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Escuela Técnica Superior de Ingenieros Agrónomos
Universidad Politécnica de Madrid.

Analysis of the impact of globalization and economic growth on food security in developing countries

Tesis doctoral

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Madrid 2015

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EL SECRETARIO

A Diego y a mis hijos Eva, Mateo y María

Agradecimientos

Durante el proceso de elaboración de esta tesis he recibido el apoyo, la confianza, y los ánimos de muchas personas. A todas ellas se debe este trabajo.

En primer lugar, quiero expresar mi inmenso agradecimiento a Alberto Garrido. Agradezco especialmente su confianza y compromiso personal con el buen fin de esta tesis. Ha sido una lección de vida el contar con su apoyo, su interés por el avance de la tesis y su exigencia para mejorar en cada paso.

Gracias también a Laura Barrios del Centro Superior de Investigaciones Científicas (CSIC) por su apoyo incondicional en la resolución de dudas y mejoras de los modelos econométricos. Contar con su apoyo y aprobación ha conferido mucha rigurosidad a los resultados obtenidos en esta tesis.

Gracias al apoyo de las instituciones que han financiado parte de esta investigación y cuyos proyectos han sido fuente de conocimiento e inspiración. Gracias a Gonzalo Marín de la Fundación Canal de Isabel II, por la interesante experiencia que hemos compartido avanzando en el conocimiento de la cooperación internacional. Gracias también a la Fundación Botín. Me ha brindado la oportunidad de compartir trabajo con el equipo de investigadores del Observatorio del Agua que me ha nutrido de ideas para seguir adelante con la tesis. Mostrar mi agradecimiento a Consuelo Varela por darme la oportunidad de participar en el proyecto MEDIATION y a Elena López-Gunn por contar con mi apoyo en el proyecto HEREDERA. Ambas colaboraciones me han aportado enriquecedoras experiencias y herramientas para abordar los constantes retos de la investigación.

Gracias a la Universidad Politécnica de Madrid por los servicios a disposición de sus estudiantes. En especial, agradecer la inmejorable atención del servicio de documentación de la Biblioteca de la ETSI Agrónomos de Madrid.

Mi inmenso agradecimiento al CEIGRAM. Gracias a su directora Inés Mínguez y ex director, Alberto Garrido, por abrirme las puertas del CEIGRAM y facilitarme todos los medios materiales, técnicos y humanos para poder trabajar en la tesis y hacer que mi esfuerzo diario fuera más llevadero. Y destaco, sin dudarlo, el equipo humano. El cálido ambiente del CEIGRAM, el compañerismo y el respeto entre los trabajadores han sido cruciales en este proyecto. Gracias Esperanza Luque, Begoña Cadiñanos y

Katerina Kucerova. Siempre han tenido un “si” para mí, y siempre han tenido palabras de ánimo y un ratito de conversación para desahogarse. Gracias a mis compañeros y amigos que me ayudaron a arrancar, mostrándome su paciencia y ayuda desinteresada, Paula Novo, Jorge Ruíz, Roberto Rodríguez y Gloria Salmoral. Gracias a los que me ayudaron a seguir, por el buen ambiente que generan y la amistad que brindan, Marina Gil, Lola Rey, Insa Niemeyer, Daniel Chico, Elena Vivas, Teresa Maestro, Ana Felix, Sol García, Ruth Cunninham, Axel Blas y Marina Morente. Y gracias a quienes me animaron a hacer el esfuerzo final; Berta Sánchez porque en el tramo final de la tesis ha estado muy presente y siempre dispuesta a ayudarme a mejorar. Gracias a Bárbara Willaarts a la que dedico con toda sinceridad parte de este éxito. Porque Bárbara vio claramente este final, me lo supo transmitir y me ha apoyado en todo momento.

Muchas gracias a todo el equipo de Economistas sin Fronteras. Gracias por estar siempre atentos y dispuestos a ayudar. Mi grata experiencia en esta organización durante seis años ha asentado mi compromiso por trabajar en la generación de cambios por una economía más justa. Mi actual participación en su Junta Directiva también me ha ayudado a relativizar el peso de la tesis doctoral y gestionar mejor su proceso de elaboración.

Muchas gracias a mis grandes amigos de toda la vida, Jima, Elena, Rebeca, Marta, Vanessa, Juanjo, Ana y Peri. Gracias por estar siempre ahí, por vuestra paciencia y desproporcionada percepción de los retos que voy alcanzando. Me hacen sentir como si fuera “de otra dimensión”. Muchas gracias a mis recientes amigos Maite y Ale. Por compartir las noches de los viernes los buenos y malos momentos. Siempre han confiado en mí y me han ayudado siempre que lo he necesitado.

Escribir esta tesis hubiera sido mucho más difícil sin la presencia de toda mi familia. Gracias a mis padres, Maricarmen y Antonio, por su incondicional amor y generosidad, sin los cuales esta tesis hubiera sido inviable. Gracias por vuestra incansable insistencia por mejorar y tratar de alcanzar las metas para las que estoy preparada. Gracias porque lo he conseguido. Gracias a mis hermanos, Isabel, Antonio y Lucía, porque siempre están dispuestos a ayudar y han mantenido la armonía necesaria en la familia para no bajar el ritmo de trabajo. Agradezco especialmente la ayuda de mi hermana Lucía. No olvido que fue ella quien puso la semilla de este proyecto y no dudo en que lo haría un millón de veces más. Gracias por nuestra gran complicidad.

Gracias a toda mi familia política, especialmente a Dany, Momi, Pepe y Maripili porque nunca han dudado de mi y se han mantenido diariamente preocupados por ayudarme en infinidad de tareas.

Mi más sincero agradecimiento a mi marido, Diego, y a mis queridísimos hijos, Eva, Mateo y María. Me resulta prácticamente imposible expresar de manera escrita todo el agradecimiento que siento. Ellos son el sentido de mi vida y el verdadero motor del esfuerzo del día a día.

Con todo mi corazón, muchas gracias a todos.

Summary

Despite the significant reductions of hunger, food security still remains a global challenge. Food security is a wide concept that embraces multiple dimensions, and has spatial-temporal scales. Because of its complexity, the identification of the drivers underpinning food insecurity and the prioritization of measures to address them are a subject of intensive debate.

This thesis attempts to assess the impact of globalization and economic growth on food security in developing countries with a macro level scale (country) and using a long-term approach. The influence of globalization is addressed in a sequential way. First, the impact of public-private investment in infrastructure on agricultural exports in developing countries is analyzed. Secondly, an assessment is conducted to determine the impact of agricultural exports on food security indicators. The impact of economic growth focuses on the parallel changes in income inequality and how the income distribution influences countries' food security performance. Furthermore, the thesis analyzes to what extent economic growth helps accelerating food security improvements.

To address the above mentioned goals, various econometric models are formulated. Models use panel data procedures combining cross-sectional data of 52 countries and time series data from 1991 to 2012. Yearly data are expressed both in levels and in changes. The estimation models applied are random effects estimation and fixed effects estimations, both in levels and in first differences. The thesis includes four families of econometric models, each with its own set of robustness checks and specifications.

The results qualify the relevance of globalization and economic growth as enabling mechanisms for improving food security in developing countries. Concerning globalization, two main conclusions can be drawn. First, results showed that enhancing foreign private investment in infrastructures contributes to increase agricultural exports. Second, agricultural exports appear to have a negative impact on national food security indicators. These two conclusions suggest that trade and financial openness per se do not contribute directly to improve food security in development countries. Both measures should be accompanied by investments and

policies to support the development of national high value productive sectors, to strengthen the domestic economy and reduce its external dependency.

Referring to economic growth, despite the unquestionable fact that income growth is a pre-requisite for reducing undernourishment, results suggest that it is a necessary but not a sufficient condition. Three additional strategies should accompany economic growth to intensifying its impact on food security. Firstly, it is necessary that income growth should be accompanied by a better distribution of income. Secondly, income growth needs to be followed by investments and policies in health, sanitation and education to improve food security. Even if economic growth falters, sustained improvements in the access to drinking water may still give rise to reductions in the percentage of undernourished people. And thirdly, long-term economic growth appears to have a greater impact on reducing hunger than growth regimes that combine periods of growth peaks followed by troughs. Macroeconomic stability is a necessary condition for accelerating food security.

Finally, the thesis finds that the developing countries analyzed have experienced different non-linear paths toward improving food security. Results also show that a higher initial level of undernourishment and economic growth result in a faster response for improving food security.

Resumen

A pesar de los importantes avances en la reducción del hambre, la seguridad alimentaria continúa siendo un reto de dimensión internacional. La seguridad alimentaria es un concepto amplio y multidimensional, cuyo análisis abarca distintas escalas y horizontes temporales. Dada su complejidad, la identificación de las causas de la inseguridad alimentaria y la priorización de las medias para abordarlas, son dos cuestiones que suscitan un intenso debate en la actualidad.

El objetivo de esta tesis es evaluar el impacto de la globalización y el crecimiento económico en la seguridad alimentaria en los países en desarrollo, desde una perspectiva macro y un horizonte temporal a largo plazo. La influencia de la globalización se aborda de una manera secuencial. En primer lugar, se analiza la relación entre la inversión público-privada en infraestructuras y las exportaciones agrarias. A continuación, se estudia el impacto de las exportaciones agrarias en los indicadores de seguridad alimentaria. El estudio del impacto del crecimiento económico aborda los cambios paralelos en la distribución de la renta, y cómo la inequidad influye en el comportamiento de la seguridad alimentaria nacional. Además, se analiza en qué medida el crecimiento económico contribuye a acelerar el proceso de mejora de la seguridad alimentaria.

Con el fin de conseguir los objetivos mencionados, se llevan a cabo varios análisis econométricos basados en datos de panel, en el que se combinan datos de corte transversal de 52 países y datos temporales comprendidos en el periodo 1991-2012. Se analizan tanto variables en niveles como variables en tasas de cambio anual. Se aplican los modelos de estimación de efectos variables y efectos fijos, ambos en niveles y en primeras diferencias. La tesis incluye cuatro tipos de modelos econométricos, cada uno de ellos con sus correspondientes pruebas de robustez y especificaciones.

Los resultados matizan la importancia de la globalización y el crecimiento económico como mecanismos de mejora de la seguridad alimentaria en los países en desarrollo. Se obtienen dos conclusiones relativas a la globalización. En primer lugar, los resultados sugieren que la promoción de las inversiones privadas en infraestructuras contribuye a aumentar las exportaciones agrarias. En segundo lugar, se observa que las exportaciones agrarias pueden tener un impacto negativo en los

indicadores de seguridad alimentaria. La combinación de estas dos conclusiones sugiere que la apertura comercial y financiera no contribuye por sí misma a la mejora de la seguridad alimentaria en los países en desarrollo. La apertura internacional de los países en desarrollo ha de ir acompañada de políticas e inversiones que desarrollen sectores productivos de alto valor añadido, que fortalezcan la economía nacional y reduzcan su dependencia exterior.

En relación al crecimiento económico, a pesar del incuestionable hecho de que el crecimiento económico es una condición necesaria para reducir los niveles de subnutrición, no es una condición suficiente. Se han identificado tres estrategias adicionales que han de acompañar al crecimiento económico con el fin de intensificar su impacto positivo sobre la subnutrición. Primero, es necesario que el crecimiento económico sea acompañado de una distribución más equitativa de los ingresos. Segundo, el crecimiento económico ha de reflejarse en un aumento de inversiones en salud, agua y saneamiento y educación. Se observa que, incluso en ausencia de crecimiento económico, mejoras en el acceso a agua potable contribuyen a reducir los niveles de población subnutrida. Tercero, el crecimiento económico sostenible en el largo plazo parece tener un mayor impacto positivo sobre la seguridad alimentaria que el crecimiento económico más volátil o inestable en el corto plazo. La estabilidad macroeconómica se identifica como una condición necesaria para alcanzar una mayor mejora en la seguridad alimentaria, incluso habiéndose mejorado la equidad en la distribución de los ingresos.

Por último, la tesis encuentra que los países en desarrollo analizados han experimentado diferentes trayectorias no lineales en su proceso de mejora de sus niveles de subnutrición. Los resultados sugieren que un mayor nivel inicial de subnutrición y el crecimiento económico son responsables de una respuesta más rápida al reto de la mejora de la seguridad alimentaria.

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Acronyms

CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CEIGRAM	Research Centre for the Management of Agricultural and Environmental Risks
CERDI	Centre D'etudes et de Recherches sur le Developpement
CNRS	Centre National de la Recherche Scientifique
CSIC	Centro Superior de Investigaciones Científicas
ETSI	Escuela Técnica Superior de Ingenieros
EU	European Union
FAOIU	FAO Indicator of Undernourishment
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GFSI	Global Food Security Index
GHI	Global Hunger Index
GNI	Gross National Income
HDI	Human Development Index
HRCI	Hunger Reduction Commitment Index
IAD	Institutional Analysis and Development framework
IDB	Inter-American Development Bank
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IICD	International Institute for Communication and Development
INRA	Institut National de la Recherche Agronomique
IPC	International Poverty Center
IPEA	Institute of Applied Economic Research
LAC	Latin American Countries
MDF	Medium Density Fibreboard
NBER	National Bureau of Economic Research
ODA	Official Development Aid
OECD	Organization for Economic Co-operation and Development
PCSE	Panel Corrected Standard Errors
PHI	Poverty Hunger Index
PPIAF	Public Private Infrastructure Advisory Facility

PPP	Public Private Partnerships
SLS	Stage Least Squares
TNC	Transnational Corporations
UN	United Nations
UDHR	Universal Declaration of Human Rights
UNCTAD	United Nations Conference on Trade and Development
UNICEF	United Nations Children's Fund
UNDP	United Nations Development Programme
UNTT	United Nations Task Team
USDA	United States Department of Agriculture
VIF	Variance Inflation Factor
WB	World Bank
WFP	World Food Program
WFWS	World Summit on Food Security
WHH	Welthungerhilfe
WHO	World Health Organization
WTO	World Trade Organization

1 General Introduction

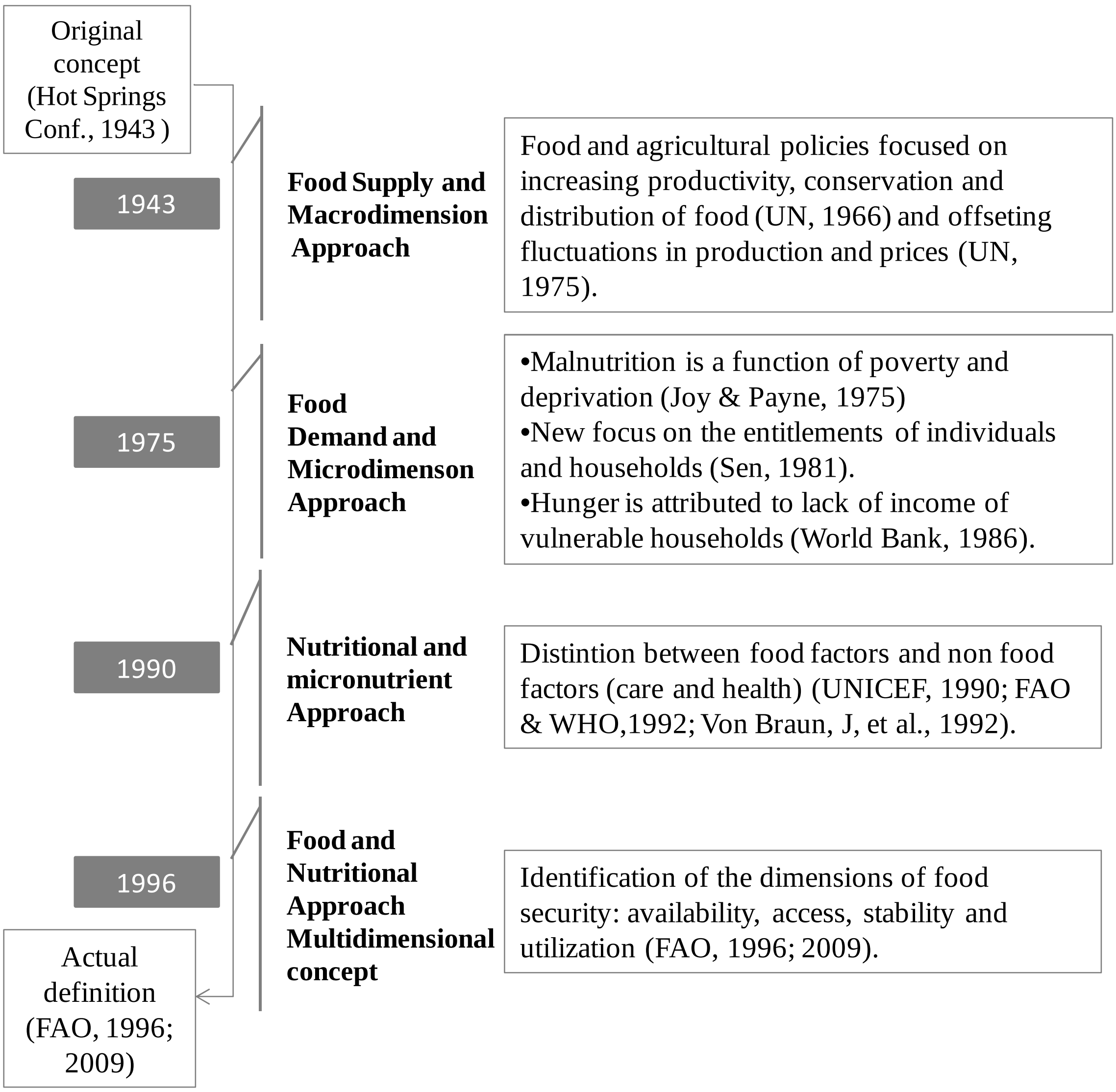
1.1 The challenge of food security: state of art

1.1.1 Food security: The evolving concept and its measures

Food security has been a concern since 1943 when it was first defined. During World War II, food security was considered as “freedom from want” in relation to food and agriculture (Hot Springs Conference, 1943). The notion of food security has evolved significantly in the last seventy years and it is now a well-established concept: “*Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life*” (FAO, 1996; 2009). The right to adequate food as a human right was first formally recognized by the United Nations in the Universal Declaration of Human Rights (UDHR, art. 25) in 1948, as a part of the right to a decent standard of living.

