lot but the other estimates present similar coefficients and significance. This result means that the covariate that indicates the territorial distribution of the phenomenon is very important but that the relationships between the other covariates in the model and the FIES measure of food insecurity are still important, or – in other words -that the model still represent the relations of individual food insecurity with its social and economic determinants. The Likelihood-ratio test that compares the two model is very high and significative (LR chi2=7496.79; Prob > chi2=0.0000), meaning that the role of world Regions in the model is very important. This will be taken into account in the next Section, where the model will be estimated separately for each Area.

The estimate of the model has been repeated, excluding from the analysis every time a different covariate. In model III, the "age" covariate has been deleted. In this case, the decrease of the Rsquare is much lower than in the previous case, indicating that the variable age has a lower weight in determining the model. Nonetheless, the Rsquare decrease, and therefore also this covariate can add useful information to the study of the complex phenomenon.

In the IV and V models, the covariates related to "marital status" and "location of the household" have been deleted, with similar results: a small decrease of the Rsquare and the check of the robustness of the model, whose estimates do not change sign or significance.

The Rsquare decreases more eliminating from the analysis the covariate related to the level of education achieved by the respondents (model VI). In this model too, the sign and values of the estimated coefficients do not change noticeably.

Table 4.10. Analysis of Robustness *(Robust ordered logit: coefficient and significance)*

FIES score	I	II	III	IV	V	VI
Gender ref male						
Female	0.05	0	0.063	0.094	0.045	0.086
	[0.000]	[0.976]	[0.000]	[0.000]	[0.000]	[0.000]
Age	-0.005	-0.01	-	-0.003	-0.005	-0.002
	[0.000]	[0.000]	-	[0.000]	[0.000]	[0.000]
Education ref Primary						
Secondary	-0.491	-0.684	-0.465	-0.5	-0.522	-
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	-
Tertiary	-1.127	-1.434	-1.104	-1.148	-1.181	-
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	-
Extreme poverty (<$1.25/day)						
Not in extr poverty	-0.985	-1.264	-0.988	-0.985	-1.02	-1.102
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Number of children	0.089	0.137	0.097	0.085	0.09	0.097
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Marital status ref Single						
Married/Couple	-0.04	-0.138	-0.127	-	-0.028	-0.025
	[0.007]	[0.000]	[0.000]	-	[0.064]	[0.096]
Separated/Div	0.442	0.377	0.304	-	0.452	0.489
	[0.000]	[0.000]	[0.000]	-	[0.000]	[0.000]
Widow	0.428	0.442	0.387	-	0.437	0.466
	[0.000]	[0.000]	[0.000]	-	[0.000]	[0.000]
Location ref far or rural area						
A small town or village	-0.136	-0.118	-0.141	-0.132	-	-0.2
	[0.000]	[0.000]	[0.000]	[0.000]	-	[0.000]
A large city	-0.209	-0.195	-0.216	-0.203	-	-0.384
	[0.000]	[0.000]	[0.000]	[0.000]	-	[0.000]
A suburb of a large city	-0.263	-0.218	-0.275	-0.269	-	-0.428
	[0.000]	[0.000]	[0.000]	[0.000]	-	[0.000]
World Regions ref Africa						
Americas	-0.461	-	-0.49	-0.403	-0.466	-0.557
	[0.000]	-	[0.000]	[0.000]	[0.000]	[0.000]
Asia	-0.934	-	-0.947	-0.983	-0.926	-1.039
	[0.000]	-	[0.000]	[0.000]	[0.000]	[0.000]
Europe	-1.37	-	-1.41	-1.349	-1.367	-1.614
	[0.000]	-	[0.000]	[0.000]	[0.000]	[0.000]
Oceania	-1.789	-	-1.861	-1.767	-1.829	-2.085
	[0.000]	-	[0.000]	[0.000]	[0.000]	[0.000]
cut1	-1.91	-1.772	-1.766	-1.868	-1.836	-1.627
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut2	-1.515	-1.393	-1.372	-1.476	-1.443	-1.242
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut3	-1.191	-1.082	-1.048	-1.154	-1.119	-0.924
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut4	-0.822	-0.729	-0.68	-0.788	-0.751	-0.562
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut5	-0.493	-0.413	-0.351	-0.46	-0.422	-0.237
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut6	-0.164	-0.094	-0.021	-0.133	-0.093	0.089
	[0.000]	[0.000]	[0.306]	[0.000]	[0.000]	[0.000]
cut7	0.176	0.235	0.319	0.205	0.246	0.425
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut8	0.778	0.825	0.921	0.805	0.848	1.023
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N_observations	144231	145201	144231	144231	144231	144231
Wald CHI2	37043.65	29895.1	36782.14	36157.46	36735.69	34079.9
Prob> CHI2	0	0	0	0	0	0
Pseudo R2	0.0872	0.0704	0.0868	0.0848	0.0866	0.0789

Source: author's elaboration on FIES data

It is worth mentioning that, including Countries fixed effects in the baseline model, the results do not change: the coefficients of the ordered logistic regression remain of the same sign.

4.3.4. Determinants of food insecurity in different World Regions

Both the results of the model and the analysis of robustness have emphasised the importance of the geographic component in explaining the phenomenon of food insecurity. Therefore, the ordered logit model has been estimated also separately for the different geographic areas. Repeating the analysis separately for each Region allows us to point out the peculiarities of the risk of individual food insecurity in different areas of the globe.

Table 4.11 shows the results from applying the model [4.5] for the five world Regions separately. We can appreciate several differences in the determinants of food insecurity.

First of all, the highest coefficients are related to the covariate referring to extreme poverty, and the estimates indicate that extremely poor individuals present a higher probability of being food insecure. This relationship is not significant only in Oceania.

Another very important covariates, whose significance spams in all the Regions is the level of Education achieved. The results show that individuals with a higher level of education are less likely to be food insecure in every Region, as well as in the global model. The dummies that indicate secondary and tertiary education are significantly lower that the reference value, primary education. As highlighted by Smith et al. (2017a), this result strengthens the importance of education as a determinant of food insecurity, and a higher level of education could be a tool to overcame hunger and to increase household resilience (d'Errico et al 2018).

Personal and demographic characteristics of the population present more mixed results. Women present a higher risk of food insecurity in Africa, America and Europe, while in Asia the probability of being food insecure is lower for women and in Oceania the (positive) coefficient is not significant.

Like in the global model, the "age" factor presents negative coefficients: elders appear to have a lower probability of being food insecure than young people.

The number of children in the household is definitely another factor related to the risk for being food insecure in all the FAO Regions, as well as in the global model: the higher the number of children, the higher the risk of food insecurity, and the results are significant in every world Region.

The marital status of the individual gives more mixed evidences. In Africa, in the Americas, and in Europe being married or with a partner is related to a lower risk of food insecurity, while in Asia, married people present a higher risk of food insecurity. In Oceania, married

people present a lower probability of being food insecure, but the result is not significant. Living without a partner (being single, widowed, or divorced) appears as a significant factor of fragility toward the risk of food insecurity in all the Regions.

Table 4.11. Coefficients and standard errors[(a)] for the determinants of FIES in different Regions

	Africa		Americas		Asia		Europe		Oceania	
FIES Score	Coef.	Robust Std. Err	Coef.	Robust Std. Err	Coef.	Robust Std. Err	Coef.	Robust Std. Err	Coef.	Robust Std. Err
Gender										
Male	0	(base)	0	(base)	0	(base)	0	(base)	0	(base)
Female	0.003	0.019	0.076	0.027	-0.008	0.020	0.224	0.026	0.262	0.139
Age	-0.001	0.001	-0.004	0.001	-0.009	0.001	-0.005	0.001	-0.030	0.005
Level of education										
Primary	0	(base)	0	(base)	0	(base)	0	(base)	0	(base)
Secondary	-0.319	0.021	-0.785	0.031	-0.436	0.022	-0.745	0.033	0.041	0.278
Tertiary	-0.936	0.050	-1.416	0.047	-0.980	0.032	-1.497	0.042	-0.613	0.301
Extreme poverty										
Yes	0	(base)	0	(base)	0	(base)	0	(base)	0	(base)
Not extremely poor	-1.004	0.021	-0.912	0.043	-0.942	0.031	-1.124	0.095	-0.338	0.797
Marital status										
Single	0	(base)	0	(base)	0	(base)	0	(base)	0	(base)
Married	-0.168	0.024	-0.179	0.037	0.240	0.029	-0.007	0.040	-0.428	0.210
Widow Divorced Separated	0.293	0.038	0.090	0.049	0.815	0.046	0.542	0.048	0.343	0.279
Other marital status	0.505	0.040	0.260	0.040	0.905	0.107	0.107	0.059	-0.465	0.287
Number of children	0.032	0.005	0.175	0.012	0.139	0.006	0.159	0.016	0.260	0.064
Location										
Farm or Rural area	0	(base)	0	(base)	0	(base)	0	(base)	0	(base)
Small_town	-0.215	0.022	-0.135	0.035	-0.035	0.025	-0.043	0.035	0.204	0.226
Large_city	-0.501	0.028	-0.300	0.037	-0.108	0.025	0.160	0.036	-0.279	0.294
Suburb	-0.295	0.037	-0.404	0.065	-0.260	0.039	-0.054	0.055	-0.098	0.195
Other_location	-0.105	0.134	-0.067	0.116	0.129	0.153	-0.036	0.201	0.425	1.165
/cut1	-1.890	0.036	-1.508	0.066	-0.770	0.045	-0.582	0.108	-0.194	0.882
/cut2	-1.561	0.036	-1.160	0.065	-0.300	0.045	-0.172	0.108	0.260	0.882
/cut3	-1.274	0.036	-0.886	0.065	0.065	0.045	0.217	0.108	0.635	0.885
/cut4	-0.958	0.035	-0.550	0.065	0.474	0.045	0.717	0.108	0.957	0.882
/cut5	-0.630	0.035	-0.264	0.065	0.819	0.045	1.124	0.109	1.265	0.885
/cut6	-0.298	0.035	0.005	0.065	1.190	0.046	1.524	0.110	1.530	0.888
/cut7	0.038	0.035	0.305	0.065	1.579	0.047	1.918	0.112	1.949	0.894
/cut8	0.589	0.036	1.081	0.066	2.199	0.049	2.573	0.117	2.509	0.888
Pseudo R2	0.0379									

Source: Author's elaboration on FIES data

Results regarding the relationship between living location and food insecurity give indication towards a fragility of rural areas: the dummies related to an urban location indicate a lower risk of food insecurity. Coefficients are not significant in Oceania.

The model estimated separately for the different world Regions allows to identify the population group most affected by the risk of food insecurity: people with a low level of education, extremely poor people, families with many children.

4.3.5. Extension: is gender mitigated by education and other specific factors?

This section investigates the dynamics of gender-based disparities in individual food insecurity: is women's vulnerability in food insecurity moderated by education, location or age? So far, the appearance of a pro-men gap has been documented across the whole sample. Whether gender-based differentials in food insecurity would differ across population sub-groups, as the question of whether gender inequalities in diet are exacerbated or mitigated by specific factors, such as education or poverty status, has important policy implications. To this end, the modelling approach allows for gender to vary by education, poverty, place of residence and marital status.

Following Dercon and Singh (2013), this is achieved in practice by augmenting the basic cross-sectional model using an interaction variable between the gender dummy and each of those factors.

A significance of the interaction term and a change in the gender coefficient would suggest that that specific factor magnified or mitigated gender inequalities in food insecurity (table 4.12).

While people living in every Region presents a lower probability of being food insecure, the interaction coefficients between gender and geographical region all positive for females compared to men (model VIII). We can conclude that the disadvantage of women with respect to the risk of being food insecure spam globally.

In terms of Rsquare, this interaction does not add very much to the completeness of the model, that present the same value of the index, compared with the original one. In accordance with the principle of parsimony, to be followed in the construction of the econometric model, including this interaction can be avoided.

In model IX – that include the interaction of gender with the level of education - we note that the male advantage disappears for women with a degree of secondary level (college or similar). The coefficient related to university level education is not significant. Women with a higher education are really less exposed to the risk of being food insecure, This result is interesting, but statistically it does not add very much information to the conclusion obtained by the original model (the Rsquare value is the same).

Table 4.12 Ordered logit model with interaction *(Robust coefficients and significance)*

FIES score	VII	VIII	IX	X	XI	XII
Gender ref male						
Female	0.014	-0.035	0.067	0.04	0.056	0.059
	[0.603]	[0.075]	[0.000]	[0.095]	[0.007]	[0.002]
age	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Gender*age	0.001	-	-	-	-	-
	[0.141]	-	-	-	-	-
Education ref. Primary						
Secondary	-0.491	-0.493	-0.466	-0.491	-0.491	-0.491
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Tertiary	-1.126	-1.131	-1.157	-1.127	-1.127	-1.127
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Extreme poverty (less than 1.25$ per day)						
Not in poverty	-0.985	-0.986	-0.985	-	-0.984	-0.985
	[0.000]	[0.000]	[0.000]	-	[0.000]	[0.000]
Number of children	0.089	0.088	0.089	0.089	0.088	0.089
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Marital status ref single						
Married	-0.038	-0.036	-0.04	-0.04	-	-0.041
	[0.012]	[0.016]	[0.008]	[0.007]	-	[0.007]
Separated/divorced	0.44	0.442	0.441	0.442	-	0.441
	[0.000]	[0.000]	[0.000]	[0.000]	-	[0.000]
Widow	0.43	0.431	0.429	0.429	-	0.428
	[0.000]	[0.000]	[0.000]	[0.000]	-	[0.000]
Location ref. Farm or rural area						
A small town or village	-0.136	-0.136	-0.136	-0.136	-0.136	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
A large city	-0.209	-0.208	-0.209	-0.209	-0.209	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
A suburb of a large city	-0.263	-0.261	-0.263	-0.263	-0.264	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
World Regions ref Africa						
Americas	-0.461	-0.516	-0.461	-0.461	-0.46	-0.461
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Asia	-0.935	-0.954	-0.934	-0.934	-0.934	-0.935
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Europe	-1.37	-1.525	-1.371	-1.37	-1.369	-1.37
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Oceania	-1.79	-1.902	-1.79	-1.789	-1.788	-1.788
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Interaction Gender*Region (ref male*Africa)						
Female*Americas	-	0.109	-	-	-	-
	-	[0.001]	-	-	-	-
Female*Asia	-	0.043	-	-	-	-
	-	[0.109]	-	-	-	-
Female*Europe	-	0.278	-	-	-	-
	-	[0.000]	-	-	-	-
Female*Oceania	-	0.204	-	-	-	-
	-	[0.125]	-	-	-	-
Interaction Gender*Education (ref male*Primary)						
Female*Secondary	-	-	-0.046	-	-	-
	-	-	[0.044]	-	-	-
Female*Tertiary	-	-	0.061	-	-	-
	-	-	[0.097]	-	-	-
Interaction Gender*Poverty (Extremly poor)						
Male not poor	-	-	-	-0.992	-	-
	-	-	-	[0.000]	-	-
Female not poor	-	-	-	-0.979	-	-
	-	-	-	[0.000]	-	-
Interaction Gender*Marital status (ref single)						
Male Married	-	-	-	-	-0.02	-
	-	-	-	-	[0.310]	-
Male Separated Div	-	-	-	-	0.349	-
	-	-	-	-	[0.000]	-
Male Widow	-	-	-	-	0.448	-
	-	-	-	-	[0.000]	-
Female Married	-	-	-	-	-0.055	-
	-	-	-	-	[0.005]	-
Female Separated div	-	-	-	-	0.477	-
	-	-	-	-	[0.000]	-
Female Widow	-	-	-	-	0.413	-
	-	-	-	-	[0.000]	-

Table 4.12 follows. Ordered logit model with interaction *(Robust coefficients and significance)*

FIES score	VII	VIII	IX	X	XI	XII
Interaction Gender*Location (ref Farm or rural area)						
Male*Small town	-	-	-	-	-	-0.13
	-	-	-	-	-	[0.000]
Male*Big city	-	-	-	-	-	-0.209
	-	-	-	-	-	[0.000]
Male*Suburb	-	-	-	-	-	-0.245
	-	-	-	-	-	[0.000]
Female*Small town	-	-	-	-	-	-0.141
	-	-	-	-	-	[0.000]
Female*Big city	-	-	-	-	-	-0.208
	-	-	-	-	-	[0.000]
Female*Suburb	-	-	-	-	-	-0.279
	-	-	-	-	-	[0.000]
cut1	-1.928	-1.957	-1.898	-1.915	-1.91	-1.905
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut2	-1.534	-1.563	-1.504	-1.521	-1.516	-1.511
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut3	-1.21	-1.239	-1.18	-1.197	-1.192	-1.187
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut4	-0.841	-0.87	-0.811	-0.828	-0.823	-0.818
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut5	-0.512	-0.541	-0.482	-0.499	-0.494	-0.489
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut6	-0.182	-0.211	-0.152	-0.169	-0.164	-0.159
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut7	0.158	0.129	0.187	0.171	0.176	0.181
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
cut8	0.76	0.731	0.79	0.773	0.778	0.783
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N_observat~n	144231	144231	144231	144231	144231	144231
Wald Chi2	37045.26	36999.55	37061.25	37045.2	37065.18	37052.72
R-squared	0.0872	0.0873	0.0872	0.0872	0.0872	0.0872

The interaction of gender and extreme poverty included in the model X reflects the result of the two separate variables: being extremely poor has a positive relation with being food insecure, both for men and for women.

The inclusion of the interaction between gender and marital status do not add any information at all, being the relation between food insecurity and marital status the same for both genders (model XII).

It is possible to conclude that there is not very much gain in knowledge including interactions between the variable genders and other and the other covariates, with the exception of education. In this case, we note that achieving a higher lever for education really makes a difference for women, also against food insecurity.

In terms of robustness, the fact that the interactions do not add significant information indicates that the model include all the covariates needed to describe the phenomenon, given the available data.

In terms of multicollinearity, the fact that the interactions are not relevant and do not change the sign or significance of the estimated coefficient means that the relations among covariates – that of course are present – do not affect the quality of the model. Studying this very complex

phenomenon and its even more complicated relations with explaining factors, the fear in designing a model is that some relations – like the one with gender – can be only determined by other covariates, like the one with regions. This means that, being the women's situation different in different cultures, the coefficients that determine the relation between gender and food insecurity could be spurious. Studying the interaction of the two covariates, and verifying that the coefficients of the model do not change noticeably, allow us to think that the coefficient between FIES and the covariates are not spurious. Then, adding or not the interaction term will be a choice of the scholar. A choice that can be made according to the subject of the study.

I have also analysed different interaction that could be useful to explain the phenomenon and increase the capacity of the model to represent the relations between food insecurity and the covariates. In particular, given the importance of the geographical distribution of the phenomenon, I have considered the interaction between region and education, and region and location of the household. None of them gave any improvement to the model. Also the interaction between poverty and education gave any significant indication: being poor increase the probability of being food insecure, regardless the level of education achieved.

The only interaction that gives further insight is the one between number of children and poverty: also for the household that are not poor, an high number of children in the household increases the risk of being food insecure. The inclusion of this interaction in the model slightly increase the Rsquare, therefore adding useful information. In the future, this is a characteristic of the household that is worth to analyse more in depth.

4.4. A classification of Countries by level of development

The distribution of a phenomenon could not depend exclusively on topographical elements such as spatial proximity and related metrics, but also on characteristics of the population of the areas in question (Benassi and Naccarato 2016; Benassi and Naccarato 2017). As world regions appeared too uneven with respect to the level of development, the world countries have been grouped on the basis of three indicators forming the Human Development Index (HDI), because this indicator summarizes economic and social aspects of the level of development (Anand and Sen 1997). In this way, clusters have been identified that are homogeneous with respect to the level of development measured by the indicators forming the UN Human Development Index.

The analysis of food insecurity by level of development could also be useful to verify if, in order to maximize the effects of policies on food insecurity, policy makers have to take into account also similarities in the level of development of the population of the areas in question.

Human development is a process of enlarging people's choices. The most critical ones are to lead a long and healthy life, to be educated and to enjoy a decent standard of living. Additional choices include political freedom, guaranteed human rights and self-respect - what Adam Smith called the ability to mix with others without being "ashamed to appear in public".

In order to have further insight on the analysis of food insecurity, analysing FIES by level development, I have added to the data set three indicators composing the Human Development Index (HDI), because this indicator summarizes economic and social aspects of the level of development, and it can be considered most established measure.

The (HDI) was created under the human development approach, of the economist Mahbub Ul Haq (1996). It is anchored in the Nobel laureate Amartya Sen's work on human capabilities, and it is a measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living.

The health dimension is assessed by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. The standard of living dimension is measured by gross national income per capita.

Rather than the composite human development index, that presents some drawbacks in the aggregation method (Burchi and De Muro 2016), I preferred to take into account the effects of every single dimension that the indicator considers: Life expectancy at birth, Mean years of schooling, and Gross national income (GNI) per capita. Life expectancy at birth: Number of years a new-born infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life. Mean years of schooling: Average number of years of education received by people ages 25 and older, converted from education attainment levels using official durations of each level. Gross national income (GNI) per capita: Aggregate income of an economy generated by its production and its ownership of factors of production, less the incomes paid for the use of factors of production owned by the rest of the world, converted to international dollars using PPP rates, divided by midyear population. Main data sources are, respectively, UNDESA (2015), UNESCO Institute for Statistics (2015), and World Bank (2015a), IMF (2015) and United Nations Statistics Division (2015). Data on the

Human Development Index for 2014 have been downloaded from the UN website. Some missing data (e.g. Kosovo, Somalia) have been filled with data included in the Development Report of the single countries. Then data on the three indicators have been merged with the FIES dataset.

The HDI was created under the human development approach, of the economist Mahbub Ul Haq (1996). It is anchored in the Nobel laureate Amartya Sen's work on human capabilities, and it is a measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living (UNPD 2015).

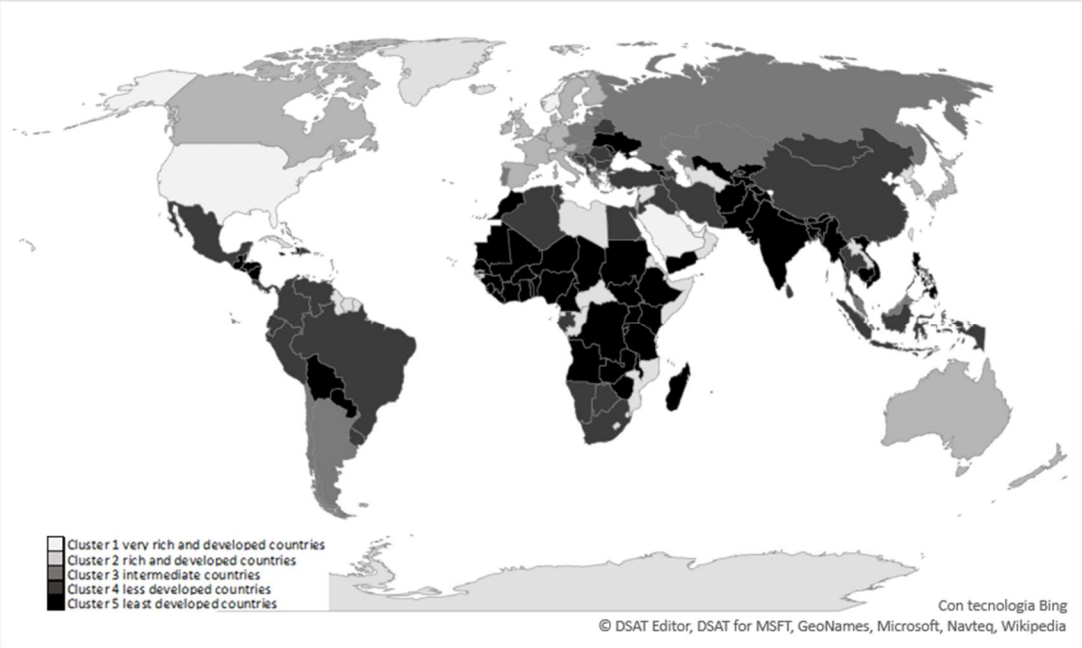
The health dimension is measured by life expectancy at birth, the education dimension is assessed by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age, while the standard of living dimension is determined by gross national income per capita.

We used three of these indicators: Life expectancy at birth, Mean years of schooling, and Gross national income (GNI) per capita. Instead of using the threshold defined for the index, that present some subjective choices in the aggregation process (e.g. a composite index using geometric mean), we prefer to group the countries with similar level of development using a Hierarchical Cluster Analysis (Ward method), as in Marden (2015). This procedure allowed us to group Countries according to their level of development, identifying similar groups to take into account into the model, in order to control the different characteristics of each Country. The results obtained are coherent with other methods of aggregation, such as hierarchical cluster with single linkage and k-means methods.

Five clusters have been obtained: 1. Countries with very high income and high level of development (HDI ranging from 0.816 to 0.944, average 0.888); 2. High income and development (West Europe, HDI from 0.824 to 0.935, av. 0.898); 3. Medium-high development Countries (Est Europe and South America, with a HDI from 0.779 to 0.880, and average 0.835); 4. Lower development (China, some Asia, North Africa, from 0.628 to 0.818, with an average of 0.741); 5. Low level of development (Africa, India, South-Est Asia, HDI ranging from 0.348 to 0.745), with an average of 0.55).

As shown in figure 4.3, as widely known in the literature, less developed countries are present mostly in the southern half of the world.

Figure 4.3. Countries by cluster



Source: author's elaboration on UN HDI data

4.5. The model: social and economic factors related to the FIES by level of development

As shown above (Section 4.2.3), personal and familiar characteristics, such as gender, age, and education at individual level and household income, household composition (couples, lone parents, with or without children), location of dwelling are factors that influence food insecurity at individual level.

The study analyses food insecurity measured by the FIES, in relation with such variables (Grimaccia and Naccarato 2018). In this way, we will improve the understanding of how household and individual factors affect food insecurity across countries. Moreover, comparisons of food insecurity in different economic and demographic subpopulations across the world indicate the groups of population that are target of most may reflect the effective policies.