As Figure 1.1 shows, there are four main evolutionary stages in the articulation of the concept of food security. It evolved from a concept focused on the concern of global food supply (UN, 1966; 1975) to a concept that considered the right of people to food (Joy & Payne, 1975; Sen, 1981; World Bank, 1986). In 1990 nutritional and micronutrients improvements became a central component of food security planning (UNICEF,1990; FAO and WHO, 1992; Von Braun *et al.,* 1992). Finally in 1996 a new definition was agreed in the Rome Declaration on world food security, which was ratified in the subsequent World Summit on Food Security in 2009 (FAO, 1996; 2009), whereby food and nutrition are considered jointly from a multidimensional approach: availability, access, utilization and stability. In this thesis, it is used the term of food security as a concept that comprises all the dimensions and food and nutritional aspects.

Figure 1.1. Evolution of Food and Nutrition security concept

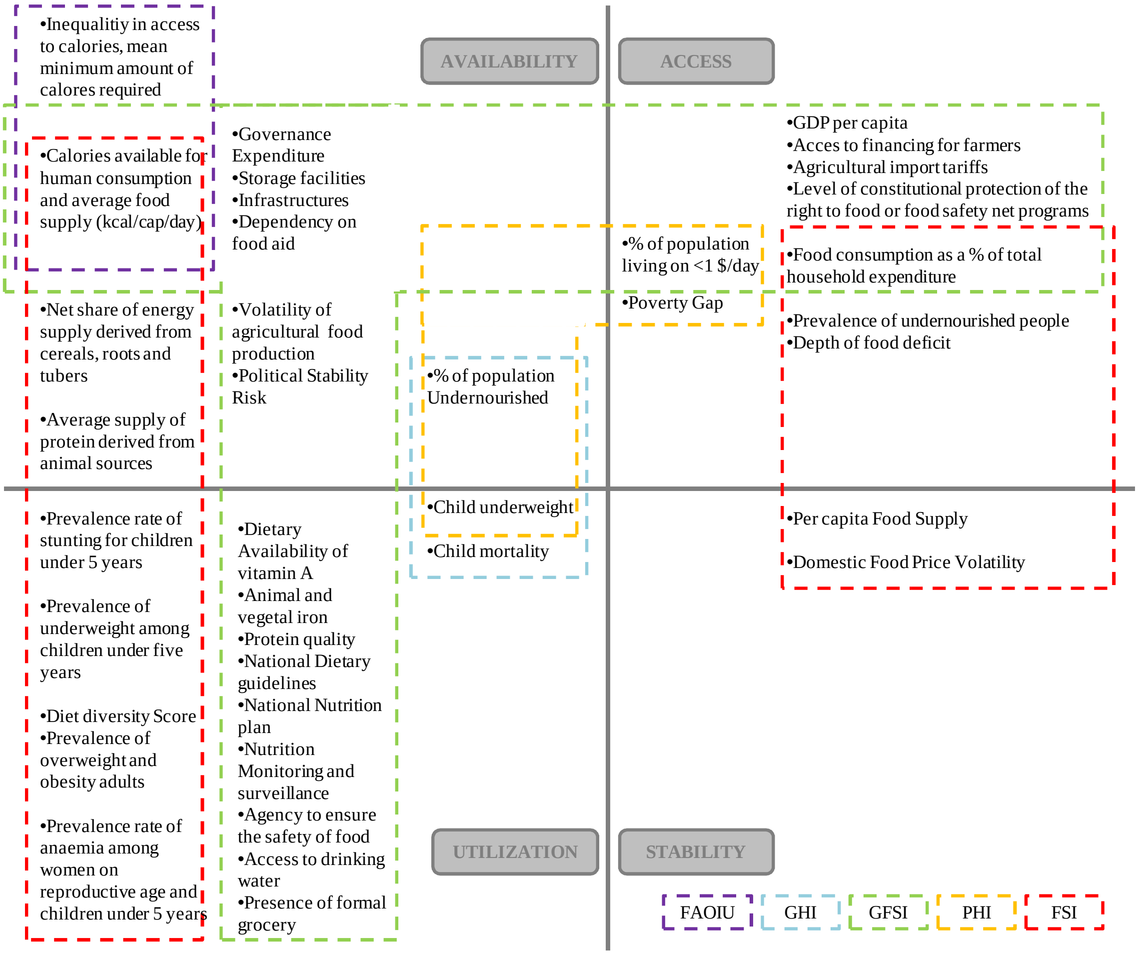


Source: Own elaboration.

According to the State of Food Insecurity report, 805 million people are estimated to be chronically undernourished in 2012–14 (FAO, IFAD and WFP, 2014). The vast majority of the chronically undernourished live in developing countries. Under-nutrition is not the sole expression of malnutrition. Presently, the international community have realized that it has to face the double burden of malnutrition. Reductions in the prevalence of undernourishment coincide with increases in the prevalence of overweight and obesity. Obesity has more than doubled since 1980 and more than 1.4 billion adults were overweight in 2008. Obesity is not only caused by financial affluence. Although the prevalence of adult obesity is currently much higher in developed countries than in developing countries, high prevalence rates of overweight are also found in low-income countries or even within the same household whose members may be suffering from undernourishment (FAO, WFP and IFAD, 2012). Besides undernourishment, overweight and obesity, a recent concern has arisen about the micronutrients deficiencies (vitamin A, iron, iodine and zinc), a condition that has been called hidden hunger. About 2 billion people are affected by micronutrient deficiencies (Thompson & Amoroso, 2014).

Correctly measuring food security is a daunting task. As it is a multidimensional and multilevel concept and it can be analyzed in the long and short term, a single indicator cannot summarize its complexity (Barrett, 2010). There are indicators for each dimension and composite indicators that capture more than one dimension (Willaarts *et al.,* 2014).

Figure 1.2. Food Security indicators



Source: Willaarts et al. (2014)

As Figure 1.2. shows, some of the existing composite food security indicators focused on macro-level dimensions: FAO Indicator of Undernourishment (FAOIU), the Global Hunger Index (GHI), the Global Food Security Index (GFSI), the Poverty and Hunger Index (PHI), the Hunger Reduction Commitment Index (HRCI). There are also indicators focused on micro-level dimensions: the anthropometric indicators (measure nutritional outcomes) and the medical and biomarkers indicators (measure micronutrient deficiencies). A small number cover one dimension (FAOIU) and assemble more than two dimensions (GFSI and PHI). Thus, stability dimension is clearly under-represented since it is only analyzed with two single indicators and one composite indicator.

1.1.2 Threats to global food security

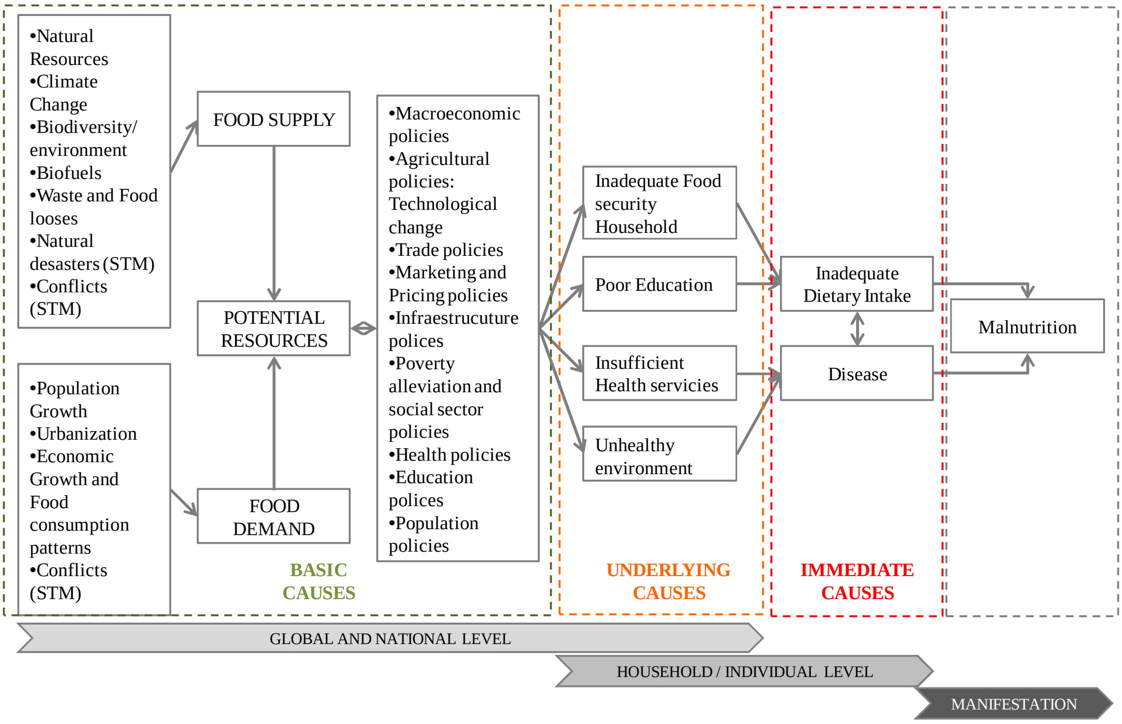
Global food security is threatened by many interconnected variables and drivers, such as population growth, urbanization, changing food consumption patterns, the need for better management of scarce resources, environmental sustainability concerns, biofuels climate change and the volatility of the agricultural prices. The global population surpasses 7 billion people and it is projected to reach 9 billion by 2050 (UN, 2011b). The urban population will increase from 60% of the total population (2011) to 70% in 2050 (UN, 2012). Rapid urbanization can outstretch the capacity of the cities to absorb the growing number of inhabitants and lead to the development of slums (Matuschke, 2008). Population growth is also accompanied by income per capita growth and changes in food consumption patterns. Population with middle income per capita (2-13 US$/day) has increased from 33% in 1990 to 49 % in 2005 (Chen y Ravallion, 2008; Ravallion, 2009). Rising income levels generally result in more diverse diets. Mainly in developing countries consumers shift some consumption away from lower value cereals to higher value livestock products (Regmi *et al.,* 2001; Gerbens-Leenes *et al.*, 2010). Considering growth population and changing food consumption pattern, food production is projected to increase by 70% by 2050 (Bruinsma, 2009). Feed the world is a challenge for the agriculture production (Sumpsi, 2012) and the agricultural policies (Bardají, 2014). Although the main concerns focus on food supply, there are also food demand issues. Gustavsson *et al.,* (2011) highlight the problem of the food losses occurring along the entire food chain. One-third of food produced for human consumption is lost or wasted (almost 1.3 billion tons per year).

Increasing food production will put greater pressure on available land resources (Kastner *et al.,* 2012). Agriculture already uses 11% of world land surface for crop production (FAO, 2011c) and feeding a growing world population will require an additional 2.7–4.9 million hectares of cropland per year on average (Lambin and Meyfroidt, 2011). The estimations suggest that the total additional land demand for 2030 will rise to 285-792 million hectares. Different land uses will be competing for the available land. Biofuel production will require between 81-147 million additional hectares and grazing land up to 150 million additional hectares (Lambin and Meyfroidt, 2011). Furthermore, land use change is causing land degradation. In 2011, about one third of global land suffered from degrading ecosystem services (FAO, 2011c) and degraded land affected more than 20% of cultivated areas (Bai *et al.,* 2008). Agriculture uses about 70% of all water withdrawn (FAO, 2011c). According to Falkenmark and Lannerstad (2010), the annual per capita agricultural water requirements are 1,300m^3 for a food supply level of 3,000 kcal/day per person with 20% derived from animal foods. They conclude that there will be enough water in the world to support the foreseen population but the problem will be how to allocate food production to the people in dry and overpopulated countries. By 2050, sixty percent of the population will live in countries where farmers face difficulties to access to irrigation water (Rockström *et al.*, 2011).

Climate change is an additional threat to the four dimensions of food security (FAO, 2008; Porter *et al*., 2014). The effects of climate change on crop and terrestrial food production are evident in several regions of the world. There is a large negative sensitivity of crop yields and weed and pest proliferation to extreme temperatures (Nelson *et al.,* 2009; Sánchez *et al.,* 2014). Climate trends are affecting the abundance and distribution of harvested aquatic species and the nutritional quality of food and fodders are negatively affected by the atmosphere's increasing CO_2 concentration (Porter *et al.,* 2014). Finally, the volatility of the agricultural markets is a driver of food security crises. This is a complex issue with highly differentiated impacts on consumers and producers in developed and developing countries (FAO, IFAD, UNCTAD and WFP, 2011; Sumpsi, 2013).

According to the conceptual framework of food security proposed by Pieters *et al.,* (2013), all of these threats are part of the basic causes of food security as shown in Figure 1.3.

Figure 1.3. The conceptual framework of malnutrition



Source: Own elaboration based on UNICEF (1990), Bokelon, et al.,(2005) and Pieters et al., (2013)
STM: Short term

Over the last decade, scenario analysis has been increasingly applied as a tool for dealing with the complexities and uncertainties associated with food security (Dijk and Meijerink, 2014). These studies explore the key driving forces affecting global food supply, prices and agriculture (Dorin and Paillard, 2009; Alexandratos and Bruinsma, 2012; Linehan *et al.*, 2013), biofuels (Fischer *et al.*, 2009) and climate change (Nelson *et al.*, 2010).

1.1.3 Some unsolved research questions about the key driving forces of food security

Even if the threats to food security are identified, less straightforward is to identify and understand the drivers of food insecurity. There are many studies that analyze the relationship between basic and underlying causes (Figure 1.3) and food security indicators. Thus, for example, the positive and significant impact of income per capita on food security has been widely shown (Gacitua and Bello, 1991; Wimberley and Bello, 1992; Jenkins and Scanlan, 2001; Brady *et al.,* 2007; Austin *et al.*, 2012) as has the negative impact of population growth (Jenkins and Scanlan, 2001; Scanlan, 2003; Brady *et al.,* 2007; Austin *et al.,* 2012). Seeking to test causality hypothesis, several studies propose to use econometric models and estimation techniques, such as the Granger causality test (Bezuidenhout and Naudé, 2008), gravity models (Magalhaes and Africano, 2007; Francois, *et al.*, 2007) and the panel data approach (Austin *et al.*, 2012).

There is greater disagreement about the impact of other important drivers such as globalization and economic growth (Compés *et al.*, 2002; Steinberg, 2007; Hoekstra and Mekonnen, 2012; WTO, 2014; Bertelli and Macours, 2014). Globalization, as a phenomenon of international trade expansion and accelerated international financial flows, is one of the most debated issues. Several authors claim that international trade contributes to raising incomes (Bhagwati, 2007; Salvatore, 2007; OECD, 2013; Ivanic and Martin, 2014; WTO, 2014) and provides opportunities to cover the demand for agricultural products (Hoekstra and Mekonnen, 2012; Fader *et al.,* 2013). On the opposite side, there are authors that find that agricultural exports have a negative impact on food security in agricultural producing countries, because it may generate competition between cash crop and food crop production (Austin *et al.,* 2012; Bertelli and Macours, 2014) and small farmers are not given the opportunity to participate in the international export process (Poaster, 2012). Shedding light on the relationship between trade and food security has become even more relevant since international trade has grown much faster than global output in the last 30 years, and developing economies have shown an increasing share in world merchandise exports from 33% in1995 to 48% in 2012 (WTO, 2014).