In order to verify if the observed differences would be significant, we rely on the following multivariate set-up:

$$g(y) = \text{ordered logit(y)} = \alpha c + \beta_1 \text{gender} + \beta_2 \text{ age} + \beta_3 \text{ age}^2 + \beta_4 \text{ single} + \beta_5 \text{ married} + \beta_6 \text{ widow separated divorced} + \beta_7 \text{ other marital status} + \beta_8 \text{ education} + \beta_9 \text{ extreme poverty} + \beta_{10} \text{ rural area or farm} + \beta_{11} \text{ small town or village} + \beta_{12} \text{ large city} + \beta_{13} \text{ suburb} + \beta_{14} \text{ other location} + \beta_{15} \text{ cluster1} + \beta_{16} \text{ cluster2} + \beta_{17} \text{ cluster3} + \beta_{18} \text{ cluster4} + \beta_{19} \text{ cluster5} + \varepsilon \quad [4.6]$$

where the dependent variable FIES, measured by the FIES score (score of severity of food insecurity) has been analysed in relation with:

- Observable individual characteristics: a dichotomous variable related to gender, age, age square, dummies for marital status and level of education;

- Household economic and social covariates: urban/rural location (dummies), a dummy for extreme poverty, number of children in the household;

- Country specification: a dummy for each cluster has been included, in order to consider in the model a characterization of the different territorial specificities;

The parameters αc, called thresholds or cut-points, are in increasing order ($\alpha 1 < \alpha 2 < \ldots$). Their number is $c = 1,2,\ldots,C-1$, where C is the number of categories of the ordinal variable, as defined in Section 4.3.

Our dependent variable is the FIES score, obtained by the sum of affirmative answers to each of the eight questions composing the FIES. The variable, as said above, can be expressed as an ordinal variable, with values ranging from 0 (no symptoms of food insecurity) to 8 (all symptoms of food insecurity), representing the sum of affirmative answers to each of the eight questions comprising the FIES. An ordered logistic regression has been applied on the dependent variable (Wooldridge, 2002), given the ordinal nature of the variable and having verified that the nine categories of the FIES score have a meaningful sequential order.

4.5.1. Determinants of food insecurity

The model allows us to determine factors significantly related to food insecurity at individual level, and also to link these results to a general level of development specified by the clusters identified in Section 4.4.

In our analysis, all the identified variables appear to have a significant relation with the dependent variable: gender, age, number of children in the household, marital status, location of the dwelling, poverty are all associated with the probability of experiencing food insecurity. For women, less educated people, people living in extremely poor household or with a higher number of children, the probability of a higher food insecurity increases (table 4.13).

In particular, considering individual characteristics in our model, women appear more at risk of food insecurity than men.

Table 4.13. Coefficients and standard errors for the determinants of FIES score

FIES score	Coefficients	Robust Standard Errors	z	P>|z|	[95% Confidence Interval]	
Gender						
Male	0	(base)				
Female	0.035	0.012	3.05	0.002	0.013	0.058
Age	0.037	0.002	20.33	0	0.034	0.041
Age²	0.000	0.000	-21.96	0	0.000	0.000
Education						
Primary	0	(base)				
Secondary	-0.464	0.013	-35.65	0	-0.490	-0.439
Tertiary	-1.100	0.021	-52.24	0	-1.141	-1.058
Poverty						
Extremely poor	0	(base)				
Not extremely poor	-1.060	0.016	-65.15	0	-1.092	-1.028
Number of children	0.088	0.004	24.39	0	0.081	0.095
Marital status						
Single	0	(base)				
Married	-0.307	0.017	-18.35	0	-0.340	-0.274
Widow, Divorced, Separ	0.222	0.023	9.75	0	0.178	0.267
Others	0.367	0.025	14.49	0	0.317	0.416
Location						
Farm or rural area	0	(base)				
Small town	0.077	0.014	5.39	0	0.049	0.105
Large city	0.011	0.016	0.67	0.503	-0.020	0.042
Suburb	0.199	0.023	8.59	0	0.154	0.244
Other locations	0.218	0.081	2.69	0.007	0.059	0.377
Clusters						
1. Very rich and developed countries	0	(base)				
2.Rich and developed countries	-0.135	0.040	-3.37	0.001	-0.214	-0.057
3.Intermediate dev.	0.544	0.038	14.33	0	0.469	0.618
4.Less developed countries	0.869	0.035	24.49	0	0.799	0.938
5.Least developed countries	1.689	0.035	47.58	0	1.619	1.758
cut1	0.711	0.053			0.609	0.814
cut2	1.116	0.053			1.013	1.219
cut3	1.448	0.053			1.345	1.551
cut4	1.822	0.053			1.719	1.926
cut5	2.151	0.053			2.048	2.254
cut6	2.478	0.053			2.374	2.581
cut7	2.813	0.053			2.710	2.917
cut8	3.405	0.053			3.300	3.509

Source: author's elaboration on FIES and UNHDI data

The probability of experiencing food insecurity increases with age but as people get older the effect is weaker. Not including the quadratic term, age, instead, seems not a significant factor.

As in the descriptive results and in the literature, education appears in the model as an important tool against food insecurity: having a University-level education presents the highest coefficient in the model.

As underlined in par. 4.2.2, extreme poverty is a very important risk factor of food insecurity.

Referring to the characteristics of the household, people living without a partner present a significant higher risk of food insecurity than married people.

As found in Nord (2008), food insecurity increases together with the number of children in the household.

Living in an urban area or in the outskirt of a big city determines a higher risk of food insecurity.

Considering as reference category the cluster of the richest countries, it emerges that a higher level of development of the Country implies less vulnerability of the population toward the risk of food insecurity. However, in the second cluster, including slightly less rich but very developed countries, people are less likely to present symptoms of food insecurity.

4.5.2. Determinants of food insecurity at different level of development

Repeating the analysis in the different clusters allow us to point out the different peculiarities of food insecurity at different level of development (table 4.14).

Table 4.14 shows the results obtained applying the model to the five cluster separately. It is possible to appreciate several differences across different development levels in the determinant of food insecurity.

First of all, in general, women appear to have an higher probability of presenting one or more symptoms of food insecurity, but gender presents a not significant coefficient in the fifth cluster, while in cluster 1 (very rich countries, mainly in Asia) men appear more at risk of food insecurity than women.

Age is not a significant factor of risk in cluster 1, even including a quadratic term, while in all the other clusters an increase in age correspond to a significant increase in the risk of food insecurity, but the effect decreases over time.

The most important driver against food insecurity, that is significant across the globe, is the level of education: results show that individuals with a higher level of education are less

likely to be food insecure at every level of development, as in the global model. As highlighted in many authors (d'Errico 2018, Smith et al. 2017a), this result strengthens the importance of lower education as a determinant of food insecurity.

Table 4.14. Coefficients and standard errors[(a)] for the determinants of FIES in different clusters (full model)

FIES score	Cluster 1 Very rich and developed countries	Cluster 2 Rich and developed countries	Cluster 3 Intermediate development countries	Cluster 4 Less developed countries	Cluster 5 Least developed countries
Gender					
Male	(base)	(base)	(base)	(base)	(base)
Female	-.29015***	.11279*	.16623***	.08409***	-0.00177
Age	-0.01642	.05289***	.05842***	.03951***	.03044***
Age²	-1.60E-05	-.00077***	-.0006***	-.00039***	-.00032***
Education					
Primary	(base)	(base)	(base)	(base)	(base)
Secondary	-.60141***	-.61215***	-.63238***	-.31781***	-.48943***
Tertiary	-1.0207***	-1.1206***	-1.3142***	-.94915***	-1.1949***
Poverty					
Extremely poor	(base)	(base)	(base)	(base)	(base)
Not extremely poor	0.13314	-.38593*	-.55188***	-1.0986***	-1.1022***
Number of children	.06718**	.18877***	.18957***	.24684***	.03426***
Marital status					
Single	(base)	(base)	(base)	(base)	(base)
Married	0.08223	-.56535***	-.31245***	-.50341***	-.22439***
Widow, Divorced, Separ	.43249**	.32422***	.25112***	0.0489	.22613***
Others	-0.35899	-.32593***	0.08084	.4779***	.41641***
Location					
Farm or rural area	(base)	(base)	(base)	(base)	(base)
Small_town	-0.01706	.17652*	0.0862	.12114***	.06639***
Large city	.28498*	.21821**	.14518**	0.04346	-.09844***
Suburb	.41098**	.16588*	.25256**	.09148*	.3848***
Other_location	.98206***	.84909*	0.06597	0.16115	0.03896
cut1	0.58957	1.3173***	1.2203***	0.1551	-1.2132***
cut2	.99364**	1.7434***	1.6496***	.55974***	-.81008***
cut3	1.3245***	2.0877***	2.0507***	.87646***	-.47842***
cut4	1.6147***	2.4656***	2.5012***	1.2307***	-0.09713
cut5	1.9661***	2.7712***	2.8945***	1.541***	.23634***
cut6	2.3974***	3.1961***	3.2515***	1.8356***	.56818***
cut7	2.9138***	3.6518***	3.6495***	2.1369***	.90571***
cut8	3.809***	4.3988***	4.3056***	2.6452***	1.5144***
Pseudo R^2	0.02388	0.03359	0.02265	0.03614	0.04182

Source: author's elaboration on FIES and UNHDI data

(a) Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As expected, extremely poor individuals present a higher probability of being food insecure. This relation is not significant in the richer countries where this measure of extreme poverty is not able to illustrate the phenomenon.

The risk of being food insecure increases together with the number of children in the household. This relation is significant in all the clusters, as well as in the global model. Policies should take into account the more serious risk of food insecurity in the household with children, even in developed countries.

In the first cluster, that includes the richest and most developed countries, the marital status of the individuals does not appear as the most significant determinant of food insecurity. Nevertheless, widows and divorced people are more at risk of food insecurity. However, in all other clusters, living without a partner (being single, widow or divorced) appears as a factor of fragility toward the risk of food insecurity.

Results regarding the relation between location of the dwelling and food insecurity are more mixed. However, we can see that living in a small town increase the risk of being food insecurity, compared with those living in a farm or in a rural area, in clusters 2, 4 and 5. Living in a large city is a factor related with a higher probability of being food insecure, except in least developed countries, where is true the opposite. None of these two factors are significant in most developed countries. The only factor that remain significant across the five cluster is living in the suburb of a large city, and it determines a higher risk of being food insecure.

Even in the richest countries of the first cluster we have identified the population group affected by the risk of food insecurity: people with a low level of education, families with children or living in the suburbs of large cities.

The values estimated for the parameters of the global model are more similar to those of intermediate and less developed countries. This result confirms the literature and previous analysis, that state that food insecurity is more widely spread in the developing and poorer countries.

4.6. Considering FIES-score as a count variable: an application of Poisson models

FIES-score can be also been considered as an event count variable: the realization of a non-negative integer-valued random variable representing the number of symptoms of food

insecurity for each respondent. Therefore, it is possible to choose also a Poisson or a negative binomial theoretical distribution to represent it in a model.

The Poisson probability distribution, whose functional form is

$$f(y;\mu) = \frac{\mu^y e^{-\mu}}{y!} \qquad [4.7]$$

has mean and variance equal to μ.

The dependent variable FIES-score has been then analysed in relation to the factors identified in Section 4.2.2 according to the model:

$$g(y) = \text{poisson(y)} = \text{c} + \beta_1 \text{ gender} + \beta_2 \text{ age} + \beta_3 \text{ location} + \beta_4 \text{ poverty} + \beta_5 \text{ marital status} + \beta_6 \text{ number of children} + \beta_7 \text{ education} + \beta_9 \text{ Region} + \varepsilon \qquad [4.8]$$

Table 4.15 shows the results estimated in the model.

Table 4.15: Poisson regression model for the FIES score *(Coefficients and standard errors)*

FIES score	Coefficient	Robust Standard Error	Z	P>|z|	Confidence interval 95%	
Gender						
Male	0	(base)				
Female	0.010	0.004	2.520	0.012	0.002	0.017
Age	-0.003	0.000	-20.460	0.000	-0.003	-0.003
Education						
Primary	0	(base)				
Secondary	-0.29	0.00	-67.6	0.00	-0.30	-0.29
Tertiary	-0.88	0.01	-99.7	0.00	-0.90	-0.86
Poverty						
Extreme poverty	0	(base)				
Not extremely poor	-0.477	0.005	-100.180	0.000	-0.486	-0.468
Marital status						
Single	0	(base)				
Married	-0.037	0.005	-7.12	0.000	-0.047	-0.027
Separate/divorced	0.234	0.007	32.03	0.000	0.219	0.248
Widow	0.236	0.008	30.05	0.000	0.220	0.251
Number of children	0.036	0.001	35.63	0.000	0.034	0.038
Location of the hh						
A rural area or on a farm	0	(base)				
A small town or village	-0.058	0.005	-12.65	0.000	-0.067	-0.049
A large city	-0.118	0.005	-21.52	0.000	-0.129	-0.107
A suburb of a large city	-0.113	0.008	-14.33	0.000	-0.128	-0.097
World Region						
Africa	0	(base)				
Americas	-0.211	0.006	-35.75	0.000	-0.222	-0.199
Asia	-0.602	0.005	-115.30	0.000	-0.612	-0.591
Europe	-1.039	0.007	-141.38	0.000	-1.053	-1.024
Oceania	-1.354	0.033	-41.15	0.000	-1.419	-1.290
Constant	1.728	0.007	240.74	0.000	1.714	1.742
Deviance goodness-of-fit=420237	**Prob>chi2=0**					
Pearson goodness-of-fit=467984.9		**Prob>chi2=0**				
PseudoR2= 0.1801						

Source: Author's elaboration on FIES data

The first result is that the Adjusted Rsquare is higher (0.18), compared with the ordered logit model. Considering only the ordinal nature of the dependent variable caused some losing of

information. However, the results in terms of relations with explanatory variables remain almost the same.