In relation to international financial flows, developing economies remain the major recipients of the global Foreign Direct Investment (FDI) (54%), flows that continue rising and reached 1.45 billion dollars in 2013 (UNCTAD, 2014). The increasing presence of the private investment in developing countries explains why the private sector is becoming a key actor to reach the sustainable development goal. The participation of the public sector is fundamental and pivotal, by creating adequate investment climates (González and Martinez, 2004; World Bank, 2008) and promoting public-private partnerships (UN, 2010; UNCTAD, 2011). There are many studies that analyze the impact of FDI on trade (Pramadhani *et al.*, 2007; Bezuidenhout and Naudé, 2008; Rakotoarisoa, 2011), but in light of the central role of the public-private partnership, there is a gap in the analysis of the impact of the public-private investment on trade in developing countries. Nowadays, it is pertinent and relevant to bridge this gap in order to contribute to the definition of the framework of the sustainable development goals. Furthermore, most of the studies have analyzed aggregate FDI, highlighting the opportunity to carry out a private investments research with a sector based approach (Aizenman and Noy, 2005; Ghosh, 2007).

Economic growth and how it trickles down to the poor has been one of the most widely discussed and controversial issues for decades. It is widely believed that economic growth is good for the poor (Dollar & Kraay, 2000; Richard and Adams, 2004; Donaldson, 2008) but a growing of number of authors claim that economic growth is a necessary condition but not a sufficient condition to meet undernourishment goals. Economic development policies have to take into account the investment in human development (Smith and Haddad, 2002; Alderman *et al.*, 2003; Suri *et al.*, 2011). Furthermore, wealth distribution also matters (OECD, 2013). Inequality becomes even more relevant after the debate brought up by Piketty (2014). He claims that inequality has increased since the late 1970s, with a rise in the share of total wealth going to the very highest earners, while other authors identify the opposite trend (Sala-i-Martin, 2006; Atkinson and Brandolini, 2010; Branko, 2013). The debate goes beyond trends and measurements of inequality and covers the discussion about the relationship between inequality and income growth that still remains unsolved (Ravallion, 2004; Barro, 2008; Kanbur, 2008; Santos-Paulino, 2012). Studies on this matter analyze the relationship between inequality and poverty indicators, but they do not address the impact of inequality on food security indicators. As Dijk and Meijerink (2014) recommend, it is appropriate to include inequality in food security analysis in order to improve food security assessments.

1.2 Research Objectives

Despite the progress made in reducing hunger, the international community continues to face serious challenges of hunger and undernourishment. Some food security issues remain unsolved since globally there is enough food available for the entire world population, but many people cannot afford it (FAO, 2011b) or make a inadequate use of it (FAO, WFP and IFAD, 2012). The previous section identified that food security is an evolving concept encompassing several dimensions and levels. It is threatened and affected by several interconnected variables that require the effort of researchers from a wide range of disciplines. The complexity surrounding food security and the still intense debate on its drivers explain why improving food security remains a challenging task.

In line with this, the overall objective of this research is to analyze the food security drivers and their impact on the food security at national level in developing countries, using a methodology that permits addressing causal relationships. The aim of the research is to improve the understanding on food security at national level with the objective of identifying appropriate actions and contribution to policy making in the context of food security in developing countries. To reach this goal, the thesis attempts to bridge the gaps in the scientific literature and address the following research questions:

1. Do public-private investments in infrastructure promote agricultural exports in developing countries?
2. What is the impact of agricultural exports on food security indicators in developing countries?
3. Is an equitable income distribution important to improve food security indicators in developing countries?
4. To what extent is economic growth necessary to improve food security?

To answer these questions, the specific objectives of the thesis are:

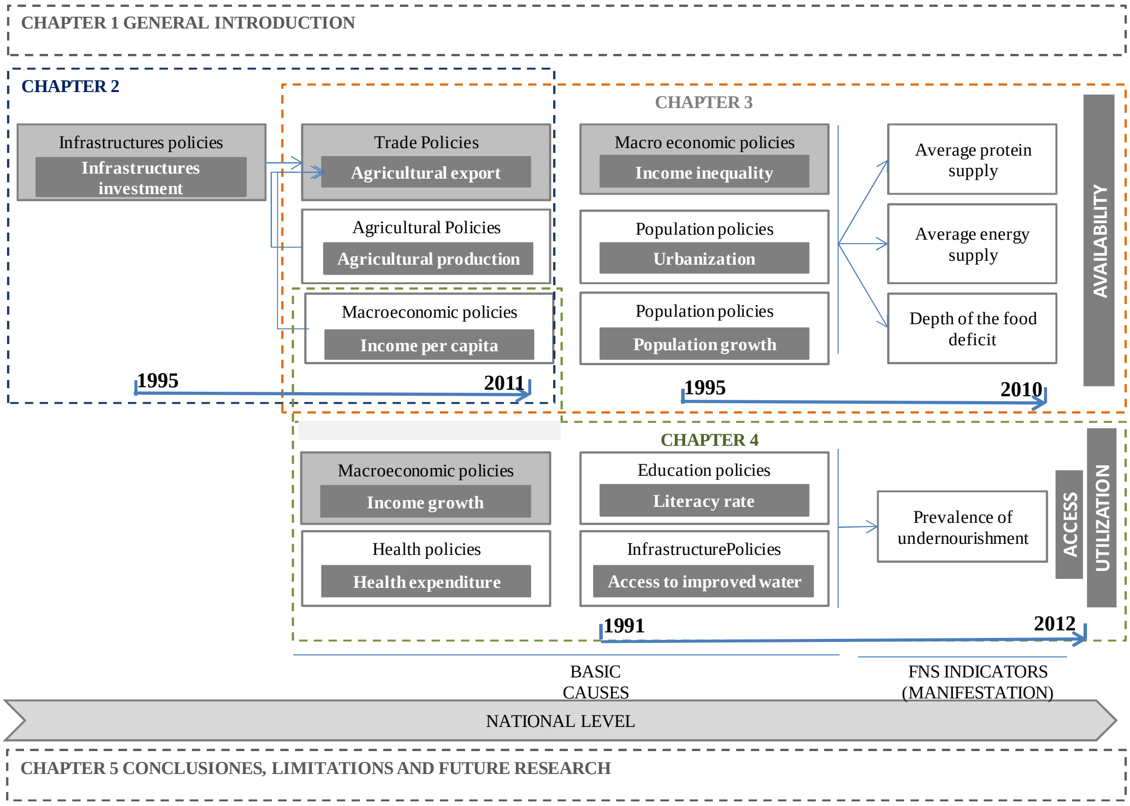
1. To analyze the trends and composition of public-private investment in infrastructure in developing countries.

2. To study the agricultural exports of developing countries and characterize the developing countries according to their trade openness.
3. To explore the impact of public-private investment in infrastructure on agricultural exports.
4. To investigate whether the promotion of agricultural exports in developing countries contributes to improve food security indicators.
5. To analyze the evolution of income distribution in developing countries and the relationship between income distribution and the development stage.
6. To investigate the importance of an equitable income distribution growth to improve food security in developing countries.
7. To analyze the trend of the prevalence of undernourishment, including the trajectories followed by the countries included in the sample.
8. To study the economic growth and food security changes jointly in developing countries. Analyzing the frequency that a given income growth is accompanied by a defined food security improvement or a given food security deterioration.
9. To identify if the food security state influences the future rate of reduction of undernourishment.
10. To examine the relevance of economic growth for accelerating improvements in food security in developing countries, and to see how economic growth interacts with other drivers, like improvements in water services and sanitation, education and health. To identify if the sustainability in the income growth trend affects the rate of reduction of the undernourishment.

1.3 Structure of the thesis

This document is organized in 5 chapters covering the context and objectives of the research, the most relevant results and the conclusions of this doctoral research. Figure 1.4 summarizes the structure of the thesis.

Figure 1.4. The structure of the thesis



(*) The shaded grey boxes are the tested explanatory variables. The non-shaded boxes are the control explanatory variables

The content of each chapter is described in the following points:

- Chapter 1 is the general introduction of the thesis and provides an overview of the context, the general and specific objectives and the research's framework. Chapters 2, 3 and 4 consist of three related studies conducted with different goals, method and data, each intended as a separated contribution to the literature.

- Chapter 2: The role of private sector in Development: The relation between public-private investment in infrastructure and agricultural exports in developing countries.

This chapter analyzes the relation between public-private investment in infrastructure and agricultural exports in developing countries with the aid of the panel data approach procedure that covers 52 developing countries and 17 years (1995-2011). The results of this chapter contribute to the definition of the role of the private sector in developing countries in order to reach the goals for sustainable development. It also draws attention to the role of trade as a means of economic development.

- Chapter 3: Does equitable income distribution matter to improve food security? An analysis of 48 developing countries.

This chapter presents an analysis of the impact of income inequality on food security in developing countries. The analysis is carried out with data on income distribution variables and food security indicators over 16 years (1995–2010) and across 48 developing countries, using panel data analysis. It also considers the relationship between inequality and economic growth. In this research context, where there is mixed evidence about the effects of the composition of economic growth on food security, the results of chapter 3 contribute to emphasize the equity goal in policies definition.

- Chapter 4: How important is economic growth to improve food security in developing countries?

This chapter analyzes the speed of change of the prevalence of undernourishment and tests whether greater economic growth accelerates reductions in undernourishment in developing countries. The analysis is carried out with the data spanning 22 years (1991–2012) and covering 35 developing countries, using panel data analysis. This chapter is a contribution to the debate in the literature about the importance of economic growth in resolving by itself the problem of undernourishment.

Finally, chapter 5 presents the main conclusions obtained in the doctoral research. It also reviews the main limitations of the results and suggests some lines for further research.

There are clear connections between the central chapters (Chapter 2, 3 and 4) that facilitate the presentation of the results and the conclusions (Figure 1.4). Firstly, the three chapters share the sample of countries and analyze a similar time period, with some clarifications that are described in section 1.4 below. Sharing the sample and period adds robustness to the results and a better understanding of the driving forces of food security in developing countries. Secondly, Chapters 2 and 3 share the goal of analyzing the role of agricultural exports in developing countries, although each chapter provides distinct contributions. Chapter 2 challenges the role of agricultural trade as a development strategy and the role of the private investor in boosting agricultural exports. Based on Chapter 2 results, the Chapter 3 considers whether the upward trend in agricultural exports is contributing to improving food security indicators in the exporting countries. Thirdly, Chapters 3 and 4 analyze the relevance of income per capita in food security improvement, but with different perspectives. Chapter 3 focuses on the analysis of the income distribution trend, its relation to income growth and its impacts on food security indicators. The analysis of Chapter 4 complements the results of Chapter 3 by investigating the intensity of the impact of income growth on the rate of reduction in undernourishment. It also analyses the relevance of the sustainable growth versus a short-term economic growth to achieve the goal of reduction in hunger.

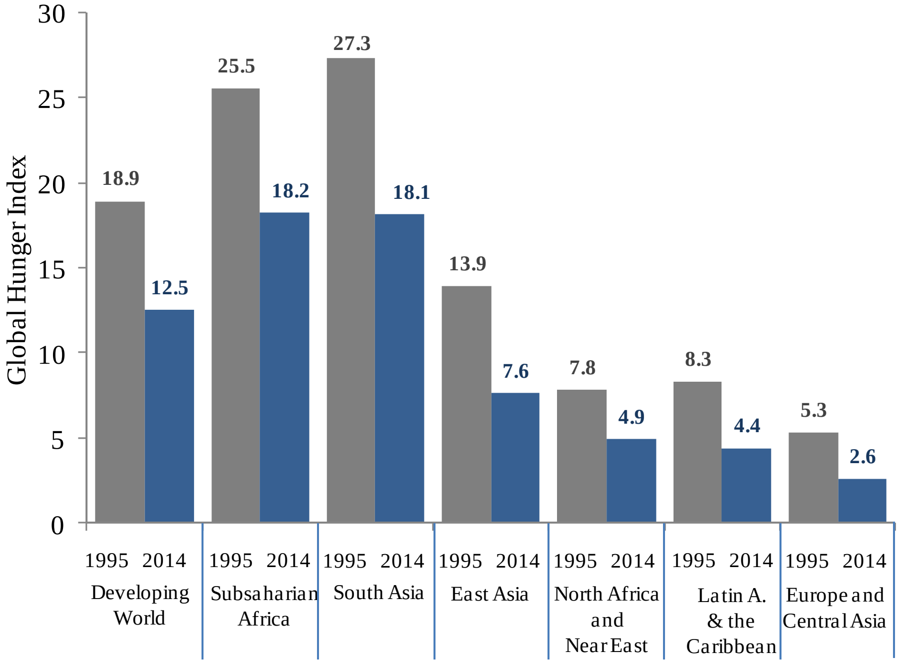
The structure of the thesis shows that the central chapters of the thesis share some of the specific objectives listed above, giving the thesis an overarching theme running through the whole document and a clear orientation to specific and overall objectives.

1.4 The scope of the study: The developing countries

The challenges of food security research are illustrated by the study of a sample of developing countries. Despite the significant progress made in combating hunger in recent years, the global hunger index (GHI) remains in a worrying scale (higher than 10)[1] in the developing world. There are differences among regions and countries. Sub-Saharan African and South Asian countries have the highest GHI scores both in1995 and 2014. These regions have, at the same time, experienced the most progress. In absolute terms, South Asian countries experienced the greatest improvements. Figure 1.5 shows the decline of more than 9 points between 1995 and 2014. GHI scores in East Asia also show an important reduction of about 6 points. North Africa and the Near East, Latin America and the Caribbean and Europe and Central Asia regions have the lowest GHI scores in 1995 and 2014.

[1] The Global Hunger Index (GHI) is a score composed of three indicators: Undernourishment, child underweight and child mortality (Figure 1.5). The GHI´ scales are: Low (<4.9), moderate (5.0-9.9), serious (10.0-19.9), alarming (20.0-29.9) and extremely alarming (>30.0) (IFPRI et al., 2014).

Figure 1.5. Global Hunger Index score by regions. Years 1995, 2014



Source: Own elaboration based on IFPRI, WHH, & Worldwide (2014)

The sample of the thesis research comprises 52 developing countries. This sample is representative of low-income and some middle-income countries (Figure 1.5). There are countries of four geographical regions, East and South Asia (10 countries), Europe and Central Asia (6 countries), North Africa and the Near East (6 countries), Sub-Saharan Africa (14 countries) and Latin America (16 countries) and. The availability of high-quality nationally representative data is one of the limitations of the inclusion of countries. Detail information of each country is provided in the Appendix 1.1.

Table 1.1. Sample of developing countries by region

Sub Saharan Africa		Latin America		East and South Asia		Europe and Central Asia	North Africa and Near East
Benin	Senegal	Argentina	Guatemala	Bangaldesh	Vietnam	Albania	Egypt
Belarus	South Africa	Bolivia	Honduras	China (People´s R.)	Malaysia	Azerbaijan	Iran
Burkina Faso	Swaziland	Brazil	Nicaragua	Indonesia		Kazakhstan	Morocco
Cameroon	Tanzania	Chile	Mexico	India		Macedonia (Former Yugoslav R.)	Syrian Arab R.
Cote d´Ivorie	Uganda	Colombia	Paraguay	Pakistan		Moldova	Tunisia
Gabon	Yemen	Costa Rica	Peru	Philippines		Ukraine	Turkey
Kenya		Ecuador	Uruguay	Sri Lanka			
Mozambique		El Salvador	Venezuela	Thailand			

Countries not included in chapter 3 (orange)
Countries not included in chapter 4 (grey)

1.5 Research context

This PhD thesis is based upon research carried out from 2011 to 2014 at the Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM) , within the Doctoral Programme of Department of Agricultural Economics and Social Sciences in the School of Agricultural Engineering, of Universidad Politécnica de Madrid. During this period, the participation of the author in different research project laid the groundwork for framing the problems addressed in the thesis and formulating its objectives, and helped her become familiar with the econometric methods applied in the empirical analyses. These research projects are:

- "Análisis de las relaciones entre el comercio de agua virtual y la Ayuda Oficial al Desarrollo en la Cooperación Internacional" funded by Canal de Isabel II Foundation (2011-2012). The aim of the publication (Soriano *et al.*, 2013) was to analyze the relationship between international financial flows (official development aid and private investment) and virtual water flows associated to agricultural trade between developed and developing countries. The context of the project was the concern about the access to land and water to ensure food provision. The scope of the study covered the whole group of official development aid recipient countries (152 countries). This Project provided the knowledge base for the thesis development.
- "Water for Food Security and Well-Being in Latin America and the Caribbean. Social and Environmental Implications for a Globalized Economy", funded by Botin Foundation (2013). The main goal of this project, which gave rise to an edited volume (Willaarts *et al.*, 2014), was to provide an analytical and facts-based view of the progress of water and food security in Latin American and Caribbean countries (LAC region). It also analyzed the contribution of LAC region to global water and food security and the challenges ahead. This project provides the solid basis on which the analysis of food security drives is supported.

1.6 Publications and presentations

The thesis has given rise to the following publications and conference presentations:

- **Soriano, B**., Garrido, A. How important is economic growth to improve food security in developing countries? Under review in *Developing and Change*.