The probability to be more food insecure is higher for women than for men. Food insecurity decreases with the increase of age. A higher level of education determines a lower number of symptoms of food insecurity. In particular, having achieved a tertiary education presents the highest coefficient in the model. As in the literature and in the results presented in the previous models, being in a condition of extreme power

We have thus explored four possible regression models, the first two related to the Poisson and the negative binomial distributions, and the other two related to the zero-inflated version of the two abovementioned models.

We chose to study also the zero-inflated Poisson (ZIP) and zero-inflated negative binomial (ZINB) regression models since they handle the phenomenon of over-dispersion by changing the mean structure to explicitly model the presence of zero counts. The presence of large zero counts is precisely one of the main features of the job vacancy variable. In order to achieve a zero-inflated model one chooses a model for the probability of having a specified count, e.g. a Poisson model, and “inflates” the zero-count prediction by introducing an additional a parameter to rise the probability of zero count given by the Poisson model.

Table 4.16. Zero Inflated Poisson regression model for the FIES score *(Coefficients and standard errors)*

FIES score	Coefficient	Robust Standard Error	z	P>|z|	Confidence interval 95%	
Gender						
Male	0	(base)				
Female	-0.007	0.004	-1.810	0.070	-0.015	0.001
Age	0.000	0.000	-2.780	0.005	-0.001	0.000
Education						
Primary	0	(base)				
Secondary	-0.124	0.004	-27.72	0.000	-0.133	-0.115
Tertiary	-0.438	0.011	-38.58	0.000	-0.461	-0.416
Poverty						
Extreme poverty	0	(base)				
Not extremely poor	-0.203	0.005	-42.95	0.000	-0.212	-0.194
Marital status						
Single	0	(base)				
Married	-0.046	0.005	-8.56	0.000	-0.056	-0.035
Separate/divorced	0.076	0.008	10.17	0.000	0.062	0.091
Widow	0.048	0.008	5.95	0.000	0.032	0.064
Number of children	0.006	0.001	5.87	0.000	0.004	0.008
Location of the hh						
A rural area or on a farm	0.000	(base)				
A small town or village	0.000	0.005	-0.06	0.949	-0.010	0.009
A large city	-0.003	0.006	-0.60	0.549	-0.015	0.008
A suburb of a large city	0.032	0.008	3.91	0.000	0.016	0.049
World Region						
Africa	0	(base)				
Americas	-0.063	0.006	-10.59	0.000	-0.075	-0.052
Asia	-0.301	0.005	-55.38	0.000	-0.311	-0.290
Europe	-0.507	0.009	-57.69	0.000	-0.524	-0.490
Oceania	-0.682	0.054	-12.70	0.000	-0.788	-0.577
Constant	1.823	0.008	240.07	0.000	1.808	1.838
Inflate cons	0.124	0.006	21.45	0.000	0.113	0.136

Source: Author's elaboration on FIES

The Vuong test indicates that the zero inflated version is better than the standard one.

4.7. Conclusions

This Chapter provides original evidence on the determinants of food insecurity using the FAO food insecurity experience scale. Thanks to this indicator available at individual level, we have obtained a more realistic measure of food insecurity. We have been able to capture the factors related to food insecurity also in very rich and developed countries.

We have been able to find out the personal and family factors of risk related to food insecurity across the globe. We have also identified the population groups more at risk of food insecurity: women, people living in household with children, low educated people. The empirical results show that gender-based differentials in food insecurity are widespread all over the world.

A further improvement of the research could focus in a more in-depth study on gender and education effects on the risk of food insecurity, being these factors the most significant in our

analysis. Moreover, the lack of the time dimension in the data has limited our analysis to the social and economic factors of food insecurity. Hopefully, with data available for a longer period, the study could achieve more final results.

In any way, our research has achieved the identification of population groups that could be made subjects of specific evidence-based policies with important impact in different countries all over the world.

Conclusions

The Food Insecurity Experience Scale (FIES) presents a notable innovation, and its validation and analysis carried out in this thesis are original contributions to the research devoted to food security and its economic and social determinants.

Starting in 2014, the FIES has been incorporated into the Gallup World Poll questionnaire, enabling for the first time to collect cross-culturally comparable information on food insecurity from individual respondents.

Even if measures of food insecurity at individual and household level existed, a common metric - able to measure food insecurity based on personal experience at the global level - was not available to be studied and used for policies. Data comparable worldwide where drawn by macroeconomic measures at the national level, and the monitoring of food insecurity was carried out at country level, thus not permitting to analyse the characteristics of food insecure people and to determine the economic and social personal factors related to individual food insecurity. Measures at household or individual level were developed and used at local level, starting from the Nineties in the US, and then in Latin America, but an instrument able to collect the direct experience of individuals across the globe was missing.

In this framework, the indicator based on the FIES has been included in the set for monitoring the Goal 2 of the SDGs: "Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)".

The present thesis offers a first original contribution, placing food insecurity self-reported measures, and FIES in particular, among the huge literature on food security, in order to capture the theoretical and epistemological background of self-experienced food security measure.

Another original contribution lies in the critical and systematical review of the literature on subjective and objective measure, contributing to the clarify the conceptualization of the differences among quantitative, subjective, and direct measure of a complex phenomenon such as food security, in analogy with a similar – but different – situation as poverty.

Furthermore, an analysis of the validity of FIES has been presented. The diverse aspects of reliability and validity have been analysed, through original and statistical sophisticated methods. The FIES presents a good level of reliability and internal consistency. Having verified also its cumulability, and its validity, through an Item Response Theory model, it can

be assessed that the measure of food insecurity associated with a respondent can be calculated with the number of positive responses to items.

However, cumulability is not perfect, and bidimensionality could be detected with an Exploratory Factor Analysis. Moreover, two items could be deleted without losing fundamental information.

Therefore, three different confirmatory factor analysis (CFA), following diverse hypothesis, have been carried out, using the Simultaneous Equation Model methodology.

The CFAs have allowed to find out a possible alternative way to collect data on individual food insecurity, identifying two sub-scales, one related to "perceived" food insecurity, and the other related to "actual experienced" episodes of food insecurity. The FIES, the subscale measuring 'Perceived' aspect of food insecurity and the subscale related to 'quantitative' activities have been tested against poverty, and in relation with other factors of food security, verifying that the two sub-scales can be administered individually or combined into one scale.

Moreover, FIES score as unique scale has been deeply analysed, with the aim of determining the significant factors that have an impact on individual food insecurity and of verifying if the scale can measure food insecurity in groups of population with different characteristics and in different occasions. Thanks to the FIES measure, surveyed with the same methodology in 147 countries, it has been possible to estimate a model to evaluate the effects of individual characteristics on food insecurity at the global level, offering further insight into the study of determinants of individual food insecurity worldwide. Different clusters of countries with homogeneous levels of human development have been identified and the model has been also estimated in each cluster. In this way, it has been possible to compare the results obtained at the global level to those of each cluster. Through this analysis, we find out which factors are common determinants, and which are specific to a certain level of development. Population groups most at risk of food insecurity have been identified: these can be made the object of tailored policies against hunger.

The analysis confirms that it is possible to determine individual characteristics of food insecure people across countries with wide cultural, social, and economic differences.

Empirical issues identify the risk factors and the most vulnerable population subgroups at different level of development of a country, taking into account similarities in social and economic conditions of countries and not only their geographic contiguity.

In the richest and more developed countries (clusters 1 and 2), key determinant of food insecurity is having a lower level of education, often related to having no a decent job. As for poverty, households with many children should be made the subject of specific policies against food insecurity.

In addition to these determinants, in less developed countries (clusters 3, 4, 5), gender appears to have a significant impact on food insecurity, and women are more at risk of food insecurity and thus should also be a target of policies.

A higher risk of food insecurity is related to dwelling in the suburbs of large cities. This area is particularly fragile at every level of development.

Identifying the specific characteristics of individuals at risk of food insecurity makes it possible to plan policies against hunger in a more targeted way, both in countries that appears more food insecure at the macro level and in the richest countries.

FIES has some limitations. One is that it lacks information on children's food insecurity. Furthermore, a shorter period of recall (e.g. the previous 30 days) could be more appropriate, helping remember the experiences of food insecurity. Correspondingly, the survey's administration should be increased to take into account seasonality. Moreover, with data available for a longer period, the study could achieve more definitive results using a panel methodology.

Data on income and consumption surveyed at the individual level, collected alongside with experienced food insecurity, could provide further insight into factors of risk of food insecure people.

Further research can be devoted to the development of a composite indicator, that could synthetize the information of FIES – or of the two sub-scales identified – according to the results of the CFAs, using the weights found out in the SEM applications.

An alternative – and very promising – way of approaching the analysis of FIES could be the application of partial ordered sets (POSET). Among the new approaches in constructing synthetic indicators, POSET theory is gaining importance in the international panorama. POSET allows to produce a synthetic indicator that is the result of multiple pairwise comparisons between the vectors of values of the different statistical units, resulting in a non-compensative approach to the definition of composite indicators. The POSET method could be employed for the construction of an individual assessment scale, also at the different levels of development. However promising the method, computational problems could arise, in

particular using all the eight items of FIES. A more promising application could be on the two subscales separately.

FIES data can be included in a more generalized attention to personal and experiential information. In the recent years, mostly after the economic and financial crisis, both the economics theory and empirical analysis extended their vision from the macro indicators to a micro approach. Keeping the level of analysis to individuals or households permits to better refine and focus economic and social policies, to population group characterized by particular factors that can be kept under consideration when building policies.

As in a system like the Sustainable Development Goals, micro indicators should be monitored alongside with macro indicators, that remain as unavoidable benchmarks for the comparisons of nations in time and place.

In the next few years, I expect that more analysis on both macro and micro indicators together should be conducted.

It does not happen very often in the life of a researcher to work on innovative data and models, available, for the first time, all over the world, to have the opportunity to validate them, and to contribute in providing indicators that can be used to improve dramatically people's life. This thesis - focused on food security based on the new FIES scale, that compared with other methods, such as anthropometric measures or data collected with household surveys, benefits for a timely availability of detailed individual data comparable at world level - is one of these rare cases. The work, among many other things, gives a first innovative example of an extended analysis possible with FIES data, also together with macro data at country level that I believe should be followed and pursued further.

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List of Acronyms

CFA Confirmatory Factor Analysis

CFS Committee on World Food Security

CSI Coping Strategies Index

FAO Food and Agriculture Organization of the United Nations

FBS Food Balance Sheets

FS Food Security

GDP Gross Domestic Product

GHI Global Hunger Index

GWP Global World Poll

FIES Food insecurity Experience Scale

HDI Human Development Index

HFIAS Household Food Insecurity Access Scale

IFPRI Institute for Food Policy Research

ILO International Labor Organization

MDGs Millennium Development Goals

PCA Principal Component Analysis

POU Prevalence of Undernourishment

PPP Purchasing Power Parity

OECD Organization for Economic Co-Operation and Development

SDGs Sustainable Development Goals

SEM Structural Equation Models

UN United Nations

UNDP United Nations Development Programme

UNICEF United Nations International Children's Emergency Fund

WFS World Food Summit

WHO World Health Organization

Appendix I

Innovative approaches in the conceptualization and measurement of food security: conversations with a statistician and an economist on combining objective and subjective measures

Interviews on the Pros and cons of objectives and perceived measures of food insecurity, referring to the FIES, also with respect to the capability approach.

I discuss this issue with two scholars who have deep knowledge of the capability approach and of food security and quality of life measure, but with different approaches: a statistician and an economist.

Filomena Maggino, professor of Social Statistics at Sapienza University of Rome (Italy) has been president of the International Society for Quality-of-Life Studies (ISQOLS), President and Co-founder of the Associazione Italiana per gli Studi sulla Qualità della Vita (Italian Association for Quality-of-Life Studies), Board member of the Research Committee on "Social Indicators" RC55 of the International Sociological Association, and member of International Association of Survey Statisticians (associated ISI – International Statistical Institute), European Association of Methodology, European Survey Research Association, Human Development and Capability Association, Società Italiana di Statistica. She is Editor-in-Chief of Social indicators Research (Springer). In the ambit of statistics applied to social research, has three main fields of research: data production, with particular reference to subjective data assessment, data analysis, with particular reference to multivariate and dimensional analysis and analytical procedures related to scaling models and complex indicators construction, and data presentation and dissemination, with particular reference to defining a model aimed at assessing their quality.

Mohan Rao, professor at the University of Amhest, Massachussets, Schumpeter Prize at Harvard University, Advisor to FAO, Consultant to UNDP, in the editorial Board of Journal of Agrarian Change, Journal of Human Development, QA-Rivista dell'Associazione Rossi-Doria, World Development, his main fields of research are Development Theory, Globalization, Theory of the State, Developing Agriculture. Among his publications, he wrote a*n Assessment of Research Needs for Food Security in Bangladesh* for the National Food Policy Capacity Strengthening Programme (FAO).

Interview with experts on subjective measures of food security

Filomena Maggino

1. *The first issue is the use of subjective/perceived indicators in the capabilities approach: is it correct? is it useful? Which advantages can be obtained with the use of subjective rather than objective indicators?*

If we use the term "subjective" in referring to the definition of phenomena, then there is no objective measure in the world, because the definition of phenomena is always subjective. We consider objective what is actually shared, and when a definition is shared, we consider it as "objective". But it is always our vision of the world, which, although shared, is ours and does not exist in nature.

In social sciences, and therefore also in economics, whatever we measure, we measure it because we have defined it, and definition is a subjective exercise.

This argument is also accepted by scientists of hard sciences, for example by physicists, so that social scientists must reconcile themselves to the fact that we have a vision of the world defined by ourselves.

The definition of subjective can also be attributed to the way we measure phenomena. If there is a subjective method of measuring a certain issue, it is clear that we do not have to accept it, because when we measure, we want to make comparisons, on different places, on different people. That is why we define and use measurement methods that ensure comparison, thus being the same in different location or with different people. In this sense, there must not be used "subjective" measurements in the sense that they measure a certain theme in different ways in different occasion of analysis.

This problem does not arise in science in general, because science exists because there is the method. I have the method because I want to make measures comparable.

There is a third framework in which we can use a "subjective" approach. When we look at reality, we realize that there are aspects directly observable and others that are not. And to detect the latter, we have to ask people directly, and they have to express themselves. For this kind of information, we can only ask the subjects, and in this case we have a subjective dimension.

If I want to know which level of education a person has achieved, I can ask him or use other methods, such as consulting registers. This indicator is objective, even if I ask directly the person, because I have other method, such as registers or archives, to collect the same information. This is a measure I can consider as objective even if I observe it asking the subject.

Clearly, in the data collection process, there could be errors, but errors can occur in any method of collect data.

However, if to get that information I am looking for I can only ask directly to that person the question on the phenomena I am interested on, because it refers only to that person, then that is a subjective measure. In this context, there are many individual or personal capacity and affective measures, such as opinions, evaluations of feelings or emotional states, typically measured with reference to a particular point in time.

Now that we have clarified the terms “subjective” and “objective”, with the three dimensions we can refer to, we understand that economics also uses subjective measures scientifically.

This is also the reason why reality is measured through indicators: because there are no direct measures. There are no direct measures because we have to define reality from our point of view and therefore, in the moment we define it, we pull out indicators to measure it. We talk about indicators because we observe a complex reality and almost never speak of a single indicator, but we describe reality with many different indicators.

2. The second topic is related to Food Security: is there a gain to the knowledge of a phenomenon such as FS using subjective indicators?

With respect to capabilities, it is not always clear what the point should be. It is an exceptional and very important perspective, which has made a breakthrough in how to look at reality, but this shift has also been made by other theories, and we must take into account also the contribution that has been given by other approaches.

Speaking of well-being, both in general and in relation to specific issues such as food security, one must decide whether to focus on outcome or process measurements. If you measure outcomes, measure goals, you can identify result indicators, but you lose control over the process leading to those

outcomes, even if the processes themselves might be policy-related. Instead, with the use of outcome indicators, the ultimate goal can be controlled very well, leaving policy makers free to choose how to reach that target. For example, in order to achieve an improvement in life expectancy, policy makers can decide whether to invest in prevention, healthcare, and to fight pollution. You can use so many different ways, but the evaluation is done not on processes but on goals. For example, in the BES Committee, it was decided to focus on the outcome, regardless of the processes implemented to achieve these goals.

By doing so, this perspective places the attention on the determinants: if I go on the goals, one must study the determinants, because it is on the determinants that policy makers can work.

Instead, the capabilities approach relies more on processes than on objectives. Despite this prospect being valuable, the goals should not be put on the fact that I create every possible opportunity for the citizen, but I must decide whether these opportunities make them achieve the goal of well-being. But when a goal is defined, you should remember that the goal is that well-being should be distributed across all groups: men and women, generations, different capabilities, and then it becomes a problem of equity.

Reasoning in terms of capabilities, if governments need to provide opportunities for everyone, I could go on forever in identifying the opportunities and support I can provide, as well as the priorities. Then it would be better defining the determinants. In addition, we have to take into account the issue of sustainability: in this sense, I have to set limits on the opportunities that can be made available.

The problem is really to identify goals. In this there are different approaches and vary from culture to culture.

The field in which this is discussed more in-depth is the measure of poverty. If I want to measure the determinants that make individuals excluded from the social context, I have the well-known measures. For example, the working poor, while working, are at risk or already below the poverty line. Furthermore, not having a cell phone, in our culture, could become a problem of isolation or social exclusion. Depending on the territory that you consider, you have to define poverty in a different way.

Only essential needs are indisputable. Among the essential need, we put food, on which we should all think the same in terms of goals. Even if in Western societies the relationship of people with food is deformed, with great abundance of food, even of poor quality, we should come to a unified definition.

But on this point too, we have several schools of thought often influenced by economic interests, which can often create problems of inequality in the distribution of food and on the ways of producing food.

Essential needs are food and a shelter, though declining in different forms depending on the cultures.

Sustainability is linked to the friction that exists between the different domains of quality of life. We need to find threads across all domains to analyze sustainability. Food is one of these. Food crosses all domains: it's health, it's social relationships, food is work, it's landscape, it's environment, it's security. So, analyzing food in all its aspects, one can assess whether a country is sustainable. When evaluating progress, you should have a systemic vision. Respect for nature must not be neglected, especially in those contexts in which we do not know the consequences of our actions.

Another cross-cutting sector is that of construction industry, which is historical heritage, is culture but it is also health, work, social relations. Building could promote well-being in different domains.

This contains also another message: when it comes to policy, we must not refer to individual domains, but we should consider these cross-cutting areas. In policy making, you should refer to these cross-cutting sectors and not to individual domains because they might conflict with others. For example, referring to job creation, it is not very useful to "invent" work, while strategic sectors need to be developed.

These cross-cutting strategic areas are those on which policies are to be assessed. And they are essential needs that cross all domains.

3. Is the Food Insecurity Experienced Scale more useful in the micro perspective vs the macro measurement? What are the pros and cons of the use of FIES in the two approaches?

As far as FIES is concerned, there are two dimensions in the scale: the behaviour of the subject, and then the dimension of perceptions and evaluations. It could therefore be a two-dimensional scale.

Conceptually, behaviours, as already stated, should be kept separate from perceptions and evaluations. It would be best to keep the two dimensions distinct. And within the domain of the subjective dimension, perception could be distinguished from evaluation. Much of the literature on well-being has fallen in this confusion, sometimes muddling happiness and satisfaction. You can be very happy with your life but do not be happy, and vice versa. For reasons that are so personal and difficult to understand. A distinguished example is the World Database of Happiness of Veenhoven, where he mixes everything together, confusing happiness and satisfaction.

In particular, it is unsuitable to compare happiness in different contexts or nations. In Italy, the word "happiness" comes from felix that means "case". In English, it comes from "to happen", that means "occur, befall", with an approach that is more concrete than the Italian one. In German, happiness and chance, luck are expressed with the same word.

In the measure of well-being, all these measures are needed: evaluation, perceptual, objective one.

Mohan Rao

1. *The first issue is the use of subjective/perceived indicators in the capabilities approach: is it correct? is it useful? Which advantages can be obtained with the use of subjective rather than objective indicators?*

Even from an epistemological point of view, it is perfectly reasonable to seek the subjective responses of individuals. Because, truth is not exclusively objective. I believe that truth is simultaneously objective and subjective.

How do you know something is true? You do not have direct access to things in themselves. You have access only to things through your own mind, through your own subject.

Therefore, at the deepest level of philosophy, of epistemology, "how do we know something is true", I think our subject is necessarily involved - whatever you might perceived to be the objective world – in identifying conclusions.

In conclusion, philosophically, I have no objection on taking subjective approach and the objective approach, but I will insist in taking both the approaches.

2. The second topic is related to Food Security: is there a gain to the knowledge of a phenomenon such as FS using subjective indicators?

Food insecurity, at an extreme, is completely objective, and it is when a person is about to die. Literally, he is going to die in 5 minutes, because he has been hungry for the last 20 days. It is an objective fact. You do not have to ask him "are you food insecure?". Literally he is dying right in front of your eyes.

But short of that extreme hunger situation, the range of hunger, the range of food insecurity is tremendous.

Therefore, we need subtle observations and subtle measurements. When someone is about to die you just need gross measure but in any other case it is needed subtle and sophisticated evaluation.

When we look at "objective" measures of hunger, food insecurity, and so on we find that there are very good reasons to use them, but there are also very good reasons to be careful in using them, because they are subject to error, they are subject to interpretation, they are subject to data quality problems, they are subject to interviewer's recording bias. Even objective data has to initially recorded by human being. Data does not jump out of the field into your computer. It is a human social process that records the data.

So, there is no doubt that there are errors which are quoted "objective" errors and there are errors that are quoted subjective errors which exist even in the so-called objective instruments of food insecurity measurement.

Given that qualification of subjective sources and given the fact that hunger - as much as any other experience of human beings – is also very much a subjective experience. When you are hungry, you feel it. If you are hungry, I may be not able to check that you are hungry. But when you are hungry, you may be able to tell me that you are hungry. This state the relevance of subjective measures.

In conclusion, the use of subjective measures is both correct and useful.

This confirms my philosophical view of the matter also: that all experiences are simultaneously objective and subjective. There is no way to cut out the subjective aspect. I know that there are many scientists of the opposite point of view, who will discount the subjective position.

3. Is the Food Insecurity Experienced Scale more useful in the micro perspective vs the macro measurement? What are the pros and cons of the use of FIES in the two approaches?

Regardless of whether the subjective responses that you get from the FIES scores are correlated strongly or weakly with objective measures of food security that we get from the traditional information sources, the subjective FIES data is useful, because it gives you an answer to a simple question: what do people feel about their hunger? And you get an answer and that is important! That is very important because that is part of the experience of hunger.

In conclusion, we can state that there is a gain in knowledge.

Second related point: there is a literature, which goes back to the ninety sixties, produced at FAO, which came to the conclusion, based on the biochemistry and biology of the human body and food intake, nourishment, nutrition and so on, that the body is a homeostatic mechanism, which means that it adapts to varying external conditions of the environment through self-regulation mechanisms.

Let me give you an analogy: if you keep on living in Boston, you will get used to the wind, you get used to the cold; if you keep on living in Rome, you get used to the milder temperatures of Rome. So, the body adjusts to the cold of Boston and the body adjusts to the warm of Rome.

In the same way, in people who are generally hungry, their bodies and their minds get accustomed to the hunger. People who are always full and who have three refrigerators available, they are much more accustomed to eating constantly. So, the body adapts.

Therefore, if you take two human beings, identical gender, weight etc., but one who is hungry and the other is well fed, you will find that the same amount of food would be more nutritious to the regularly hungry because that persons' rate of utilization of that food that comes to his body is much better, whereas in the second person the rate of utilization of the food that comes to his body is much worse.

This is what I mean by homeostatic balance: the adjustment of the body. Basically, the metabolic adjustment.

A lot of the diet programs, that the dieticians put out, fail a lot of people because the body get accustomed to the diet. The body goes back to the original weight.

This analogy is to say that objective data about food intake can be misleading, even scientifically speaking, because the objective data on food and nutrition intake does not control for the body's adaptation.

But this is not true for the subjective responses on FIES, because FIES asks you subjectively: "are you hungry?". If the person is hungry, that is the outcome variable which is already taking into account how much he ate, yesterday, this morning, last week, did he eat, did he not eat, effectively, implicitly, and it is also taking into account the body's metabolic and long-term homeostatic adjustment.

Therefore, keeping everything else constant, *coeteris paribus*, one could argue that the subjective response may be more scientifically valuable than the data based on food balance sheets estimates on food insecurity.

In conclusion, the first point is that knowledge about the subjective state of hunger is a very important piece of knowledge which is simply not available from the objective sources.

Second, even scientifically considered, given the body adjustment to its normal metabolic rate, it is arguable that the subjective information is actually more reliable and more informative than the objective data.

Those are the main positive points of the value of FIES.

But there are also some negative points.

The FIES interviews are affected by the Gallup world poll research design.

This is about the demographic sensitivity of FIES.

Number one: the GWP does not take into account children. This is a major gap. It does not take into account children below the age of fifteen, a major lacuna.

Lacuna number two.

In the FIES FAO website, one particular point that gets mention repeatedly is gender imbalances and gender disparities.

I came from India, where women eat last: in South Asia, in India, Pakistan, Bangladesh, women eat last. This is a literal tradition, a tradition in the highest and deepest sense. Women will first feed everybody else. They will not even seat down together with the others, they are supposed to serve the others, and after everybody else has eaten they will eat by themselves.

But in hungry families, there is not enough food. Logical inference is that hunger is felt most by the women.

This means two very important things: first, women develop a steely capacity to withstand hunger, better than men. So, when a woman says she is hungry, she must be really hungry. When a man say he is hungry, he may be not be equally as hungry as a woman.

There could be a real gender bias in FIES, depending on the context.

When you compare across gender, when you compare across cultures, you may be getting more gender bias and age bias than you will get in the objective sources of data.