- **Soriano, B**., Garrido, A. (2014) Does equitable income distribution matter to improve food security? An analysis of 48 developing countries. Under review in *The Developing Economies*.
- **Soriano, B**., Garrido, A. (2014). The role of private sector in Development: The relation between public-private investment in infrastructure and agricultural exports in developing countries. Under review in *Economía Agraria y Recursos Naturales*.
- Willaarts, B., Garrido, A., **Soriano, B**., Molano, M., Federova, O., (2014). Tracking progress and links between water and food security in Latin America and the Caribbean. In Willaarts, B., Garrido, A., and Llamas, R. (eds). Water for Food Security and Well-Being in Latin America and The Caribbean. Social and Environmental Implications for a Globalized Economy. London-Sterling, England; Santander, Spain: Earthscan-Fundación Botín. pp 432.
- Garrido, A., Arévalo, D., Flachsbarth, I., Aldaya M.M., Vanesa, C., **Soriano, B**. (2014). Globalization and Trade. In Willaarts, B., Garrido, A., and Llamas, R. (eds). Water for Food Security and Well-Being in Latin America and The Caribbean. Social and Environmental Implications for a Globalized Economy. London-Sterling, England; Santander, Spain: Earthscan-Fundación Botín. pp 432.
- Perez-Espejo, R., López- Gunn, E., Bea, M., Donoso, G. Jacobi, P., Kuroiwa, J., Matus, A., Pardo, I., Santos, A., **Soriano, B**., Willaartas, B., Zorrilla, P., Zugasti, I. (2014). Socio-economic megatrends for water and food security in Latin America. In Willaarts, B., Garrido, A., and Llamas, R. (eds). Water for Food Security and Well-Being in Latin America and The Caribbean. Social and Environmental Implications for a Globalized Economy. London-Sterling, England; Santander, Spain: Earthscan-Fundación Botín. pp 432.

- **Soriano, B**., Garrido, A., Novo, P. (2013). Agua virtual y cooperación internacional. Las relaciones entre el comercio de agua virtual y la Ayuda Oficial al Desarrollo en la Cooperación Internacional. Madrid, Spain: Fundación Canal. pp 205.
- **Soriano, B**., Garrido, A., Novo, P. Agua virtual y cooperación internacional. Las relaciones entre el comercio de agua virtual y la Ayuda Oficial al Desarrollo en la Cooperación Internacional. 8º Foro Agua para el Desarrollo de la Fundación Canal Isabel II. Madrid, 5th June 2013.
- **Soriano, B**., Garrido, A., Novo, P. Coping with increasing water and land resources limitation for meeting world's food needs: The role of virtual water and virtual land trade". Poster presented at in European Geosciences Union. Vienna, Austria, 8th -12th April 2013.
- **Soriano, B**., Garrido, A., Novo, P. (2013). La pugna por el acceso y control de la tierra y el agua. *Política Exterior*, 151.
- **Soriano, B**., Garrido, A., Novo, P. (2012). La seguridad hídrica y alimentaria global. Agua y alimentación, por derecho. Madrid, Spain: ONGAWA. Ingeniería para el Desarrollo Humano, UNESCO Etxea y Prosalus.pp 77.
- **Soriano, B**., Garrido, A., Novo, P. La seguridad hídrica y alimentaria global. Conference on Right to Water and Sanitation. Madrid, 20-21th March 2012.

2 The role of private sector in development: The relation between public-private investment in infrastructure and agricultural exports in developing countries

Abstract

Increasing foreign private investment in developing countries explains why the private sector is becoming a key actor to reach the sustainable development goal. Public-private partnerships represent a channel through which the private companies are involved in the development aim. This article analyzes the relation between public-private investment in infrastructure and agricultural exports in developing countries. For this purpose we use the panel data approach procedures (52 developing countries and 17 years, from 1995 to 2011). Results show that public-private investment in infrastructure has a positive impact on agricultural exports of development countries. This positive impact is greater in developing countries with higher income per capita rates. This suggest that the poorest countries require the intervention of public sector without which foreign private investment cannot help national economies to became active participants in international trade.

Keywords: Public-private investment in infrastructure, agricultural exports, development, panel data, developing countries.

Clasificación JEL: C33, F21, O11, Q17.

2.1 Introduction

According to the International Fund for Agricultural Development (IFAD), more than 70% of global population lived in rural areas in 2008. Agriculture is the major economic activity and the main source of livelihood for the rural population (IFAD, 2011). Boosting the agricultural sector by enhancing infrastructure investments is one of the main elements to reduce poverty in developing countries (World Bank, 1982; World Bank, 2008; Cervantes-Godoy and Dewbre, 2010). Investment in infrastructure strengthens the links between local producers and consumers and facilitates access of farmers to local and regional markets (UN, 2011a). The World Trade Organization (WTO) found that the investment in infrastructure permits developing countries reducing their transaction costs and participating in international trade under more competitive conditions (WTO, 2013). Improving farmers' access to markets is framed in the export-lead growth strategy. Policies promote the foreign direct investment in export oriented sectors, improving the commercial position in the international markets and increasing the reserves of foreign exchange reserve and incomes.

The dollar value of world merchandise trade has increased by more than 7% per year on average over the last twenty years (1980–2011). World trade has grown on average nearly twice as fast as world production. The share of developing economies in world exports has risen from 34 % in 1980 to 47 % in 2011 and the share of developed economies has dropped from 66 per cent to 53 % (WTO, 2013). Food trade shows similar trend. In last forty years, the number of calories exchanged through the global food trade has multiplied fivefold (FAO, 2011b). Developing countries have increased their share in global agricultural exports from 20-25% before Uruguay Round to more than 50% in 2010.

Developing countries still face large funding gaps in their plans to invest in infrastructure. It is estimated that infrastructure spending will have to rise between 1.8 and 2.3 trillion dollars per year by 2020 to meet the needs of developing countries. Traditional transnational corporations (TNCs) remain the largest investors in infrastructure (UNTT, 2013). The Foreign Direct Investment (FDI) has increased from

400 billion dollars in 1995 to 1.450 billion dollars in 2013 (UNCTAD, 2014). Since 1990, developing countries became the major recipients of FDI (more than 50% in 2013).

The increasing presence of the private investment in developing countries explains why private sector has been defined in post-2015 Agenda as an essential pillar to reach the sustainable development goal. The participation of the public sector is pivotal to attract foreign private investment. Public sector is responsible for creating adequate investment climates (World Bank, 2008) and promoting public-private partnerships (UN, 2010; UNCTAD, 2011; UNTT, 2013a). The World Bank has launched the initiative of consulting projects for public-private participation in infrastructure (PPIAF-Public-Private Infrastructure Advisory Facility). It gives support to developing countries to create adequate investment environments (policy guidance, development of regulation, consolidation of institutions and governance) that encourage foreign investors to invest in those sectors that the public sector cannot cover. Public-private investments projects in infrastructure reach 150 billion dollars in 2013 (World Bank, 2013). The projects cover investment in transport, telecommunications, energy and water and sanitation. We select a sample of 52 developing countries (see Appendix 2.1) that accounts for 99% of the public-private investment projects compiled in the Private Participation in Infrastructure Project Database of the World Bank (World Bank, 2014a).

Recent studies on the analysis of the relationship between investment and trade highlight the premise that it is relevant analyze more in depth the investment in infrastrucutre because the provision of infrastructure transmits the impact FDI on trade (Aizenman and Noy, 2005; Ghosh, 2007). The aim of this chapter is to analyze the relationship between public-private investment in infrastructure and the agricultural exports of developing countries. It seeks to test the hypothesis that public-private investment in infrastructure in developing countries is positively related to the volume of agricultural exports. We consider a sample of 52 countries in the period from 1995 to 2011.

The structure of the article is as follows. Section 2 reviews the literature on trade and investment. A descriptive analysis of public-private investments in infrastructures is presented in section 3. In section 4, we describe the empirical framework. First we present the sample of countries and second we detail the estimation model and the robustness testing techniques. The main results and discussion are summarized in section 5 and in section 6 we expose the principal concusions.

2.2 Literature Review

The literature about the relationship between investment and trade focuses on the identification of the complementary relation (positive sign) or substitution relation (negative sign) between FDI and international trade. There is a complementary relationship when FDI is vertical, i.e., the transnational corporation separates the production chains geographically by outsourcing some production stages abroad. FDI and trade are substitutes when FDI is horizontal, that means that transnational corporation duplicates the same activities in different countries (Fontagné, 1999). Horizontal FDI takes place between developed countries more frequently and vertical FDI between developed and developing countries (Magalhaes and Africano, 2007).

Given the fact that investment and trade are endogenous variables, a vast literature has analyzed the direction of the causality relationship between these two variables. There is a greater consensus about the fact that private investment precedes to trade (Liu *et al.*, 2001; Alguacil *et al.*, 2002; Pacheco-López, 2005; Pramadhani *et al.*,2007). Bezuidenhout and Naudé (2008) conclude otherwise that trade leads to higher private investment. Aizenman and Noy (2005) suggest that there is a bidirectional relationship between trade and investment, with no clear causality in either direction.

There are several private investment studies that use a sector based approach. Swenson and Davis (1999) analyze the private investment broken down according to the type of product, industry and manufacture production. They conclude that the relationship between trade and private investment varies depending on the level of disaggregation. If the analysis focuses on product and industry, investment and trade are substitutes. But, they are complements when the analysis is based on higher disaggregation level. Furtan and Holzman (2004) and Rakotoarisoa (2011) study the relationship between private investment in agriculture and food trade in Canada and Sub- Saharan countries, respectively. Both studies conclude that private investment in the agricultural sector and food trade are complements. Some authors highlight that the private investments research with a sector based approach have to be reinforced. Aizenman and Noy (2005) and Ghosh (2007) propose to carry out new studies based on investments in infrastructures as a part of the production process.

In relation to investment in infrastructure, the availability of infrastructure has been used in the literature as a variable to measure the domestic trade costs. The literature supports the hypothesis that domestic trade costs are significant determinants of the volume of trade between countries (Hoekman and Nicita, 2011). Trade facilitation by investing in physical infrastructure and regulatory reforms, improve the export performance of developing countries (Kyvik and Piermartini, 2004; Portugal-Perez and Wilson, 2012). Indeed, this positive impact is far important than variations in tariffs in explaining North-South trade (Francois *et al.*, 2007).

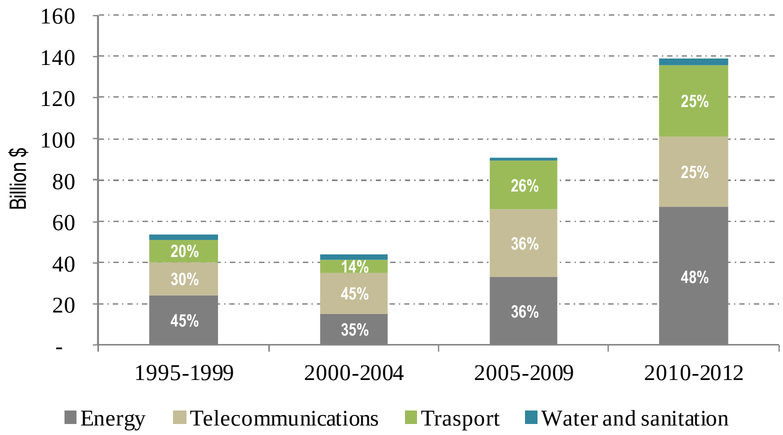
2.3 Public-private investment projects in infrastructure in developing countries

Foreign private investment in developing countries has grown rapidly in recent years. According to UNCTAD (2011), FDI in developing countries for the first time represents over 50% of global investment flows in 2010 and accounted for 778 billion dollars in 2013 (UNCTAD, 2014). There are important differences concerning the amount invested in developing countries according to their state of development. While in 2013 private investment in least developed countries and landlocked developing countries experienced a fall in FDI, countries in Asia (55% of the FDI in developing countries) and Latin America concentrated the vast majority of foreign private investment (37% of the FDI in developing countries) in 2013 (UNCTAD, 2014).

The public-private investment in infrastructure shows a similar trend to FDI trend. As Figure 2.1 shows, the public-private investment in infrastructure in the selected sample of countries stood at 50 billion current dollars in period 1990-1994. This figure has increased up to 140 billion current dollars in 2010-2012 (World Bank, 2014a). It is mainly concentrated on upper middle income countries. The major recipients of investment in infrastructure are India, China and Indonesia in Asia and Brazil and Mexico in Latin America.

There is a clear targeting of the public-private investment into the energy sector, reaching more than half of total public-private investment in period 1995-2011 (Figure 2.1).

Figure 2.1. Evolution of the public-private investment in infrastructure by investment sector (billion current dollars). Periods 1995-1999, 2000-2004, 2005-2009 and 2010-2012



Source: Own elaboration based on World Bank (2014a)

Energy sector includes projects of generation, transmission and distribution of electricity and natural gas. Energy is a key element in the development process. It is required for food processing, transportation, fertilizer production and use of industrial equipment, among other multiple uses (Stout, 1990). Telecommunications (investment in fixed access network and mobile communications), in turn, is a priority sector for investment. The International Institute for Communication and Development (IICD) promotes the investments in telecommunications, on the basis that greater access and providing timely information (prices, clients, suppliers) enhances the bargaining power of small farmers, increases trade and promotes agriculture production (IICD, 2006; IICD, 2012). Investment in telecommunications accounted for 45% of the total public-private investment in infrastructure in 2000-2004. This percentage has decreased over last years on behalf of the investment in transport and energy. Since 2005, investment in transports accounts for 25% of the public-private investment in infrastructure. The availability of adequate transportation infrastructure facilitates access of farmers to markets (World Bank, 2005). Investments in transportation include roads, bridges, tunnels, terminals and dredging of channels projects. Public-private investment in water and sanitation include water transport systems, water treatment and sewerage plants and water and sanitation services. It represents less than 5% of the public-private investment in infrastructure over the analyzed period.

More than half of the public-private investments analyzed are greenfield projects (project that involves the creation of a new company that carries out the investment). Concessions and divestitures of public companies are also among the modalities of public-private participation (near about 20% of the amount invested by each) (World Bank, 2014a). Private participation clearly leads the investment in infrastructures. Public participation that exceeded 20% of the investment in the 1990s, it has been declining over the period, representing less than 10% in 2012.

2.4 Empirical Framework

2.4.1 Description of the study sample

The sample of the study comprises 52 developing countries that it is representative of developing countries as a whole and accounts for 99% of the public-private investment projects compiled in the Private Participation in Infrastructure Project Database of the World Bank (World Bank, 2014a). There are countries with different income per capita (from least developed countries to upper middle income countries) in four geographical regions, East and South Asia, Europe and Central Asia, North Africa and Near East, Sub-Saharan Africa and Latin America.

We analyze and classify the countries of the sample according to the trade openness. It is an indicator of the orientation degree of national economies to international trade, defined as the relation between trade (sum of exports and imports of merchandise and services) and Gross Domestic Product (GDP) in a country. We apply Wilcoxon-Mann-Whitney test for independent and non-parametric samples. The sample of the study covers the period 1995-2011. The sample is divided into two sub-samples (sub-sample 1 and sub-sample 2), depending on whether trade openness is higher or lower than a reference value (Table 2.1). This value is the median of the average trade openness in period 2007-2011 by country, and it equals 70.53% (World Bank, 2014a).

Table 2.1. Sample of developing countries classified according to their trade openness. The reference value is the percentile 50 of average trade openness in period 2005-2011

Trade openness lower than median (70.53 %) (Sub-sample 1)		Trade openness higher than median 50 (70.53 %) (Sub-sample 2)	
Albania	Iran	Azerbaijan	Paraguay
Argentina	Kenya	Belarus	Philippines
Bangladesh	Mexico	Bolivia	Senegal
Benin	Pakistan	Costa Rica	Swaziland
Brazil	Peru	Côte d´Ivoire	Syria
Burkina Faso	South Africa	El Salvador	Thailand
Cameroon	Sri Lanka	Gabon	Tunisia
Chile	Tanzania	Honduras	Uganda
China	Turkey	Kazakhstan	Ukraine
Colombia	Uruguay	R. of Macedonia	Vietnam
Ecuador	Venezuela	Malaysia	Yemen
Egypt		Moldavia	
Guatemala		Morocco	
India		Mozambique	
Indonesia		Nicaragua	

Source: Own elaboration based on World Bank (2014b)

We select three target variables: GDP per capita, public-private investment in infrastructure and agricultural trade (see Appendix 2.2) [2]. Wilcoxon- Mann-Whitney test the null hypothesis (H_0) that sub-sample 1 is similar to sub-sample 2 considering each target variable. It first ranks all observations of the sample regardless of whether they belong to sub-sample 1 or sub-sample 2.

[2] We apply Wilcoxon-Mann-Whitney test to analyze the performance of agricultural production per capita, agriculture as a share of GDP, agriculture trade as a share of goods trade. In all these cases, the results show that there are not statistically significant differences between sub-sample 1 and sub-sample 2.

The observations are sorted from lowest to highest value of the target variable, assigning one to the smallest value. Rank sum is performed according to the following expressions:

$$T_1 = \sum_{i=1}^{n1} R_{1i} \qquad\qquad T_2 = \sum_{i=1}^{n2} R_{2i} \qquad [1]$$

where,

T_1= Rank sum of sub-sample 1,
R_{1i}= Ranks of i countries of sub-sample 1,
n_1= Sample size of sub-sample 1,
T_2= Rank sum of sub-sample 2,
R_{2i}= Ranks of i countries of sub-sample 2,
n_2= Sample size of sub-sample 2.
Based on rank sum, the expression of the calculation of the Mann-Whitney statistical (U_1 and U_2) is as follows. Between U_1 and U_2, we consider the lowest value to study its significance.

$$U_1 = T_1 - \frac{n_1(n_1+1)}{2} \qquad\qquad U_2 = T_2 - \frac{n_2(n_2+1)}{2} \qquad [2]$$

where,

U_1 = Mann-Whitney statistic in sub-sample 1,
n_1= Sample size of sub-sample 1,
T_1= Rank sum of sub-sample 1,
U_2 = Mann-Whitney statistic in sub-sample 2,
n_2= Sample size of sub-sample 2,
T_2= Rank sum of sub-sample 2.

We test the null hypothesis (H_0) that GDP per capita in developing countries with lower trade openness (sub-sample 1) is similar to income per capita in developing countries with higher trade openness (sub-sample 2). The results are shown in Table 2.2. The target variables are shown in the columns. For each target variable we summarize the number of observations (columns 2, 5, 8), the rank sum (columns 3, 6, 9) and the statistic Z[3] (columns 4, 7, 10). The rows present the different sub-samples analyzed: row 1 (sub-sample 1: lower trade openness,), row 2 (sub-sample 2: higher trade

3 The distribution of the statistical Mann-Whitney (U) approximates a normal distribution in large samples. In these cases, statistical can be standardized according to the following expression: Z=($U - \overline{U}$)/σ_u).

openness,) and row 3 (the whole sample). We analyze the data of 52 countries over the period 1995-2011 (17 years). The whole sample size includes 884 observations and the rank sum stands at 391.170 (N x (N+1)/2)). Depending on the variable analyzed, there are missing values that explain why the rank sum in row 3 is lower than 391.170 in same cases.

Concerning GDP per capita, it can be seen that the rank sum of sub-sample 1 (lower trade openness) is higher than the rank sum of sub-sample 2 (higher trade openness). This difference is statistically significant. It means that GDP per capita is higher in countries with lower trade openness than in those with higher trade openness.

Table 2.2. Wilcoxon-Mann-Whitney test results

	GDP per capita			Public-private investment in infrastructure			Agricultural exports		
	Nº obs.	Rank sum	Z	Nº obs.	Rank sum	Z	Nº obs.	Rank sum	Z
Sub-sample 1: Trade openness lower than median (70,53%)	442	205,935		380	171,295		419	215,444	
Sub-sample 2: Trade openness higher than median (70,53%)	441	184,351		368	108,830		415	132,751	
Whole sample	883	390,286		748	280,125		834	348,195	
			2.79 **			9.81 ***			11.65 ***

Note: *, **, *** denote statistical significant level at 10%, 5% and 1%.
Source: Own elaboration based on World Bank (2014a) and World Bank (2014b).

Similarly, there are significant differences in public-private investment and agricultural exports between sub-sample 1 and sub-sample 2. The rank sum of sub-sample 1 is higher than the rank sum of sub-sample 2 in all the cases and the differences are statistically significant. This suggests that the public-private investment in infrastructure and agricultural exports are higher in countries with lower trade openness. We conclude that, on average terms, developing countries with lower trade openness have higher

GDP per capita, attract more private investment in infrastructure and have a greater agricultural export capacity.

Differences in export capacity are also shown through the analysis of the agricultural exports trend. The agricultural exports of the countries that belongs to sub-sample 1 (lower trade openness) increased from 16 billion current dollars in 1995 to 58 billion current dollars in 2011. In this year, the agricultural exports of the developing countries of the sub-sample 2 (higher trade openness) were 31 billion current dollars. Considering the period 2007-2011, the major agricultural exporters are Thailand, Indonesia, China and Malaysia in Asia, and Brazil, Chile and Argentina in Latin America.

2.4.2 Methodology

Several studies analyze the direction and sign of the causality relationship between investment and trade. Using country specific data, authors apply Granger causality test in order to find out if the current and past performance of FDI explains exports or the causal relationship follows the opposite direction (Alguacil *et al.,* 2002; Pramadhani *et al.,* 2007). Other studies use gravity models. These models try to explain bilateral trade analyzing the variables that measure the weight of the countries involved in trade (population, GDP, FDI, and so on) and variables that measure the distance between them (trade barriers, language and so on) (Magalhaes and Africano, 2007; Bezuidenhout and Naudé, 2008). Finally, some authors broaden the sample size and analyze the relationship between investment and trade for a set of countries using panel data analysis (Gyfalson, 1997; Furtan and Holzman, 2004; Ghosh, 2007).

We compile a panel database of a sample of 52 developing countries, over the period 1995-2011. Considering the country-year as the unit of analysis, the total number of observations varies from 608 to 707, depending on the missing values. We build on previous causality studies that suggest that the private investment precedes trade (Liu *et al.*, 2001; Alguacil *et al.*, 2002; Pacheco-López, 2005; Pramadhani *et al.,* 2007). In our model, agricultural export is the dependent variable and public-private investment in infrastructure is one of the explanatory variables. We test the hypothesis that there is a positive relationship between public-private investment in infrastructure and agricultural exports (see Appendix 2.2).

In the estimation model, we analyze economic variables that have been tested previously by other authors (Model [1]). The economic variables selected are: a) Nominal annual exchange rate (Furtan and Holzman, 2004)[4]; b) GDP per capita of the exporter country (Ghosh, 2007); and c) Average world GDP per capita (Rahim and Samad, 2009). All the variables are expressed in logarithms. The estimation of the baseline model [1] is as follows:

$$L\_Agri\_X_{it} = \alpha_0 + \alpha_1 \text{L\_PPI\_infra}_{it} + \alpha_2 \text{L\_XRT}_{it} + \alpha_3 \text{L\_GDP\_cap}_{it} + \alpha_4 \text{WGDP\_cap}_{t} + \varepsilon_{it} \quad [3]$$

where,

i = 1…52 developing countries;
t = 1…17 years (period 1995–2011);
$L\_Agri\_X_{it}$ = Logarithm of agricultural exports, country i, year t;
$L\_PPI\_Infra_{it}$ = Logarithm public-private investment in infrastructure, country i, year t;
L_XRT_{it} = Logarithm nominal annual exchange rate, country i, year t;
$L\_GDP\_cap_{it}$ = Logarithm GDP per capita, country i, year t;
$L\_WGDP\_cap_{t}$ = Logarithm average world GDP per capita, year t;
ε_{it} is the error term;

We apply four techniques for testing the robustness of the results of the baseline model [1]:

1. We introduce fixed effects in the estimation model. We use dichotomous variables that identify some of the strategic characteristics of developing countries. We define a dichotomous variable that equals 1 if the country is a petroleum exporting country, and another if it has sea access. As result we present the model [2] and model [3].
2. We introduce additional control variables, tested in previous analysis, in the baseline model [1]. We consider macroeconomic stability variables as inflation and

[4] Aizenman and Noy (2005) and Ghosh (2007) propose to use the real exchange rate. Given de limited availability of real exchange rate, we use nominal exchange rate (Furtan and Holzman, 2004).

income growth volatility (Ghosh, 2007) in the model [4][5]. In model [5], we add to model [1] variables that measure the institutional quality such as general government final consumption expenditure (Gyfalson, 1997) and political regime[6] (Aizenman & Noy, 2005; Ghosh, 2007). Finally, model [6] includes variables that describe the agricultural sector: the agriculture value added (Gyfalson, 1997) and the agricultural gross production value per capita (see Appendix 2.2).

3. As has been shown in previous section, there are statistically significant differences between developing countries according to their trade openness. Taking into account this result, we define a new model [7], introducing in the baseline model [1] a new dummy variable that controls whether the country belongs to the sub-sample of countries with lower trade openness (sub-sample 1) or with higher trade openness (sub-sample 2), being 1 if the country belongs to sub- sample 1.

4. We run the baseline model [1] on the sub-sample 1 and on the sub-sample 2, separately.

2.5 Results and discussion

We first present the analysis of the partial correlations of the dependent and explanatory variables of the estimation models. As it can be seen in Table 2.3 there is a positive correlation between agricultural exports (Agri_X) and public-private investment in infrastructure (PPI_infra). This correlation provides a first clue about the potential relevance of public-private investment in infrastructure as an explanatory variable of the performance of the agricultural exports. There are other explanatory variables that show a positive correlation with agricultural exports: GDP per capita (GDP_cap), agricultural production per capita (Agri_prod_cap), world GDP per capita (WGDP_cap) and nominal exchange rate (XRT). The partial correlation between agricultural exports and agriculture value added (Agri_sector) is negative. The partial correlation between agricultural exports and inflation also shows a negative sign.

[5] Inflation is calculated as the difference of the logarithm of the consumer price index in the exporting countries. Macroeconomic volatility is the five year moving standard deviation GDP growth rate.

[6] Political regime ranges from -10 (autocracy) to 10 (full democracy).

Table 2.3. Partial correlations. Sample of 52 countries in period 1995-2011

	Agri_X	PPI_Infra	XRT	GDP_cap	WGDP_cap	Inflation	Volatility	Gov_expend	Democracy	Agri_sector	Agri_Prod_cap
Agri_x	1										
	(834)										
PPI_Infra	0.55*	1									
	(711)	(748)									
XRT	0.12*	-0.16*	1								
	(829)	(744)	(879)								
GDP_cap	0.33*	0.29*	-0.28*	1							
	(834)	(747)	(878)	(883)							
WGDP_cap	0.18*	0.15*	0.04	0.37*	1						
	(834)	(748)	(879)	(883)	(884)						
Inflation	-0.07*	0.01	-0.03	-0.03	-0.06*	1					
	(804)	(724)	(848)	(852)	(853)	(853)					
Volatility	-0.03	0.06	-0.19*	0.10*	-0.29*	0.27*	1				
	(834)	(748)	(879)	(883)	(884)	(853)	(884)				
Gov_expend	0.02	0.03	-0.18*	0.14*	0.05	0.03	0.02	1			
	(826)	(734)	(865)	(870)	(870)	(839)	(870)	(870)			
Democracy	0.03	0.13*	-0.09*	0.20*	0.04	0.03	-0.04	-0.04	1		
	(817)	(734)	(862)	(866)	(867)	(836)	(867)	(856)	(867)		
Agri_sector	-0.29*	-0.29*	0.32*	-0.84*	-0.20*	0.02	-0.08*	-0.16*	-0.18*	1	
	(816)	(727)	(857)	(862)	(862)	(831)	(862)	(858)	(848)	(862)	
Agri_prod_cap	0.24*	0.16*	-0.13*	0.79*	0.48*	0.01	0.06*	0.24*	0.12*	-0.48*	1
	(727)	(649)	(756)	(761)	(761)	(738)	(761)	(752)	(744)	(747)	(761)

*, p<0,05. The figures in parentheses indicate the number of observations.

It is worth highlighting the high negative correlation between GDP per capita and the agriculture value added (ρ= -0,84) and the high positive correlation between GDP per capita and agricultural production per capita (ρ= 0,79).

We apply tests to control the correlation and heteroskedasticity. We apply the Wooldridge test in all the regressions (Wooldridge, 2002) to identify the existence of serial correlation in the error term in the panel-data model. The test result shows that there is serial correlation. We apply Wald test revealing the existence of heteroskedasticity problems (Fox, 1997). To correct for correlation and heteroskedasticity, we apply the panel corrected standard errors (PCSE) that assumes that the disturbances are by default heteroskedastic and contemporaneously correlated across panels (Beck and Katz, 1995).

The results of the baseline model [1] are summarized in the second column of Table 2.4. As it can be seen, the coefficient of the public-private investment in infrastructure is positive and statistically significant. This result suggests that public-private investment in infrastructure enhances agricultural exports in developing countries. Our result agrees with previous results that find a positive relationship between FDI and trade (Fontagné, 1999; Alguacil *et al.*, 2002). The coefficient shows the elasticity of the agricultural trade because the variables are transformed in logarithms. Hence, it indicates that 1% increase in public-private investment in infrastructure would generate an increment of 0.08% of the agricultural exports. If we compare the coefficients of the explanatory variables we can see that the coefficient of the public-private investments is the smallest. This can be explained by the fact that investment in infrastructure is not a direct investment in agriculture but it is a cross-sectoral investment.

GDP per capita variables have the highest estimated coefficients. As the world GDP per capita increases, the agricultural exports of developing countries grows. The fact that world GDP per capita has the highest coefficient reveals the relevance of the globalization and its impact on developing economies. National GDP per capita has a positive and statically significant coefficient. As GPD per capita grows, the export capacity of developing countries improves. Finally, the exchange rate coefficient shows that the devaluation of the national currency contributes to increase agricultural exports positively. These results are consistent with those of published by Aizenman and Noy (2005) and Furtan and Holzman (2004).

Table 2.4. Results of the baseline model [1], model [2] and model [3]. Sample of 52 countries in period 1995-2011

Dependent variable: Agricultural exports

	Model [1]	Model [2]	Model [3]
PPI_infra	0.08***	0.06***	0.06***
	(0.01)	(0.01)	(0.01)
XRT	0.10***	0.05***	0.11***
	(0.01)	(0.01)	(0.01)
GDP_cap	0.44***	0.36***	0.42***
	(0.04)	(0.04)	(0.04)
WGDP_cap	0.61***	0.79***	0.62***
	(0.15)	(0.14)	(0.14)
Petrol_export		0,5***	
		(0.13)	
Access to the sea			0,94***
			(0.12)
Intercept	2.7*	1.8	1.9
	(1.3)	(1.15)	(1.22)
N	707	707	707
R^2	0.94	0.94	0.94

Note: *, **, *** denote statistical significant level at 10%, 5% and 1%. Figures in parentheses are the coefficients standard errors.

The columns 3 and 4 of the Table 2.4 present the results of the model [2] and model [3]. As Table 2.4 shows, if we introduce the dummy variables the results obtained in model [1] do not change. The sign of the public-private investment in infrastructure and the rest of the explanatory variables remain positive and statistically significant. The two coefficients of the dummy variables are positive and statistically significant. It means that the agricultural exports of the exporting petroleum countries (13 out of 52) are higher than non petroleum exporting countries. In the same way, countries with sea access (44 out of 52) have higher agricultural export capacity than landlocked countries.

Table 2.5 summarizes the results of the models [4], [5] and [6]. It can be seen that, even if new variables are considered and the number of observations is smaller, the coefficient of the public-private investment in infrastructure remains positive and statistically significant in all the models. The sign and size of the coefficient are similar to that obtained in model [1].

Table 2.5. Results of the Model [4], Model [5] and Model [6]. Sample 52 countries in period 1995-2001

Dependent variable: Agricultural exports			
	Model [4]	Model [5]	Model [6]
PPI_Infra	0.08***	0,09***	0,11***
	(0.01)	(0.01)	(0.02)
XRT	0.09***	0.09***	0.14***
	(0.01)	(0.01)	(0.02)
GDP_cap	0.49***	0.48***	
	(0.04)	(0.05)	
WGDP_cap	0.49**	0.58***	0.60***
	(0.16)	(0.15)	(0.17)
Inflation	0.05*		
	(0.02)		
Volatility	-0.07		
	(0.04)		
Gov_expend		-0.09	
		(0.11)	
Democracy		-0.22	
		(0.19)	
Agri_sector			-0.72***
			(0.07)
Agri_prod_cap			0.16**
			(0.05)
Intercept	3.37*	3.19*	6.70***
	(1.33)	(1.42)	(1.37)
N	684	688	608
R^2	0.94	0.94	0.95

Note: *, **, *** denote statistical significant level at 10%, 5% and 1%. Figures in parentheses are the coefficients standard errors.

Model [6] presents the highest elasticity of the public-private investment in infrastructure. In model [6], the GDP per capita has been removed from the model, because its correlation with agricultural sector variables (Table 2.3). The fact that the model does not consider the GDP per capita explains partially why the coefficient is higher in model [6] than in models [4] and [5]. The results show that the coefficients of the income variables remain the highest estimated coefficients and the coefficient of the exchange rate is positive a statistically significant in all the models.

Concerning the macroeconomic stability control variables, it can be seen that the coefficient of inflation is positive and statistically significant. The sign is contrary to expected. The analysis of the correlations (Table 2.3) shows a negative correlation between agricultural exports and inflation rate. The negative impact of inflation on trade variables has been found by several authors. Thus, inflation has a negative impact on trade openness (Ghosh, 2007) and on the exports as a share of GDP (Gyfalson, 1997). The coefficient of the income growth volatility is negative but not statistically significant. This result is consistent with that obtained by Ghosh (2007), who claims that the relationship between income volatility and trade is indirect and negative, but not direct.