Incidentally, I also want to point out that in many families, in many traditions, in many cultures, not only women eat less or last. If there is a limited amount of food, women are likely to go hungrier than the men, and I also suspect that the same is true for older people compared to younger people. There is an economic rationale for this because younger people have to go out and work. They need the nutrition and the energy to do the work and to bring the money that are desperately needed to the house. Older people do not go out and do the hard work, usually, they do not walk long distances in search of employment, so they are not the major breadhowners in the family and therefore they will get less food when in the family there is shortage of food. Therefore, you can also have an age bias in the responses. In the same way, old people became accustomed to lower intake, both psychologically and physiologically. Therefore, they responses are more suspect in comparison to the responses of younger man, as women's in comparison with man.

So, gender and age bias could be a problem.

The first age bias is, of course, the omission of children.

In this context, the same FAO website argue that we get internationally comparable data. But is this data really international comparable? Across all the Country of the world?

South Asia is an especially important example, because there is a lot of hunger, because there is a lot of people and because there is a huge gender data disparity, particularly when it comes to food and consumption. But South Asia is not unique. Other countries may have other kinds of bias.

Therefore, international comparability is to be significantly examined, in the respect to FIES, and other subjective sources of data.

This could be a weakness.

One other factor: in the FAO website, they mention that they use the item response theory (IRT models), on the bases of which statistic comparability can be satisfied or ensured. I can accept that it ensures statistic comparability. But my question is contextual comparability. If the contexts are not exactly comparable, then making the FIES scores statistically comparable may not solve the problem of bias. Contextual bias, cultural bias, gender bias, demographic bias, climatic bias, there are many many ways in which bias can be produced.

We already stated that FIES is a response variable that measure the outcome of the process of food security. Can it be that all the context variables are already considered in the response variable? All the contextual variables contribute to bring this result.

Exactly: one very good thing about the subjective response of FIES data is that it compares people at the end of the process. This is a very powerful argument in favour of FIES, as I have already stated.

However, suppose that you are comparing two women, one in let's say in Libya and a woman let's say in Bangladesh, same age, same occupation, and you are asking both of them: "are you hungry"? Everything is very controlled and absolutely similar, as in a controlled experiment. The difference is that the Libyan woman lives in Libyan culture, while the Bangladeshi woman lives in South Asia in the Bangladeshi culture.

Given the same objective circumstances of food availability, food access and food instability, so given the same objective circumstances, a hungry woman in Libya will feel hungrier than an equally hungry woman in Bangladesh, because Bangladeshi women became more mentally and psychologically accustomed to hunger. And Bangladeshi women's bodies became more homeostatically adjusted to low food intake.

The result is that the same level of food intake objectively speaking and given the same bodies' conditions in the two countries, you will get a lower hunger response in Bangladesh and a higher hunger response in Libya. And that is the potential bias I am referring to. I do know that this difference exists across countries and they may matter.

If we accept the existence of a bias problem, how do we adjust the FIES methodology to allow for contextual biases? So as to make the FIES internationally comparable.

The first comparability issue is within countries, comparability between men and women, between old people and young people and between adults and children. Those are all inside the cultures, societies, or nations.

The second kind of contextuality is comparability across countries, across cultures.

Regarding both, we first have to verify if there is such a bias. We have to introduce a kind of doubt about the reliability in this regard of the FIES data.

Secondly, considering that FIES data is valuable, because I am a great believer epistemologically that both objective and subjective information are equally important, and this is especially so for hunger, I will improve FIES data, by recognising its limitation also.

One of the phrases that I picked up, that is claimed on the website "Gender disparity in access to food are caught by this measurement". I would rather say that "Gender disparity in responses to access to food" are considered. That is the kind of qualification I would made.

Another limitation I would like to point out regards the four different dimensions of food security: availability, access, utilization, and stability. FIES measurement are reported on an annual basis. Therefore, I think that FIES data cannot give us much about stability. It can give us good information about access, but does not give us direct information either about availability or, given my bias problem question, either about utilization.

However, FIES can give us good information on physical access and physical availability. If you have money but there is not physical availability of food, the result comes out from the question "Are you hungry?". They are not asking "Are you hungry because you do not have money?". So, the physical availability, and the availability more generally, comes out from the FIES data.

So those are the strength and weakness of FIES data from my point of view.

Conclusions

The results of the interviews are very interesting.

First of all, the two scholars, even if they have a completely different background, being an economist and a statistician, agree on the epistemological value of the use of subjective variables. They both agree on the fact that the definition of phenomena is always subjective, because it is the accepted projection of a culture.

The statisticians underline the importance of distinguish between subjective definitions and subjective methodologies: a method that depends on the characteristics of the interviewer or of the interviewee, that is to say not accepted, is of course to decline. But if we measure subjective, personal comportments and perceptions we have a gain in knowledge, as very wisely the economist suggested.

The two scholars both underline the importance of analyse the results in different groups. The economist notes that results can resent of the culture of the interviewee, and that therefore women, for instance, could express different evaluation (self-evaluation) than men, due to cultural reasons rather than "objective" situation. The same can be said of elderly vs youth. These issues have of course to be further investigate.

The statistician noted also that not all the items of the FIES scale are subjective, but many are indeed reporting objective situation. Also this aspect can be further analysed with statistics and econometric methods.

With regard to the capability approach, they note that processes and functionalities, even if they are very important, are not the aim of the evaluation. It is better to define targets and to identify the determinants that could help policy makers to achieve such aims.

In synthesis, both the scholars conclude that the FIES scale offer a gain in knowledge on a very important issue such as food insecurity, a subject related to all the dimensions of living: health, work, social relations, conflict, and so on.

Appendix II

Household Food Insecurity Access Scale (HFIAS) Measurement Tool: Questionnaire Format (from Coates et al 2007)

1. In the past four weeks, did you worry that your household would not have enough food?

0 = No (skip to Q2)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

2. In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?

0 = No (skip to Q3)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

3. In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?

0 = No (skip to Q4)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

4. In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources

0 = No (skip to Q5)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

5. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?

0 = No (skip to Q6)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

6. In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?

0 = No (skip to Q7)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

7. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?

0 = No (skip to Q8)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?

0 = No (skip to Q9)

1=Yes ….|___|

Q8.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?

0 = No (questionnaire is finished)

1=Yes ….|___|

1.a How often did this happen?

1 = Rarely (once or twice in the past four weeks)

2 = Sometimes (three to ten times in the past four weeks)

3 = Often (more than ten times in the past four weeks)

Appendix III

Analysis of missing data

Table 1A. FIES raw_score missing observation by Country (percentage)

Country	% of Missing values	Country	% of Missing values
Afghanistan	10,5	Liberia	7,3
Albania	2,6	Lithuania	6,3
Algeria	0,3	Luxembourg	1,2
Angola	3,5	Macedonia	2,7
Argentina	0,4	Madagascar	0,3
Armenia	2,6	Malawi	0,4
Australia	0,5	Malaysia	3,0
Austria	0,2	Mali	2,9
Azerbaijan	5,8	Malta	0,4
Bahrain	1,6	Mauritania	5,8
Bangladesh	4,0	Mauritius	0,7
Belarus	11,7	Mexico	10,0
Belgium	0,3	Moldova	4,8
Belize	4,4	Mongolia	6,5
Benin	3,2	Montenegro	3,5
Bhutan	0,8	Morocco	0,9
Bolivia	0,7	Myanmar	0,0
Bosnia Herzegovina	2,3	Namibia	1,7
Botswana	1,5	Nepal	0,8
Brazil	0,1	Netherlands	0,2
Bulgaria	2,3	New Zealand	1,1
Burkina Faso	4,4	Nicaragua	1,7
Burundi	1,2	Niger	8,2
Cambodia	1,2	Nigeria	4,6
Cameroon	1,4	Northern Cyprus	2,7
Canada	1,5	Norway	0,7
Chad	1,8	Pakistan	0,8
Chile	4,9	Palestine	0,7
China	4,6	Panama	4,4
Colombia	0,7	Paraguay	0,2
Congo (Kinshasa)	8,1	Peru	5,0
Congo Brazzaville	5,3	Philippines	0,4
Costa Rica	1,8	Poland	3,6
Croatia	2,7	Portugal	0,4
Cyprus	1,2	Puerto Rico	3,2
Czech Republic	2,9	Romania	4,9
Denmark	0,8	Russia	3,5
Dominican Republic	0,3	Rwanda	0,5
Ecuador	1,0	Saudi Arabia	2,7
Egypt	1,3	Senegal	0,6
El Salvador	1,2	Serbia	2,6
Estonia	3,2	Sierra Leone	3,3
Ethiopia	2,5	Singapore	2,4
Finland	0,3	Slovakia	3,0
France	2,0	Slovenia	1,1
Gabon	1,8	Somalia	18,3
Georgia	0,0	South Africa	2,4
Germany	0,4	South Korea	3,5
Ghana	1,9	South Sudan	6,1
Greece	0,0	Spain	0,6
Guatemala	1,0	Sri Lanka	1,7
Guinea	2,2	Sudan	8,1
Haiti	17,7	Sweden	1,2
Honduras	2,1	Switzerland	0,3
Hong Kong	1,3	Taiwan	0,4
Hungary	3,9	Tajikistan	16,6
India	6,0	Tanzania	1,6
Indonesia	2,5	Thailand	0,7
Iran	1,2	Togo	1,9
Iraq	2,0	Tunisia	3,8
Ireland	0,3	Turkey	1,0
Israel	4,3	Uganda	0,3
Italy	2,9	Ukraine	6,4
Ivory Coast	1,6	United Arab Emirates	1,7
Jamaica	3,8	United Kingdom	0,6
Japan	0,4	United States	3,1
Jordan	0,2	Uruguay	0,9
Kazakhstan	10,2	Uzbekistan	1,5
Kenya	0,8	Venezuela	4,9
Kosovo	4,6	Vietnam	2,6
Kuwait	1,0	Yemen	1,9
Kyrgyzstan	8,1	Zambia	0,1
Latvia	3,7	Zimbabwe	1,2
Lebanon	2,4	WORLD	2,9

Table A2 FIES raw_score missing observation by Item (percentage)

		WORRIED	
FIES	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	2,3	0,6	2,9
Total	99,4	0,6	100,0

		ATELESS	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	1,9	1,0	2,9
Total	99,0	1,0	100,0

		FEWFOOD	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	1,9	0,9	2,9
Total	99,1	0,9	100,0

		HEALTHY	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	2,1	0,8	2,9
Total	99,2	0,8	100,0

		HUNGRY	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	2,0	0,9	2,9
Total	99,1	0,9	100,0

		RUNOUT	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	2,0	0,9	2,9
Total	99,1	0,9	100,0

		SKIPPED	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	2,0	0,9	2,9
Total	99,1	0,9	100,0

		WHOLDAY	
	Valid Data	Missing	Total
Valid Data	97,1	0,0	97,1
Missing	1,9	0,9	2,9
Total	99,1	0,9	100,0

Appendix IV

Item Response Theory: detailed tables

Item	Label	Mean	Std Dev	Item-Total R	Item Reliab Index	Excl Item R	Excl Item Alpha
1	WORRIED	0.331	0.471	0.810	0.381	0.736	0.919
2	HEALTHY	0.312	0.463	0.828	0.384	0.762	0.917
3	FEWFOOD	0.327	0.469	0.834	0.391	0.769	0.916
4	SKIPPED	0.215	0.411	0.836	0.344	0.782	0.915
5	ATELESS	0.261	0.439	0.859	0.377	0.807	0.913
6	RUNOUT	0.206	0.404	0.832	0.337	0.778	0.915
7	HUNGRY	0.181	0.385	0.823	0.317	0.769	0.916
8	WHLDAY	0.121	0.326	0.694	0.226	0.624	0.926

Each of the following item histograms shows scaled mean-item-scores for cases with total scores that fall into each of 15 z-score intervals.
Scaled mean-item-score = 100*(m-min)/(max-min), where m = mean-item-score, min = minimum item score in the data, and max = maximum item score in the data.
If data are scored right or wrong then the scaled mean-item-score is percent correct.