Referring to institutional quality (third column of Table 2.5), our model does not identify a direct relationship between institutional quality and trade. The coefficients of the government expenditure and democracy are no statistically significant. These results are consistent with the other results that do not find the direct impact of institutional quality on trade (Aizenman and Noy, 2005; Ghosh, 2007). Rodrik (1998) identifies this relationship and claims that the institutional quality enhances exports. Finally, we obtain the results of the model [6], in which GDP per capita variable is removed due to the correlation with additional agricultural sector variables (Table 2.3). The coefficient of agriculture value added is negative and statistically significant. It is the highest coefficient in the model [6]. The direction of the effect implies that higher agricultural value is followed by lower agricultural exports. In making sense of this result, we return to the negative correlation found between GDP per capita and agriculture value added (Table 2.3). An increment of GDP per capita is accompanied by a reduction of the agriculture value added. As income grows, the investments in high added value productive sectors increase and the contribution of agriculture to GDP decreases. Dependence theory poses that this result does not always take place (Prebisch, 1959). Agricultural export revenues fund imports of manufactured goods from developed countries, instead of being invested in high value productive sectors (Import-substitution industrialization, ISI). Gyfalson (1997) concludes that an intensification of the agriculture in an economy may ultimately harm exports. Agriculture does not make use of qualified manpower and high technology that confer benefits to other manufactured industries where there is higher trade liberalization. Bertola and Ocampo (2012) highlight that Latin American economies are not taking advantage of the boom in agricultural exports to invest in productive sectors unrelated to natural resources. Achieving a sustainable economic growth requires bridging the technology gap with industrialized countries. Finally, as is expected, the coefficient of agricultural production is positive and statistically significant. As agricultural production rises, the agricultural exports increase.

In section 2.4 we classified the countries of the sample according to the trade openness and defined two sub-samples (Table 2.1). Table 2.6 summarizes the results of model [1] considering the sub-sample 1 (countries less open to trade) and sub-sample 2 (countries more open to trade). The second column of the Table 2.6 presents the model [7] that includes the dummy variable (trade openness) that equals to 1 if the country belongs to sub-sample 2. The column 3 and 4 show the results of the model [1] that runs on the sub-sample 1 and sub-sample 2 respectively.

Table 2.6. Results of the model [7], sample 52 countries in period 1995-2001. Results of model [1], sub-sample 1 (26 countries less open to trade) and sub-sample 2 (26 countries more open to trade) in period 1995-2001

Dependent variable: Agricultural exports

	Model [7]	Model [1] Sub-sample 1	Model [1] Sub-sample 2
IPP_Infra	0.04**	0.11***	0.04*
	(0.01)	(0.02)	(0.01)
XRT	0.09***	0.02	0.15***
	(0.02)	(0.02)	(0.03)
GDP_cap	0.39***	0.15**	0.42***
	(0.03)	(0.05)	(0.07)
WGDP_cap	0.63***	1.50***	0.12
	(0.14)	(0.19)	(0.24)
Trade openness	-1.01***		
	(0.07)		
Intercept	3.68**	1.97	6.66***
	(1.25)	(1.65)	(2.02)
N	707	357	350
R^2	0.94	0.95	0.93

Note: *, **, *** denote statistical significant level at 10%, 5% and 1%. Figures in parentheses are the coefficients standard errors.

As shown in Table 2.6 the results of the model [7] are similar to those in those in model [1]. The coefficient of public-private investment remains positive and statistically significant. The sign of the dummy variable (trade openness) is negative and statistically significant. It indicates the countries that belong to sub-sample 2. The negative sign shows that the agricultural exports of the countries that belongs to sub-sample 2 (those with higher trade openness) are lower than the exports of the countries of sub-sample 1. This result confirms the results of the Wilcoxon-Mann-Whitney test presented in section 2.4.

There are no modifications in the results when we consider the sub-sample 1 and sub-sample 2 separately (column 3 and 4). All the coefficients remain positive a statistically significant, even if the number of observations drops to 350. Comparing the results of the model run on the sub-sample 1 and sub-sample 2, the following results stand out: (1) The coefficient of the public-private investment in infrastructure in sub-sample 1 is higher than sub-sample 2. This means that the same investment in countries with higher income generates a higher improvement in exports than in those with lower incomes. This result is consistent with the findings of (Portugal-Perez & Wilson, 2012). They state that the impact of investments in infrastructure on exports appears increasingly important the richer a country becomes. This result may explain why private investment is focused mainly on higher income countries; (2) The coefficient of GDP per capita is higher in sub-sample 2 than in sub-sample 1, suggesting that income generates higher improvements in agricultural exports in low income countries than in middle-upper income countries; (3) the coefficient of the world GDP per capita is positive and statistically significant in sub-sample 1, but it is not with sub-sample 2. This result reflects that global agricultural demand does not impact on agricultural exports of lower income developing countries because they do not have as much export capacity to participate in international trade.

2.6 Conclusions

The private sector is increasingly present in developing countries and plays an important role in reaching the sustainable development goals. Private investments in infrastructure may boost trade as a key element in development strategies. The goal of the article was analyze the relationship between public-private investment in infrastructure and agricultural exports in developing countries. We test the hypothesis that the public-private investment in infrastructure has a positive impact on the agricultural exports, using a panel data approach that covers 52 countries and 17 years (1995-2011). The results obtained provide evidence of three main contributions.

First, public-private investment in infrastructure contributes positively to increasing agricultural exports in developing countries. After a few robustness tests, we confirm the positive and significant relationship between public-private investment in infrastructure and agricultural trade. According to this conclusion, the private sector contributes to sustainable development goals through the growth of agricultural exports in developing countries.

Secondly, the investment in infrastructure and its impact does not show the same performance across the countries analyzed. This finding leads to conclude that the intensity of the positive impact of the public-private investment on agricultural exports depends on the GDP per capita of the exporting country. The impact of the public-private investment in infrastructure is stronger in higher income countries than in lower income countries. The fact that the same public-private investment in infrastructure generates higher agricultural exports in higher income countries explains why the private investors are focusing on higher income countries. Further, this result is even more relevant if we consider the developed and emerging countries concern to access to natural resources in order to cover their food demand. The least developed countries do not raise the interest of private foreign investors. Private investment in these countries is declining and public-private infrastructure investment does not exceed 20% of the amount invested in the most advanced developing countries. Sustainable development goals have to define measures that enhance public-private investment in infrastructure, with special emphasis in less developed countries. This conclusion suggest that the poorest countries require the intervention of public sector without which foreign private investment cannot help national economies to became active participants in international trade. Public-private investment agreed in the framework of a policy of export-led growth should be accompanied by measures that enable farmers to participate in markets by enhancing education, promoting the access to assets and social capital and strengthening institutional structures and financial security (Lapar *et al.*, 2003).

The third conclusion supports the economic thinking that, although trade openness is being actively promoted as a key component in development strategies, trade does tend to reduce poverty if exporting earnings are reinvested in high value productive sectors. Results show that the agricultural export capacity of a country increases as the participation of agriculture in the national economy (as a share of GDP) decreases. The contribution of the private sector to achieve the sustainable development goals will depend on the ability of the recipient country to invest the export earnings in economic sectors unrelated to natural resources and reducing the technological gap.

3 Does equitable income distribution matter to improve food security? An analysis of 48 developing countries

Abstract

There is mixed evidence in the literature about the effects of the composition of economic growth on food security. This chapter tests whether income inequality has a negative impact on food security in developing countries. The analysis is carried out with the data collected on income distribution variables and food security indicators over 16 years (1995–2010) and across 48 developing countries, using panel data analysis. Results reveal that income inequality has a negative impact on food security. Because of the small variation over time of the gini index, we consider both the inequality level and the relationship between inequality and economic growth. Although inequality is detrimental for food security, in those countries where development is accompanied by a decrease of inequality food security indicators improve faster than in those where inequality is increasing. Our article shows that policies should focus on making income growth more inclusive and more equitable.

Keywords: food security, gini index, agricultural exports

JEL: I3, F1, O1

3.1 Introduction

Food insecurity has been one of the most globally discussed issue in the last years. Despite the efforts that have been made, hunger and malnutrition remain at worrying levels. In 2011-2013 one in eight persons in the world were estimated to be suffering from chronic hunger, regularly not getting enough food to conduct an active life (FAO, IFAD and WFP, 2013). There is enough food available to provide everyone in the world but many people are very poor to afford it (FAO, 2011b). Hunger and poverty are inextricably linked. Not every poor person is hungry, but almost all hungry people are poor. So one of the challenges of eliminating global hunger is raising the incomes of the poor (OECD, 2013). Growth can raise incomes but higher economic growth may not reach everyone.

This article contributes to the literature on the relation between income inequality and poverty (Ravallion, 2004; Sala-i-Martin, 2006; Barro, 2008), addressing the impact of income inequality on food security. According to FAO, the reason hunger is persistent lies in the distribution of food and the resources required to access it (FAO, IFAD, and WFP, 2002). Thus, income growth is necessary, but the composition of growth matters too. More equal growth leads to faster improvements in the food security of the poorest (OECD, 2013). USDA (2012) concludes that the decline in the number of food insecure people over the next decade in Latin American Countries has been caused by an improvement in income distribution.

Our analysis is framed in the dependency theory and the empirical work on the relationship between food security and agricultural exports. Several authors found that agricultural export dependency has a negative impact on food security because it generates a competition between cash crop and food crop production, and hence export-oriented production do not meet local consumption needs (Gacitua and Bello, 1991; Wimberley and Bello, 1992; Austin *et al.*, 2012). An anecdotal, but nonetheless illustrative example, is the case of Paraguay: a country which has seen its exports growing significantly in the last years, but its food security indicators have deteriorated while most other LAC countries' improved significantly (Willaarts *et al.*, 2014).

The goal of this research is to analyze the impact of income distribution on food security in developing countries. We test the hypothesis that income inequality has a negative impact on food security. The analysis is carried out with the data collected on gini index and three different food security indicators over 16 years (1995–2010) and across 44 developing countries using the panel data analysis. The chapter is organised as follows. In section 2 we describe the dimension and level of food security considered within the time and geographical scope of the study, and we identify the variables used to measure it. In this section we also review the literature about the relationship between food security and agricultural exports. In the section 3 we review the literature about inequality and growth, and report our own exploratory results focusing on various measurements of inequality and growth pertaining to our countries' database. In the section 4 we present the model specification and the model estimation. The results and discussion are presented in the sections 5 and 6. Finally, the section 7 highlights the main conclusions.

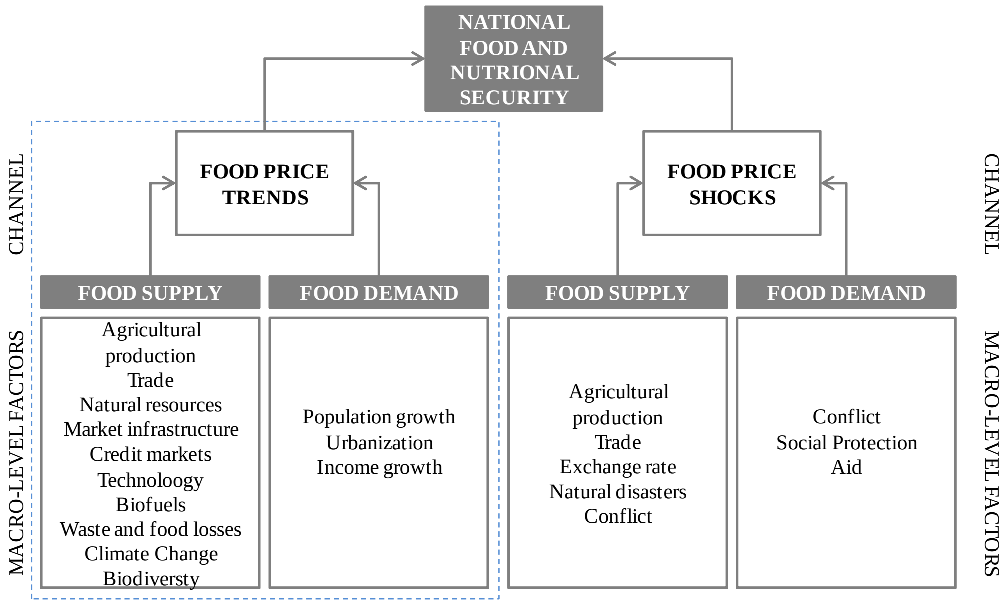
3.2 Food security and trade dependency in developing countries

3.2.1 Food security: Definition and evolution

Food security can be analyzed at different levels of aggregation, from individual, household, national up to international level. At the World Food Summit in 1996, food security was defined as the situation "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". National food security is used to check if a country produces the food that its population demands and is able to afford. It is a function of the countries' production capacity, trade and institutional systems to provide an adequate supply of food to inhabitants. It depends on macro-level factors, including internal food production, income generation and distribution, foreign exchange, earning capacity, provision on availability of storage and transportation. This chapter is focused on food security at national level.

According to Pieters, *et al.*, (2013) the major channel through which macro-level factors affect national food security is the food price channel. Figure 3.1 depicts the channels through which food demand and food supply can be affected by macro-level policies in the short and long run.

Figure 3.1. Macro-levels drivers of National Food Security



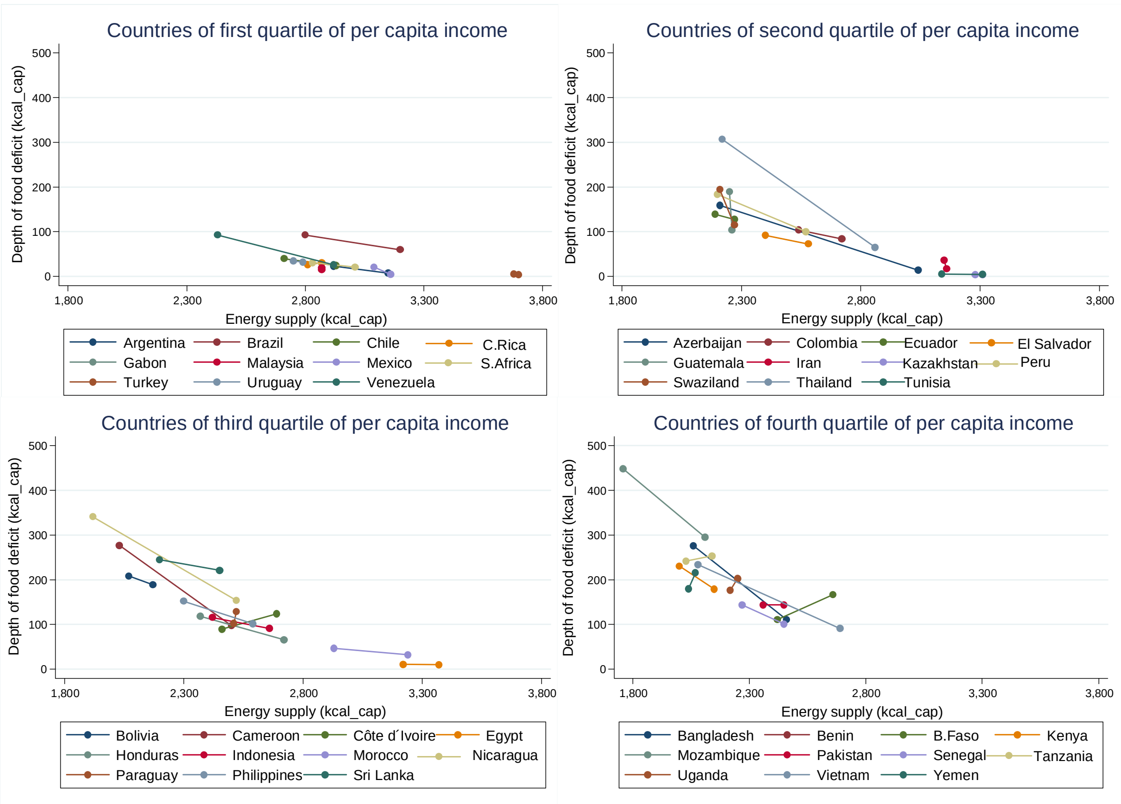
(*) The dashed blue line identify the macro-level factors on which the study is based on.

Source: Own elaboration based on Pieters *et al.*, (2013)

Food security is a broader concept that includes health and nutrition outcomes and consumption outcomes. This study focuses on consumption outcomes, because they are the direct result of a food security situation and do not depend on factors like health provision or culture. We analyze two indicators of consumption status: average energy supply (kcal/cap/day) and average protein supply (gr/cap/day) (Gacitua and Bello, 1991; Wimberley and Bello,1992; Scanlan, 2001; Brady *et al.,* 2007). We complete the analysis adding a variable that measures the severity of hunger (Austin *et al.*, 2012). This variable is the depth of the food deficit (kcal/cap/day) and results from the calculation of the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished population, multiplied by the number of undernourished and normalised by the total population.