ITEM 1 LABEL: WORRIED MEAN = 0.331 STD DEV = 0.471

Scaled mean-item score

Z	0 10 20 30 40 50 60 70 80 90 100	N	%	SCORE
<-3.25	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	4450	3.01	77.28
-3.00		0	.00	.00
-2.50		0	.00	.00
-2.00		0	.00	.00
-1.50		0	.00	.00
-1.00		0	.00	.00
-.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	93450	63.22	100.00
.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	8498	5.75	100.00
.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	15489	10.48	100.00
1.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	5984	4.05	100.00
1.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	5299	3.58	100.00
2.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	19105	12.92	100.00
2.50		0	.00	.00
3.00		0	.00	.00
>=3.25		0	.00	.00

ITEM 2 LABEL: HEALTHY MEAN = 0.312 STD DEV = 0.463

Scaled mean-item score

Z	0 10 20 30 40 50 60 70 80 90 100	N	%	SCORE
<-3.25	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	4450	3.01	70.70
-3.00		0	.00	.00
-2.50		0	.00	.00
-2.00		0	.00	.00
-1.50		0	.00	.00
-1.00		0	.00	.00
-.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	93450	63.22	100.00
.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	8498	5.75	100.00
.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	15489	10.48	100.00
1.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	5984	4.05	100.00
1.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	5299	3.58	100.00
2.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	19105	12.92	100.00
2.50		0	.00	.00
3.00		0	.00	.00
>=3.25		0	.00	.00

ITEM 3 LABEL: FEWFOOD MEAN = 0.327 STD DEV = 0.469

Scaled mean-item score

Z	0 10 20 30 40 50 60 70 80 90 100	N	%	SCORE
<-3.25	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	4450	3.01	66.38
-3.00		0	.00	.00
-2.50		0	.00	.00
-2.00		0	.00	.00
-1.50		0	.00	.00
-1.00		0	.00	.00
-.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	93450	63.22	100.00
.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	8498	5.75	100.00
.50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	15489	10.48	100.00
1.00	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	5984	4.05	100.00

```
   1.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5299   3.58 100.00
   2.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX19105  12.92 100.00
   2.50 |                                                     0    .00    .00
   3.00 |                                                     0    .00    .00
 >=3.25 |                                                     0    .00    .00

 ITEM   4   LABEL: SKIPPED      MEAN =       0.215         STD DEV =       0.411
Scaled mean-item score
    Z   0   10   20   30   40   50   60   70   80   90  100    N    %    SCORE
 <-3.25 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                 4450   3.01  68.58
  -3.00 |                                                    0    .00    .00
  -2.50 |                                                    0    .00    .00
  -2.00 |                                                    0    .00    .00
  -1.50 |                                                    0    .00    .00
  -1.00 |                                                    0    .00    .00
   -.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX93450  63.22 100.00
    .00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 8498   5.75 100.00
    .50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX15489  10.48 100.00
   1.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5984   4.05 100.00
   1.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5299   3.58 100.00
   2.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX19105  12.92 100.00
   2.50 |                                                    0    .00    .00
   3.00 |                                                    0    .00    .00
 >=3.25 |                                                    0    .00    .00

 ITEM   5   LABEL: ATELESS      MEAN =       0.261         STD DEV =       0.439
Scaled mean-item score
    Z   0   10   20   30   40   50   60   70   80   90  100    N    %    SCORE
 <-3.25 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                  4450   3.01  65.57
  -3.00 |                                                    0    .00    .00
  -2.50 |                                                    0    .00    .00
  -2.00 |                                                    0    .00    .00
  -1.50 |                                                    0    .00    .00
  -1.00 |                                                    0    .00    .00
   -.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX93450  63.22 100.00
    .00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 8498   5.75 100.00
    .50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX15489  10.48 100.00
   1.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5984   4.05 100.00
   1.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5299   3.58 100.00
   2.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX19105  12.92 100.00
   2.50 |                                                    0    .00    .00
   3.00 |                                                    0    .00    .00
 >=3.25 |                                                    0    .00    .00

 ITEM   6   LABEL: RUNOUT       MEAN =       0.206         STD DEV =       0.404
Scaled mean-item score
    Z   0   10   20   30   40   50   60   70   80   90  100    N    %    SCORE
 <-3.25 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                  4450   3.01  66.76
  -3.00 |                                                    0    .00    .00
  -2.50 |                                                    0    .00    .00
  -2.00 |                                                    0    .00    .00
  -1.50 |                                                    0    .00    .00
  -1.00 |                                                    0    .00    .00
   -.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX93450  63.22 100.00
    .00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 8498   5.75 100.00
    .50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX15489  10.48 100.00
   1.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5984   4.05 100.00
   1.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5299   3.58 100.00
   2.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX19105  12.92 100.00
   2.50 |                                                    0    .00    .00
   3.00 |                                                    0    .00    .00
 >=3.25 |                                                    0    .00    .00

 ITEM   7   LABEL: HUNGRY       MEAN =       0.181         STD DEV =       0.385
Scaled mean-item score
    Z   0   10   20   30   40   50   60   70   80   90  100    N    %    SCORE
 <-3.25 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                  4450   3.01  68.97
  -3.00 |                                                    0    .00    .00
  -2.50 |                                                    0    .00    .00
  -2.00 |                                                    0    .00    .00
  -1.50 |                                                    0    .00    .00
  -1.00 |                                                    0    .00    .00
   -.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX93450  63.22 100.00
    .00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 8498   5.75 100.00
    .50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX15489  10.48 100.00
```

```
   1.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5984   4.05 100.00
   1.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5299   3.58 100.00
   2.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX19105  12.92 100.00
   2.50 |                                                      0    .00    .00
   3.00 |                                                      0    .00    .00
 >=3.25 |                                                      0    .00    .00

 ITEM   8   LABEL: WHLDAY       MEAN =       0.121         STD DEV =       0.326
Scaled mean-item score
    Z   0   10   20   30   40   50   60   70   80   90  100    N    %    SCORE
 <-3.25 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                  4450   3.01  66.20
  -3.00 |                                                    0    .00    .00
  -2.50 |                                                    0    .00    .00
  -2.00 |                                                    0    .00    .00
  -1.50 |                                                    0    .00    .00
  -1.00 |                                                    0    .00    .00
   -.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX93450  63.22 100.00
    .00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 8498   5.75 100.00
    .50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX15489  10.48 100.00
   1.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5984   4.05 100.00
   1.50 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 5299   3.58 100.00
   2.00 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX19105  12.92 100.00
   2.50 |                                                      0    .00    .00
   3.00 |                                                      0    .00    .00
 >=3.25 |                                                      0    .00    .00
```

Appendix V
Exploratory factor analysis: detailed tables

Latent Roots (Eigenvalues)

1	2	3	4	5	6	7	8
5.331	0.815	0.422	0.332	0.313	0.279	0.262	0.245

Empirical upper bound for the first Eigenvalue = 5.5816.

Chi-Square Test that all Eigenvalues are Equal, N = 147825
CSQ = 839166.1072 P = 0.0000 df = 28.00

Chi-Square Test that the Last 6 Eigenvalues Are Equal
CSQ = 14655.6766 P = 0.0000 df = 18.81

Latent Vectors (Eigenvectors)

	1	2
ATELESS	0.372	0.055
SKIPPED	0.365	-0.156
RUNOUT	0.364	-0.213
HUNGRY	0.362	-0.352
FEWFOOD	0.356	0.397
HEALTHY	0.353	0.404
WORRIED	0.344	0.389
WHLDAY	0.307	-0.575

Standard Error for Each Eigenvector Element

	1	2
ATELESS	0.001	0.002
SKIPPED	0.001	0.003
RUNOUT	0.001	0.002
HUNGRY	0.001	0.002
FEWFOOD	0.001	0.002
HEALTHY	0.001	0.002
WORRIED	0.001	0.002
WHLDAY	0.001	0.003

Component loadings

	1	2
ATELESS	0.859	0.050
SKIPPED	0.843	-0.141
RUNOUT	0.841	-0.192
HUNGRY	0.836	-0.318
FEWFOOD	0.821	0.359
HEALTHY	0.816	0.365
WORRIED	0.795	0.351
WHLDAY	0.709	-0.519

Variance Explained by Components

1	2
5.331	0.815

Percent of Total Variance Explained

1	2
66.638	10.188

Rotated Loading Matrix (VARIMAX, Gamma = 1.0000)

	1	2
HEALTHY	0.843	0.297
FEWFOOD	0.843	0.305
WORRIED	0.819	0.293
ATELESS	0.658	0.555
SKIPPED	0.515	0.683
WHLDAY	0.157	0.865
HUNGRY	0.388	0.806
RUNOUT	0.478	0.718

"Variance" Explained by Rotated Components

1	2
3.192	2.954

Percent of Total Variance Explained

1	2
39.905	36.921

Appendix VI

Confirmatory factor analysis: detailed tables

1. Simultaneous Equation Model with 1 factor

sem (L1 -> worried,) (L1 -> healthy,) (L1 -> fewfood,) (L1 -> skipped,) (L1 -> ateless,) (L1 > (L1 -> hungry,) (L1 -> whlday,), vce(robust) latent(L1) nocapslatent
Endogenous variables: Measurement: worried healthy fewfood skipped ateless runout hungry whlday
Exogenous variables: Latent: L1
Fitting target model:
Iteration 0: log pseudolikelihood = -271258.17
Iteration 1: log pseudolikelihood = -264186.77
Iteration 2: log pseudolikelihood = -263076.57
Iteration 3: log pseudolikelihood = -263075.05
Iteration 4: log pseudolikelihood = -263075.05
Structural equation model Number of obs = 147,825
(4597 observations with missing values excluded)

Estimation method = ml
Log pseudolikelihood= -263075.05
(1) [worried]L1 = 1

	Coeff.	Robust standard error	z	P>|z|	[95% Conf. Interval]	
Worried	<-					
L1	1	(constrained)				
_cons	0.331013	0.001224	270.45	0	0.328614	0.333412
healthy	<-					
L1	1.014457	0.002147	472.5	0	1.010249	1.018665
_cons	0.311943	0.001205	258.88	0	0.309582	0.314305
fewfood	<-					
L1	1.040129	0.00218	477.05	0	1.035856	1.044402
_cons	0.327428	0.001221	268.26	0	0.325036	0.32982
skipped	<-					
L1	0.945797	0.003078	307.25	0	0.939764	0.951831
_cons	0.215363	0.001069	201.43	0	0.213267	0.217458
ateless	<-					
L1	1.03849	0.002514	413.04	0	1.033562	1.043418
_cons	0.260599	0.001142	228.25	0	0.258361	0.262836
runout	<-					
L1	0.923779	0.003166	291.76	0	0.917574	0.929985
_cons	0.205811	0.001052	195.72	0	0.20375	0.207872
hungry	<-					
L1	0.870438	0.003435	253.43	0	0.863706	0.877169
_cons	0.181221	0.001002	180.88	0	0.179257	0.183185
whlday	<-					
L1	0.603858	0.003726	162.06	0	0.596555	0.611161
_cons	0.121137	0.000849	142.74	0	0.119473	0.1228
var(e.worried)	0.093807	0.000596	0.092646	0.094982		
var(e.healthy)	0.083281	0.000579	0.082154	0.084424		
var(e.fewfood)	0.082133	0.000571	0.081021	0.08326		
var(e.skipped)	0.054807	0.000415	0.053999	0.055626		
var(e.ateless)	0.055036	0.000409	0.05424	0.055844		
var(e.runout)	0.054532	0.000415	0.053725	0.055351		
var(e.hungry)	0.051675	0.000392	0.050913	0.052448		
var(e.whlday)	0.059921	0.000343	0.059253	0.060596		
var(L1)	0.127637	0.000612	0.126444	0.128841		

Fit statistic
Likelihood ratio |
chi2_ms(20) | 70440.803 model vs. saturated
p > chi2 | 0.000
chi2_bs(28) | 839185.976 baseline vs. saturated
p > chi2 | 0.000
Population error |
RMSEA | 0.154 Root mean squared error of approximation
90% CI, lower bound | 0.000
upper bound | .

```
          pclose |     0.000   Probability RMSEA <= 0.05
Information criteria |
             AIC | 526198.103   Akaike's information criterion
             BIC | 526435.794   Bayesian information criterion
Baseline comparison  |
             CFI |     0.916   Comparative fit index
             TLI |     0.883   Tucker-Lewis index
Size of residuals    |
            SRMR |     0.048   Standardized root mean squared residual
              CD |     0.933   Coefficient of determination
------------------------------------------------------------------------------
```

2. Simultaneous Equation Model with 2 factors

sem (L1 -> worried,) (L1 -> healthy,) (L1 -> fewfood,) (L2 -> runout,) (L2 -> hungry,) (L2 -> whlday, > struct(_lexogenous, diagonal) vce(robust) latent(L1 L2) nocapslatent

```
(3977 observations with missing values excluded)
Endogenous variables
Measurement: worried healthy fewfood runout hungry whlday
Exogenous variables
Latent: L1 L2
Fitting target model:
Iteration 0: log pseudolikelihood = -264489.58
Iteration 1: log pseudolikelihood = -263606.93
Iteration 2: log pseudolikelihood = -263538.91
Iteration 3: log pseudolikelihood = -263538.79
Iteration 4: log pseudolikelihood = -263538.79
Structural equation model Number of obs = 148,445
Estimation method = ml
Log pseudolikelihood= -263538.79
( 1) [worried]L1 = 1
( 2) [runout]L2 = 1
```

Measurement	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Worried	<-					
L1	1	(constrained)				
_cons	0.331726	0.001222	271.45	0	0.32933	0.334121
Healthy	<-					
L1	1.071981	0.003415	313.89	0	1.065288	1.078675
_cons	0.312466	0.001203	259.74	0	0.310108	0.314824
Fewfood	<-					
L1	1.060455	0.003367	314.94	0	1.053855	1.067054
_cons	0.327913	0.001219	269.12	0	0.325525	0.330301
Runout	<-					
L2	1	(constrained)				
_cons	0.206002	0.00105	196.25	0	0.203945	0.20806
Hungry	<-					
L2	1.050069	0.003878	270.81	0	1.042469	1.057669
_cons	0.181374	0.001	181.35	0	0.179413	0.183334
Whlday	<-					
L2	0.734101	0.004026	182.33	0	0.72621	0.741993
_cons	0.121284	0.000847	143.14	0	0.119623	0.122945
var(e.worried)	0.079289	0.000658			0.07801	0.08059
var(e.healthy)	0.051199	0.000598			0.05004	0.052385
var(e.fewfood)	0.060255	0.000632			0.059028	0.061506
var(e.runout)	0.056272	0.000613			0.055084	0.057486
var(e.hungry)	0.030171	0.000524			0.029161	0.031216
var(e.whlday)	0.048753	0.00039			0.047995	0.049524
var(L1)	0.142394	0.000722			0.140987	0.143816
var(L2)	0.107293	0.000716			0.1059	0.108705

```
Fit statistic       |     Value   Description
Likelihood ratio     |
       chi2_ms(9) |  98096.155   model vs. saturated
         p > chi2 |     0.000
      chi2_bs(15) | 537944.656   baseline vs. saturated
         p > chi2 |     0.000
Population error     |
```

```
          RMSEA |     0.271   Root mean squared error of approximation
 90% CI, lower bound |     0.000
       upper bound |         .
          pclose |     0.000   Probability RMSEA <= 0.05
Information criteria |
            AIC | 527113.575   Akaike's information criterion
            BIC | 527291.919   Bayesian information criterion
Baseline comparison  |
            CFI |     0.818   Comparative fit index
            TLI |     0.696   Tucker-Lewis index
Size of residuals    |
           SRMR |     0.309   Standardized root mean squared residual
             CD |     0.986   Coefficient of determination
------------------------------------------------------------------------------
```

3. Simultaneous Equation Model with 2 factors with interaction

```
sem (L1 -> worried, ) (L1 -> healthy, ) (L1 -> fewfood, ) (L2 -> runout, ) (L2 -> hungry, ) (L2 -> whlday, > struct(_lexogenous, diagonal)
vce(robust) latent(L1 L2 ) cov( L1*L2) nocapslatent
(3977 observations with missing values excluded)
Endogenous variables
Measurement: worried healthy fewfood runout hungry whlday
Exogenous variables
Latent: L1 L2
Fitting target model:
Iteration 0: log pseudolikelihood = -217029.9
Iteration 1: log pseudolikelihood = -217003.24
Iteration 2: log pseudolikelihood = -217003.22
Structural equation model Number of obs = 148,445
Estimation method = ml
Log pseudolikelihood= -217003.22
( 1) [worried]L1 = 1
( 2) [runout]L2 = 1
```

Measurement	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Worried	<-					
L1	1	(constrained)				
_cons	0.331726	0.001222	271.45	0	0.32933	0.334121
Healthy	<-					
L1	1.052135	0.002745	383.32	0	1.046755	1.057515
_cons	0.312466	0.001203	259.74	0	0.310108	0.314824
Fewfood	<-					
L1	1.051479	0.002817	373.24	0	1.045957	1.057
_cons	0.327913	0.001219	269.12	0	0.325525	0.330301
Runout	<-					
L2	1	(constrained)				
_cons	0.206002	0.00105	196.25	0	0.203945	0.20806
Hungry	<-					
L2	0.973167	0.003084	315.59	0	0.967123	0.979211
_cons	0.181374	0.001	181.35	0	0.179413	0.183334
Whlday	<-					
L2	0.688441	0.003843	179.14	0	0.680909	0.695974
_cons	0.121284	0.000847	143.14	0	0.119623	0.122945
var(e.worried)	0.076476	0.000596			0.075316	0.077654
var(e.healthy)	0.054088	0.000513			0.053092	0.055103
var(e.fewfood)	0.059843	0.000544			0.058787	0.060919
var(e.runout)	0.046234	0.000471			0.04532	0.047167
var(e.hungry)	0.037358	0.000419			0.036546	0.038189
var(e.whlday)	0.050965	0.000371			0.050243	0.051698
var(L1)	0.145208	0.000654			0.143932	0.146495
var(L2)	0.117331	0.00069			0.115987	0.118691
cov(L1,L2)	0.102284	0.000559	183.01	0	0.101189	0.10338

Fit statistic	**Value**	**Description**

Likelihood ratio |

chi2_ms(8) | 5025.019 model vs. saturated

p > chi2 | 0.000

chi2_bs(15) | 537944.656 baseline vs. saturated

p > chi2 | 0.000

Population error |

RMSEA | 0.065 Root mean squared error of approximation

90% CI, lower bound | 0.063

upper bound | 0.067

pclose | 0.000 Probability RMSEA <= 0.05

Information criteria |

AIC | 434044.439 Akaike's information criterion

BIC | 434232.690 Bayesian information criterion

Baseline comparison |

CFI | 0.991 Comparative fit index

TLI | 0.983 Tucker-Lewis index

Size of residuals |

SRMR | 0.019 Standardized root mean squared residual

CD | 0.971 Coefficient of determination

4. Simultaneous Equation Model with 3 factors

sem (L1 -> worried,) (L1 -> healthy,) (L1 -> fewfood,) (L2 -> skipped,) (L2 -> ateless,) (L2 > (L3 -> whlday,), covstruct(_lexogenous, diagonal) method(adf) latent(L1 L2 L3) nocapslatent
(4382 observations with missing values excluded)
Endogenous variables
Measurement: worried healthy fewfood skipped ateless runout whlday
Exogenous variables
Latent: L1 L2 L3
Structural equation model Number of obs = 148,040
Estimation method = adf
Discrepancy = .541007
(1) [worried]L1 = 1
(2) [skipped]L2 = 1
(3) [whlday]L3 = 1

Measurement	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Worried	<-					
L1	1	(constrained)				
_cons	0.156091	0.001028	151.87	0	0.154076	0.158105
Healthy	<-					
L1	1.295274	0.009126	141.93	0	1.277387	1.313161
_cons	0.131693	0.000984	133.81	0	0.129765	0.133622
Fewfood	<-					
L1	1.149698	0.007862	146.23	0	1.134288	1.165108
_cons	0.143161	0.001004	142.59	0	0.141193	0.145129
Skipped	<-					
L2	1	(constrained)				
_cons	0.001457	0.000581	2.51	0.012	0.000319	0.002596
Ateless	<-					
L2	195.4802	72.16091	2.71	0.007	54.04738	336.9129
_cons	0.012805	0.000694	18.46	0	0.011445	0.014164
Runout	<-					
L2	0.303613	0.044406	6.84	0	0.216578	0.390647
_cons	-0.00257	0.000544	-4.72	0	-0.00364	-0.0015
Whlday	<-					
L3	1	(constrained)				
_cons	-0.00705	0.000356	-19.78	0	-0.00775	-0.00635
var(e.worried)	0.075584	.	.	.		
var(e.healthy)	0.057354	.	.	.		

var(e.fewfood)	0.057523	.	.	.
var(e.skipped)	0.052215	.	.	.
var(e.ateless)	0.05427	.	.	.
var(e.runout)	0.05367	.	.	.
var(e.whlday)	1	.	.	.
var(L1)	0.051232	0.000536	0.050193	0.052294
var(L2)	3.48E-05	1.28E-05	1.69E-05	7.17E-05
var(L3)	0.10657	.	.	.

Fit statistic

Discrepancy		
chi2_ms(.)	.	model vs. saturated
p > chi2	.	
chi2_bs(21)	124102.118	baseline vs. saturated
p > chi2	0.000	
Population error		
RMSEA	.	Root mean squared error of approximation
90% CI, lower bound	0.000	
upper bound	.	
pclose	.	Probability RMSEA <= 0.05
Baseline comparison		
CFI	1.000	Comparative fit index
TLI	.	Tucker-Lewis index
Size of residuals		
SRMR	0.473	Standardized root mean squared residual
CD	0.992	Coefficient of determination

.

Appendix VII

Descriptive analysis

Table AA.1 FIES rawscore (rows) by GENDER (columns) – percentage distribution

	Male	Female	Total	N
0	47.643	52.357	100.000	82207
1	45.619	54.381	100.000	11243
2	44.775	55.225	100.000	8498
3	44.502	55.498	100.000	8658
4	45.733	54.267	100.000	6831
5	45.822	54.178	100.000	5984
6	47.349	52.651	100.000	5299
7	46.448	53.552	100.000	7165
8	46.022	53.978	100.000	11940
Total	46.779	53.221	100.000	
N	69151	78674		147825

Test statistic	Value	df	Prob
Pearson Chi-square	71.421	8.000	0.000

Table AA.2 FIES rawscore (rows) by AGE CLASS (columns) - percentage distribution

	15-24 years old	25-44 years old	45-64 years old	65 years old and more	Total	N
0	17.807	36.947	29.823	15.422	100.000	82207
1	21.009	40.888	26.550	11.554	100.000	11243
2	19.652	41.869	26.959	11.520	100.000	8498
3	19.300	42.966	26.034	11.700	100.000	8658
4	21.973	43.171	25.355	9.501	100.000	6831
5	22.142	43.566	24.682	9.609	100.000	5984
6	23.476	44.386	24.325	7.813	100.000	5299
7	22.010	45.178	24.229	8.583	100.000	7165
8	23.417	44.045	23.744	8.794	100.000	11940
Total	19.472	39.677	27.814	13.037	100.000	
N	28785	58652	41116	19272		147825

Test statistic	Value	df	Prob
Pearson Chi-square	1925.555	24.000	0.000

Table AA.3 FIES rawscore (rows) by LOCATION OF THE HOUSEHOLD(columns) - percentage distribution

	A rural area or on a farm	A small town or village	A large city	A suburb of a large cty	Total	N
0	21.162	33.242	34.273	10.774	100.000	82207
1	28.889	32.536	30.108	7.907	100.000	11243
2	30.384	32.208	29.077	7.790	100.000	8498
3	30.908	34.546	27.154	6.768	100.000	8658
4	32.792	35.090	24.228	7.349	100.000	6831
5	34.258	34.408	24.181	6.584	100.000	5984
6	34.950	33.950	22.231	8.341	100.000	5299
7	36.734	35.087	20.935	6.699	100.000	7165
8	39.095	35.226	17.487	7.822	100.000	11940
Total	26.616	33.613	29.934	9.299	100.000	
N	39345	49688	44250	13746		147825

Test statistic	Value	df	Prob
Pearson Chi-square	4485.215	32.000	0.000

Table AA.4 FIES rawscore (rows) by MARITAL STATUS (columns) - percentage distribution

	Single	Married	Separated/Widow	Others	Total	N
0	27.479	55.271	12.490	4.759	100.000	82207
1	27.688	53.802	12.932	5.577	100.000	11243
2	27.348	52.907	14.180	5.566	100.000	8498
3	26.288	52.414	14.876	6.422	100.000	8658
4	28.590	51.091	13.453	6.866	100.000	6831
5	29.178	48.880	14.388	7.553	100.000	5984
6	29.307	48.500	13.701	8.492	100.000	5299
7	29.100	46.532	14.515	9.853	100.000	7165
8	31.307	44.146	16.482	8.065	100.000	11940
Total	27.991	52.840	13.346	5.823	100.000	
N	41378	78110	19729	8608		147825

	Test statistic	Value	df	Prob
	Pearson Chi-square	1180.750	24.000	0.000

Table AA.5 FIES rawscore (rows) by EDUCATIO (columns) - percentage distribution

	Primary	Secondary	Tertiary	Total	N
0	23.089	53.273	23.261	100.000	82207
1	33.381	52.361	13.964	100.000	11243
2	38.774	50.377	10.591	100.000	8498
3	41.511	48.995	9.217	100.000	8658
4	48.558	43.171	7.861	100.000	6831
5	49.415	43.800	6.584	100.000	5984
6	51.859	42.650	5.284	100.000	5299
7	56.525	38.730	4.480	100.000	7165
8	63.417	33.250	2.965	100.000	11940
Total	34.004	49.233	16.422	100.000	
N	50267	72779	24276		147825

	Test statistic	Value	df	Prob
	Pearson Chi-square	15599.004	32.000	0.000

Table AA.6 FIES rawscore (rows) BY ESTREME POVERTY (columns) - percentage distribution

	Extreme poor	Not extremely poor	Total	N
0	5.743	94.257	100.000	81750
1	12.331	87.669	100.000	11175
2	15.847	84.153	100.000	8443
3	19.310	80.690	100.000	8607
4	26.344	73.656	100.000	6772
5	29.063	70.937	100.000	5932
6	33.926	66.074	100.000	5229
7	40.073	59.927	100.000	7092
8	49.014	50.986	100.000	11813
Total	15.657	84.343	100.000	
N	22987	123826		146813

	Test statistic	Value	df	Prob
	Pearson Chi-square	22134.396	8.000	0.000

Table AA.7 FIES raw score (rows) by NUMBER OF CHILDREN IN THE HOUSEHOLD (columns) - percentage distribution

	0	1	2	3	4 or more	Total	N
0	58.111	18.520	13.898	5.326	4.144	100.000	81387
1	45.021	20.538	17.758	8.405	8.278	100.000	11077
2	43.499	19.510	17.349	9.934	9.707	100.000	8375
3	40.122	19.651	18.902	9.972	11.353	100.000	8544
4	36.358	18.714	18.610	11.793	14.525	100.000	6733
5	35.207	18.357	18.730	12.295	15.411	100.000	5905
6	31.055	19.330	19.985	13.092	16.538	100.000	5194
7	29.966	18.821	19.907	14.179	17.128	100.000	7088
8	28.177	18.088	19.427	13.895	20.413	100.000	11875
Total	48.546	18.807	16.050	8.076	8.522	100.000	
N	70963	27491	23461	11805	12458		146178

Test statistic	Value	df	Prob
Pearson Chi-square	12177.598	32.000	0.000