Figure 3.2 graphs the evolution of the average energy supply and the depth of food deficit. It compares the values of both variables in 1995 and in 2010. As Figure 3.2 shows, the relationship between both measures is negative. As average energy supply increases the depth of food deficit decreases. Most of the developing countries have experienced an improvement in both food security indicators, although the intensity of the recovery is not the same among developing countries. Depth of food deficit is higher and decreases more sharply in those countries in which the average energy intake is lower than 2,800 kcal /cap/day. The depth of food deficit ranges between 100 kcal/cap/day and 448 kcal/cap/day in countries where food deficit is lower than 2,800 kcal/cap/day. These countries are those classified in the third and fourth quartile per capita income. Once energy intake exceeds 2,800 kcal/cap/day, the food deficit ranges from 110 kcal/cap/day to 4 kcal/cap/day. This is the case of countries classified in first quartile of income per capita. There are some exceptions to this regularity. In some countries, although nutritional status improves, the depth of the food deficit increases. These exceptions are found mostly in those countries classified in third and fourth quartile of income per capita, for example in some African countries (Cameroon, Benin, Burkina Faso and Yemen).

Figure 3.2. Evolution of Average Energy Supply and Depth of Food Deficit in a sample of developing countries classified by quartiles of per capita income. Years 1995, 2010



Source: Own elaboration based on food security indicators (FAO, 2014)

3.2.2 *Trade dependency Theory*

The impact of the growth of agricultural exports on the food security in developing countries is an unsettled issue in the academic literature. OCDE (2013) remarks that trade has an important role in raising incomes through the creation of wealth for both exporters and importers. Increasing food sales and exports lead to a higher income and, given the greater supply, the staples become cheaper. The assumption is that if households see their income increase they will also increase their food security, by consuming more and/or better quality food. Ivanic and Martin (2014) conclude that in the long run food prices increases benefit the poor farmers. They benefit from increases in wages and higher agricultural profits. These approaches are in line with claims about trade openness being a means to stimulate economic growth even if the benefits were not always equally shared (Firebaugh and Beck, 1994; Dollar and Kraay, 2004; Bhagwati, 2007).

An alternative view posed by dependency theory claims that investment and trade dependence is an impediment to development in developing countries. The unbalanced terms of trade relationships for developing countries obstruct their alleviation of poverty progress (Stiglitz and Charlton, 2005; Dos Santos, 2009; Rodrik, 2012).

Applying the dependency argument to food security, empirical studies support the conclusion that agricultural trade has a negative influence on food security in developing countries. Braun and Kennedy (1986) explain that the negative relationship is due to the competition between cash crop and food crop production. Gacitua and Bello (1991) and Austin *et al.,* (2012) also consider that the negative effect of primary exports on food consumption may be explained by the changes in the production structure stimulated by exports promotion policies and export-oriented production do not meet local consumption needs. Wimberley and Bello (1992) showed that export oriented food production increases the dependence of food imports, concluding that poor people become more vulnerable to price fluctuation in global food markets. Moreover, small farmers may lose their land and their ability to meet their own food needs. They can become marginally employed with low and unstable wages, due to a capital-intensification of export agriculture. Bertelli and Macours (2014) point that labor-constrained households may abandon food crops for cash crops, with potential detrimental effect on their own food security. In the short run, food price increases raise poverty because the poor farmers spend a large shares of their income on food and they are net buyers of food (Ivanic and Martin, 2014).

The impact of trade expansion on food security depends on factors such as the easy adoption of export crops, the labor absorption, institutional support and land distribution (Poaster, 2012).

3.3 Inequality and Development

3.3.1 Literature Review

The existence of a poverty-inequality trade-off in the poorer countries is still an unsettled issue in the literature. Theoretical literature establishes that income distribution has a complex multi-dimensional relationship with economic growth. The empirical literature continues debating as to whether the effect of overall income inequality on growth is negative, positive or insignificant.

The debate focuses on the inverse-U-shaped relation known as Kuznets curve. Inequality rises at early stages of development and falls at the later stages (Kuznets, 1955). Barro (2000, 2008) applies a cross sectional analysis of panel of countries to test the empirical regularity of Kuznets curve, concluding that higher inequality tends to retard growth in poor countries but promotes growth in richer ones. When GDP per capita is below US$2,000 (referred to year 1985) growth tends to fall with greater inequality. When GDP per capita is above US$2,000 growth tends to rise with inequality. This maximum of the Kuznets curve is similar to that estimated by Jauch and Watzka (2012) and Xu *et al.,* (2003)(US$1,250– US$2,350).

Alesina and Rodrik (1994), Persson and Tabellini (1994) and Aghion, *et. al*. (1999) conclude that there is a negative relation between income inequality and growth. The findings of Hongyi and Zou (1998) and Forbes (2000) stand in sharp contrast with the negative relation between inequality and growth. They conclude that income inequality is positively associated with economic growth. Banerjee and Duflo (2003) suggest that any direction change in inequality may be detrimental to growth. Voitchovsky (2005) emphasizes that inequality at different parts of the income distribution can affect growth differently. Inequality at the top end of the distribution is positively associated with growth, while inequality in the left tail of income distribution is negatively related to growth. The top end and low bottom of the income distribution are defined as the distances from the top quintile and bottom quintile to the median income.

There are several theories about the relationship between inequality and growth that identify different channels through which inequality may affect economic growth depending on the stage of development and level of inequality. The first channel is the presence of credit market imperfections and limited access to credit. In this situation, investment opportunities depend on individuals' level of income. As a result of high level inequality and limited funds to borrow, some individuals will not be able to carry out productive investment. In this case a reduction in inequality promotes economic growth (Aghion and Bolton, 1997). The second one is the political economy. An economy with high inequality rates will attempt to redistribute resources, possibly reducing investment and delaying growth (Alesina and Rodrik, 1994). The third one is the sociopolitical unrest like instability of political institutions, antisocial initiatives and disruptive activities. Through this dimension, more inequality tends to reduce the productivity and tends to reduce growth (Fajnzylber *et al.*, 2002; Glaeser *et al.*, 2003). Finally, inequality affects growth through the saving rates. Some post-Keynesian economists claim that individuals´ saving rate rise with the level of income. Inequality enhances the process of development by channeling resources towards the owners of capital whose marginal propensity to save is higher (Galor and Moav, 2004).

Ravallion (2004) does not find a systematic trade-off between growth and inequality, although he argues that no correlation does not mean that there is no impact. He finds that the median rate of decline in poverty in countries with rising incomes and falling inequality is seven times higher than in countries with rising incomes and rising inequality (1.3% per year) (Ravallion, 2001). More recent studies based on non-parametric analysis within countries support that there is no evidence of Kuznets curve (Frazer, 2006; Gallup, 2012). Gallup, (2012b) and Dhonge and Miao (2013) study the pattern of convergence of inequality as income levels rise and they find that, as economies grow, inequality tends to fall in high inequality countries and tends to rise in low inequality countries. Sala-i-Martin (2006) concludes that, as a consequence of convergence of the incomes of most populated countries in the world (China e India) to the incomes of the citizens of OCDE, the world inequality has declined between 1980-2000. He qualifies that within-countries inequality has increased and across-countries inequality has decrease over the sample period.

3.3.2 Analysis of the relationship between inequality and growth

In this article we analyze the income distribution of a sample of 48 developing countries in the period 1995-2010. We use gini index as a measure of income inequality. In order to find if there is evidence of Kuznets curve in our gini index dataset we define the following determinants of inequality equation, as proposed by other authors (Barro, 2000, 2008; Jauch and Watzka, 2012).

$$L\_Gini_{it} = \alpha_0 + \alpha_1 \mathrm{L\_GDP\_cap}_{it} + \alpha_2 \mathrm{L\_GDP\_cap}^2_{\mathrm{it}} + \beta'_3 \mathbf{L\_X}_{it} + \varepsilon_{it}$$

[1]

According to the inverted U-Shaped hypothesis, α_1 should be significant and positive and α_2 should be significant and negative. Gini index and GDP per capita (GDP_cap) are transformed into logarithm (L), and then squared ($\mathrm{L\_GDP\_cap}^2_{\mathrm{it}}$). $\mathbf{X}_{\mathrm{it}}$ represent control variables, as primary/secondary/higher schooling, rule of law index, democracy index proposed by Barro (2000) and the share of government expenditure in GDP and the share of agricultural sector in total value added proposed by Clarke *et al.* (2003).

The relation between L_Gini and quadratic L_GDP-cap turns out to be statistically significant, as shown in the

Table 3.1. In this specification L_GDP_cap and its square are the only regressors, aside from a single constant term. Our results Gini dataset regression) are consistent with those obtained by Barro (2000). The coefficient of L_GDP_cap is significant and positive and the coefficient of L_GPD_cap squared is significant and negative, so the Kuznets hypothesis on the evolution of income inequality in economic development is not rejected.

Table 3.1. Results of inequality equation

Dependent variable: Gini Index

	Gini dataset regression	Barro, R. regression [1]
L_GDP_cap	0.533***	0.407***
	(0.14)	(0.09)
L_GDP_cap squared	-0.029***	-0.0275***
	(0.009)	(0.0056)
N	557	254

Source: Own elaboration and Barro, R. (2000)

***, denote statistical significance level at 1%

(1) Panel Data of 68 countries and four years (1960, 1970, 1980, 1990). Random Effects estimation (Barro, 2000)

We divide our sample of 48 countries according to the findings of Barro (2008) related to the maximum of Kuznets curve (US$2,000 in 1985). We update this value to 2002 (middle year of 1995-2010 period) using the United States annual inflation rate. The result is that the maximum of Kuznets curve is US$3,340. We classify the developing countries considering whether the average GDP per capita in the period 1995-2010 is below or above US$3,340. As a result we have one sub-sample of 12 countries and another of 36 countries. Table 3.2 describes the sample and sub-samples regressions, identifying the specific countries within each group.

Table 3.2. Gini index performance in three different samples. Sample of 48 developing countries in period 1995-2010, sample of 12 developing countries with GDP per capita (average value for the period 1995-2010) less than US$3,340 (referred 2002) and sample of 36 developing countries with GDP per capita (average value for the period 1995-2010) greater than US$3,340 (referred to 2002)

	Sample	Countries below 3,340 USD(2002)	Countries above 3,340 USD(2002)
Number of countries		36	12
Countries	48	Albania, Azerbaijan, Bangladesh, Belarus, Bolivia, Burkina Faso, Cameroon, China, Cote d'Ivoire, Ecuador, El Salvador, Guatemala, Iran, Egypt, Honduras, Indonesia, Kenya, Macedonia, Moldova, Morocco, Mozambique, Nicaragua, Pakistan, Paraguay, Peru, Philippines, Senegal, Sri Lanka, Swaziland, Tanzania, Thailand, Tunisia, Uganda, Ukraine, Viet Nam, Yemen	Argentina, Brazil, Chile, Colombia, Costa Rica,Kazakhstan, Malaysia, Mexico, South Africa, Turkey, Uruguay, Venezuela
Min-max value of Gini	25.62 - 67.4	25.62 - 62.78	29.04 - 67.4
Gini trend (1)			
Positive trend	19	16	3
Negative trend	29	20	9
Gini-GDP_cap relationship(2)			
Positive relationship	16	13	3
Negative relationship	32	23	9

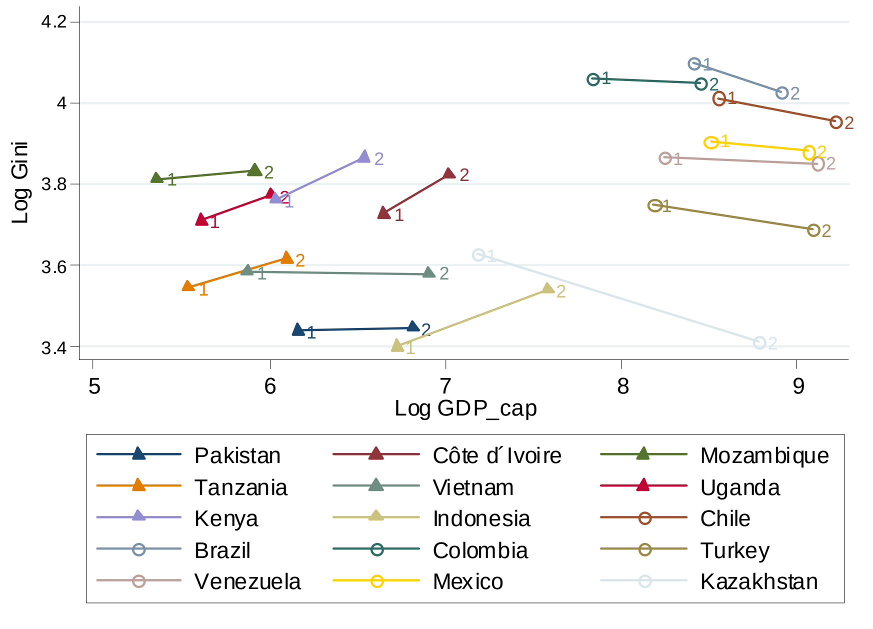
(1) Gini Trend: Gini Index and year linear regression

(2) Gini-GDP_cap relationship: Gini index and GDP_cap linear regression

Table 3.2 shows that income inequality (gini index) ranges from 25.62 to 67.6 across countries and it is higher in more developed countries (GDP per capita above US$3,340) than in less developed countries (GDP per capita below US$3,340). The maximum value of gini index is 62.78 in less developed countries and it rises to 67.4 in more developed countries. These data reflect the upward trend in inequality in the early stages of development. If we analyze the evolution of gini index in each country we find different trends. The evolution of gini index among less developed countries is not homogeneous. The gini index exhibits a positive trend in 16 out of 36 countries and a negative trend in the rest. Most of the more developed countries show an improvement in its income distribution. The gini index has a negative trend in 9 out of 12 countries. Besides there is a significant negative relationship between gini index and GDP per capita in 9 out of 12 more developed countries. These results show that income inequality begin falling once reached a certain stage of development.

Figure 3.3 shows the evolution of GDP per capita and gini index of a selection of developing countries. To avoid the missing values, it compares the average values of GDP per capita and gini index in the periods 1995-1999 and 2005-2010. It can be seen that changes in gini index are slower than changes in GPD per capita. Almost all improvements in GDP per capita between the two periods are higher than 50 per cent. Countries on the left side of the figure (GDP per capita below US$3,340 and identified with a triangle) show an increase in gini index that it ranges from 2 per cent in Mozambique to 15 per cent in Indonesia, between the two periods. Among the countries showed on the right side (identified by a circle), the decreases in gini index range from 1 per cent in Colombia to 19 per cent in Kazakhstan, between the two periods. These results show that gini index has a little variation within countries, although it presents a higher variation across countries.

Figure 3.3. Evolution of GDP per capita and gini index of a selected countries of the sample. Comparison of the average values of GDP per capita and gini index in periods 1995-1999 (1) and 2005-2010 (2)



Source: Own elaboration based on Word Development Indicators (World Bank, 2014b)

3.4 The Modeling Framework

3.4.1 Model specification

This article is an empirical contribution to the debate on the importance of the composition of growth to alleviate hunger (Jenkins and Scanlan, 2001; FAO *et al.*, 2002; Scanlan, 2003; USDA, 2012; FAO, 2013). We test the hypothesis that income inequality has a negative impact on food security in developing countries. To analyze this, we use a model similar to that used in empirical works on food security and trade dependency (Gacitua and Bello, 1991; Wimberley and Bello, 1992, Brady *et al.*, 2007; Austin *et al.*, 2012). In this framework, authors analyze the impact of agricultural exports on food security and they use as a control variable the GDP per capita. The results of these studies show that increasing GDP per capita has a positive significant effect on food security but do not consider its distribution. Our contribution to these models is the addition of income distribution as a explanatory variable of food security based on the study of Jenkins and Scanlan (2001).

We define three baseline models according to the food security variable analyzed (dependent variable). We analyze two indicators of consumption status - average protein supply (gr/cap/day) and average energy supply (kcal/cap/day) - and the depth of the food deficit (kcal/cap/day). In our models food security is assumed endogenously depended on income per capita (GDP_cap), income distribution (Gini index), agricultural export (Agri_export) and control variables. The specification of the model is presented below.

$$Food\ Security_{it} = \alpha_0 + \alpha_1 \text{L\_Agri\_export}_{it} + \alpha_2 \text{L\_GDP\_cap}_{it} + \alpha_3 \text{L\_Gini\_Index}_{it} + \alpha_4 \text{Kuznets}_i + \beta' \mathbf{X}_{it} + \varepsilon_{it} \quad [2]$$

With Food Security $_{it}$ (with *i* denoting each of the 48 developing countries; *t* year 1995-2010). We denote each of our dependent variables (a) Average protein supply in Protein model (b) Average energy supply in Energy model and (c) Depth of food deficit in Food deficit model. So three separated models of type [2] are fitted for each of the three food security indicators (a, b and c).

In order to control the relationship between economic development and income distribution we define a dummy variable (Kuznets) that equals one if the data refers to countries with GDP per capita above US$3,340. In these countries, the relationship between income and inequality is negative, as income rises inequality declines. $\mathbf{X}_{it}$ represents the control variables used. Following previous empirical research, we include variables that impact on food supply such as agricultural production per capita (Gacitua and Bello, 1991; Jenkins and Scanlan, 2001; Austin *et al.,* 2012) and food imports (Pieters *et al.,* 2013) and on food demand such as population growth and urban population (Jenkins and Scanlan, 2001; Scanlan, 2003; Brady *et al.,* 2007; Austin *et al.,* 2012).

3.4.2 Estimation Method

We use a series of unbalanced panel regression models for 48 developing countries in 1995- 2010 period. Using the country-year as the unit of analysis, the total number of observations varies from 504 to 652, depending on the missing values. All variables are expressed in logarithms.

We apply Wooldridge test (Wooldridge, 2002) to identify serial correlation in the idiosyncratic error term. In linear panel-data models, serial correlation biases the standard errors and causes the results to be less efficient. Wooldridge method uses the residual from a regression in first differences. If the residuals estimated in the first different model (ϵ_{it}) are not serially correlated then Corr ($\Delta\epsilon_{it}$, $\Delta\epsilon_{it-1}$)= - 0.5. The test contrasts the null hypothesis that the coefficient on the lagged residuals is equal to - 0.5. In our database, the hypothesis of no serial correlation is rejected. Another common problem is the heteroskedasticity in the residuals. To test this presence we apply Wald statistic for groupwise heteroskedasticity. The null hypothesis of homocedasticity is rejected. We address autocorrelation and heteroskedasticity by using a regression with panel-corrected standard errors for linear cross-sectional time-series models. The parameters are estimated by Prais-Winsten regression.

To test for multicollinearity, we use the variance inflation factor (VIF) to measure how much a variable is contributing to the standard error in the regression. The common rule is that if VIF is higher than five, then the multicollinearity is high. The variance inflation factor takes a value below four. The variables included in the models are sufficiently independent that multicollinearity is not a problem.

Table 3.3 shows the pair wise correlation coefficients between the variables included in the model. All correlation coefficients are bellow 0.5 except those between GDP per capita (GDP_cap) and agricultural production per capita (Prod_cap) and GDP per capita and urban population (urban), that it is higher. We consider this exception in the discussion of the results. As expected, the coefficient correlation between GDP per capita and Kuznets dummy is positive and significantly (0.65, p<0.01) according to its definition.

Table 3.3. Pair wise correlation coefficients

	GDP-cap	Gini Index	Kuznets	Agri_export	Prod_cap	Food Import	Pop. Growth	Urban
GDP-cap	1							
Gini Index	0.29*	1						
Kuznets	0.65*	0.31*	1					
Agri_export	-0.19*	0.02	-0.21*	1				
Prod_cap	0.74*	0.09*	0.46*	-0.14*	1			
Food Import	-0.43*	-0.22*	-0.33*	0.24*	-0.29*	1		
Pop. Growth	-0.24*	0.31*	-0.34*	0.31*	-0.23*	0.28*	1	
Urban	0.71*	0.33*	0.63	-0.28*	0.57*	-0.36*	-0.38*	1

*, denote statistical significance level at 1% after Bonferroni adjustment

Similarly to the models of Gacitua and Bello (1991), Wimberley and Bello (1992), Jenkins and Scanlan (2001) and Austin *et al.* (2012) our model does not include country fixed effects. The main goal of this chapter is the explanation of the influence of income distribution on food security across countries and not within countries. The random effects results reflect cross-sectional differences among countries, as well as variations over time within countries. Random effects estimation may be biased because we are not controlling for omitted variables. To address this problem it is recommended to use country fixed effects regression in order to control the effects of time-invariant variables with time-invariant effects. One potentially significant limitation of fixed effects models is that they cannot assess the effects of variables that have little within-group variation, as it is the case of income inequality. The standard errors from fixed effects models may be too large. Conversely, random effects models will often have smaller standard errors, but the trade-off is that their coefficients are more likely to be biased (Allison, 2009). So we have to forego fixed effects estimation assuming that our results are exposed to potential omitted variable bias and hence accept that our estimators may be overestimated. Table 3.4 summarizes the measures and statistics for the variables included in the model.

Table 3.4. Measures and descriptive statistics for variables included in the models

Variable	Measure	Source	Obs	Mean	Std. Dev.	Min	Max
Protein	gr/cap/dayn [(1)]	FAO	768	70.20	15.92	33	108
Energy	kcal/cap/day [(1)]	FAO	759	2,625	400	1,760	3,700
Food Deficit	kcal/cap/day [(1)]	FAO	688	113	84	1	448
GDP_cap	Current $/cap	World Bank	768	2,480	2,339	141	13,559
Gini Index	0-100 ratio	World Bank	637	43.81	9.14	25.62	67.40
Highest/Lowest quintile ratio	0-100 ratio	World Bank	684	11.70	8.00	3.60	65.12
Kuznets	Dummy (0-1)	World Bank	768	0.25	0.43	0	1
Agri_export	Percent of merchandise exports	World Bank	731	5.51	9.91	0.02	75.88
Prod_cap	Current $/cap	World Bank	704	314	203	30	1,416
Food Import	Percent of total imports	World Bank	735	12.33	6.23	1.86	39.10
Pop. Growth	Percent change in total population	World Bank	768	1.48	0.98	-1.75	4.23
Urban pop.	Percent of total population	World Bank	768	51.60	20.75	11.66	93.31

[(1)] FAO calculates this figures on 3-year average. Each figure is assigned to the last average year. The average 1993-1995 is the figure which falls in 1995 and so on

Due to missing values in gini index, income share held by the highest quintile and income share held by the lowest quintile, we interpolate linearly the inter-period missing values. The detail of the interpolation performed is summarized in the Appendix 3.1, Appendix 3.2 and Appendix 3.3.

3.5 Results

The results of the regression models are summarized in Table 3.5. The first three columns detail the results of the baseline model for each dependent variable: average protein supply (1), average energy supply (2) and depth of food deficit (3). Columns 4, 5 and 6 show the results of the models considering a different income distribution variable. It is the ratio between income share held by highest quintile and income share held by the lowest quintile. The columns from 7 to 9 show the results of three baseline models with food supply control variables. Finally the last three columns (10, 11, 12) summarize the results of baseline models with food demand control variables.

As it has been mentioned, the model is framed in agricultural export dependency models. Our results show that agricultural export dependency has a negative impact on food security. The negative sign of the coefficient (elasticity) of agricultural exports in energy model means that an increase in agricultural exports decreases the average energy supply. The results of food deficit model show that agricultural exports have a positively significant elasticity. It means that an increase in agricultural exports increase the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished population. These results are consistent with other found in the literature (Gacitua and Bello, 1991; Wimberley and Bello, 1992; Jenkins and Scanlan, 2001; Austin *et al.,* 2012). The protein model´s results are not conclusive. In the protein model the elasticity of agricultural exports is negative but not significant (columns 4, 7, 10), except in the baseline model (column 1).

As expected, food security improves with greater GDP per capita. This is also consistent with the results of previous empirical studies (Gacitua and Bello, 1991; Wimberley and Bello, 1992; Jenkins and Scanlan, 2001; Brady *et al.,* 2007; Austin *et al.,* 2012). In our protein and energy models the GDP per capita has a significant positive coefficient suggesting that progress in income level increases protein intake and calorie intake. In the case of food deficit, GDP per capita has a significantly negative coefficient. It means that an increase in income level reduces the depth of food deficit.

The results also confirm that in addition to GDP per capita the distribution of income also matters and that the effect is significant. Our results confirm the hypothesis that an appropriate composition of growth is indispensable to alleviate hunger (OECD, 2013). The gini index has a significant negative coefficient in protein and calorie models which means that a reduction of income inequality enhances food security. In Food deficit model, gini index has a significant positive coefficient. These results complement those obtained by Jenkins and Scanlan (2001). They consider rural/urban disparity as a proxy of a social welfare inequality and the find that an increase in urban/rural disparity reduces food supply in the period between 1970 and 1990. Growth strategies should take into consideration the participation of poor people in growth. Increasing income of the poor population encourages the access to food across the most vulnerable people. Some of the growth enhancing policies that are likely to reduce inequality are those that improve education and technical skills (De Gregorio and Jong-Wha, 2002), reduce the inequality in labor markets (Acemoglu, 2000) and design adequate taxes and cash transfers systems(Joumard and Bloch, 2012).

Comparing the coefficients of GDP per capita and gini index it can be seen that the coefficient of gini index is around twice the coefficient of GDP per capita. This result may be explained by the performance of gini index. Unlike the rest of the explanatory variables, the gini index changes are more clearly observed in the long run than in the short run, similar to food security indicators (dependent variables). The negative impact of income distribution on food security is corrected by considering if income and inequality have a positive or negative relationship (Kuznets *v*ariable). As results show, the Kuznets variable has a positive significantly coefficient in protein and energy model. This suggests that the indicator of food security is adjusted upwardly in those countries where economic growth is accompanied by an improvement in income distribution. It means that countries with the same level of inequality have different levels of food security depending on the relationship between income and inequality. In those countries where the relationship between growth and inequality is negative the indicators reveal a better food security situation than in those where this relationship is positive. The negative significant sign of the coefficient of Kuznets variable in food deficit model means that the model is corrected downward because a reduction of food deficit is an improvement in food security. These results support the findings of Ravallion (2001), who concluded that poverty reduction is higher in those countries where growth is accompanied by a reduction of inequality.

The results of the protein model are similar to those of energy model. Both of them analyze food security variables referred to nutritional status. But there are differences between protein-energy models and food deficit model. The effect of GDP per capita on food deficit is around five times higher than the effect of GDP per capita on calorie and energy intake. The elasticity of gini index is nearly three times higher in food deficit model than in the protein and energy models and the impact of agricultural exports on food security is about six times larger intense in food deficit model than on energy model. The conclusion is that depth of food deficit is more sensitive to income, its distribution and agricultural exports than average measures of nutritional status (energy and protein supply). These independent variables explain to a great extent the performance of the food security situation of undernourished population than average population. Other authors also find that behind the average measures the situation of most vulnerable population is not usually reflected (Ravallion, 2001; Sala-i-Martin, 2006).

Table 3.5. Results of regression with panel-corrected standard errors. Baseline models (1,2,3), Baseline models with highest-lowest quintile rate (4,5,6), Baseline models with food supply control variables (7,8,9) and Baseline Models with food demand control variables (10, 11,12)

Dependent variables: Average protein supply (Protein Model), Average energy supply (Energy model) and Depth of food deficit (Food Deficit Model)

	Baseline Models			Baseline Models_Highest quintile/ Lowest quintile ratio			Baseline Model: Food Supply Control Variables			Baseline Model: Food Demand Control Variables		
	1	2	3	4	5	6	7	8	9	10	11	12
Explicative variables	Protein Model	Energy Model	Food Deficit Model	Protein Model	Energy Model	Food Deficit Model	Protein Model	Energy Model	Food Deficit Model	Protein Model	Energy Model	Food Deficit Model
Agriexport_ln	-0.008*	-0.005*	0.074**	-0.006	-0.005*	0.068**	-0.006	-0.007*	0.088***	-0.005	-0.006*	0.06*
	(0.004)	(0.002)	(0.02)	(0.003)	(0.002)	(0.022)	(0.004)	(0.003)	(0.026)	(0.003)	(0.002)	(0.024)
GDP_cap_ln	0.092***	0.075***	-0.375***	0.083***	0.067***	-0.301***	0.065***	0.046***	-0.381***	0.069***	0.06***	-0.29***
	(0.007)	(0.006)	(0.056)	(0.007)	(0.006)	(0.046)	(0.009)	(0.007)	(0.071)	(0.007)	(0.005)	(0.061)
Gini_Index_ln	-0.221***	-0.141***	0.694**				-0.185***	-0.129***	0.638*	-0.203***	-0.109***	0.752**
	(0.03)	(0.026)	(0.256)				(0.029)	(0.026)	(0.261)	(0.024)	(0.024)	(0.262)
Kuznets (0-1)	0.208***	0.099***	-1.574***	0.199***	0.131***	-1.96***	0.26***	0.099***	-1.564***	0.186***	0.064**	-1.276***
	(0.02)	(0.023)	(0.246)	(0.014)	(0.015)	(0.271)	(0.023)	(0.022)	(0.261)	(0.021)	(0.019)	(0.232)
Hihtest/Lowest Ratio_ln				-0.046***	-0.032***	0.198***						
				(0.008)	(0.006)	(0.047)						
Prod_agraria_ln							0.019*	0.018**	-0.030			
							(0.008)	(0.006)	(0.056)			
Food_import_ln							0.001	0.0001	-0.056			
							(0.005)	(0.004)	(0.038)			
Pop_growth_ln										-0.138***	-0.087***	0.167
										(0.019)	(0.016)	(0.171)
Urban_ln										0.081***	0.109***	-0.358*
										(0.019)	(0.019)	(0,162)
Constant	4.34***	7.82***	4.69***	3.67***	7.41***	6.44***	4.3***	7.91***	5.13***	4.32***	7.56***	4.88***
	(0.115)	(0.104)	(1.011)	(0.056)	(0.043)	(0.289)	(0.127)	(0.104)	(1.031)	(0.1)	(0.115)	(1.181)
N	611	606	544	652	647	586	571	566	504	611	606	544
R^2 adjusted	0.96	0.95	0.92	0.96	0.94	0.92	0.97	0.94	0.92	0.97	0.95	0.92

***,**,* denote statistical significance levels at 1%, 5% and10%. Coefficients standard errors are shown in parenthesis.

In order to check the negative impact of income distribution on food security we include in the baseline models another income distribution variable different than the gini index. We analyze the ratio between income share held by highest quintile and income share held by the lowest quintile (ratio highest/lowest quintiles). This ratio ranges from 0 to100 (see Table 3.4). The higher this ratio, the higher is the difference between rich and poor people (inequality). The correlation coefficient between gini index and the ratio highest/lowest quintiles is 0.87 ($p<0.01$).

The results of this analysis are summarized in columns 3, 4 and 5. We obtain the similar results to the baseline models´. An increase in income and a reduction in income inequality improve food security indicators. Agricultural exports dependency still shows a negative impact on food security. The elasticity of the ratio highest-lowest quintiles ratio is around five times lower than the gini index coefficient. This means that an overall level inequality variable (gini index) has a higher explanatory capacity of food security situation than a variable that measures the shape in income distribution (ratio highest/lowest quintiles). Both variables have different distribution functions. Gini index exhibits an approximately normal distribution, with mean at 43.73, with a minimum value of 25.62 and a maximum of 67.4. The ratio highest/lowest quintiles has a skewed positive distribution, with mean at 11.54, minimum and maximum values at 3.6 and 65.12 (see Table 3.4). The lower explanatory capacity of the ratio highest/lowest quintiles may be explained by the fact that it takes more extreme values than gini index.

To examine the robustness of our baseline regression results, we extend the baseline regression by adding more variables commonly used in food security empirical studies. We introduce in the model some of the drivers of food supply (agricultural production per capita and food imports) and food demand (population growth and urban population) in the long-term (Figure 3.1). By adding new variables (columns from 7 to 12), the results do not change significantly. Agricultural exports, income and equality continue explaining the food security situation in developing countries.

Our results show that agricultural production per capita has a significant positive impact on nutritional status, protein model and energy model. Nevertheless, there is no statistically significant relation between food production and depth of food deficit. This result may be explained by the fact that food deficit is explained further by income distribution and the correlation between GDP per capita and agricultural production is higher than 0.5 (Table 3.3). There is no consensus in the literature about the impact of agricultural production on food security. Gacitua and Bello (1991) find that agricultural output is negatively correlated with food consumption in Latin American countries. Jenkins and Scanlan (2001) conclude that increasing food supply has positive effects on child hunger rates. Austin *et al.* (2012), conclude that FAO Food Production Index has no significant relationship with the depth of hunger in Least Developed countries.

An additional supply measure is food imports, viewed as a country's ability to obtain food in the international market. Due to the globalization of food markets, this concept is essential because it isolates the international component of a country's food availability. Our results on this matter show that food imports do not have a significantly impact either on protein and energy supply or depth of food deficit. Jenkins and Scanlan (2001) conclude that food imports do not reduce child hunger.

In relation to population growth rate, its coefficient is significant and negative in the protein model and in the energy model, and positive but not significant in the food deficit model. Several studies conclude that less population growth improves food security, because higher rates of population growth strain public resources, including food security (Jenkins and Scanlan, 2001; Scanlan, 2003; Austin *et al.*, 2012; Brady *et al.*, 2007). Lastly, with respect to urban population, the results show that urbanization improves food security. The urbanization rate is significant and positive in the protein and energy models, and negative and significant in the food deficit model. A body of research supports the conclusion that urbanization improves food security. Urbanization is generally associated with improvements in well-being as income and services tend to be higher in urban areas (Jenkins and Scanlan, 2001; Scanlan, 2003; Austin *et al.*, 2012; Brady *et al.*, 2007). The finding that neither food demand nor food supply variables introduced in the food deficit model are significant (except urban ratio) is due to the fact that depth of food deficit has more to do with economic resources and its distribution than other explanatory variables (see the elasticities).

3.6 Discussion

There are some limitations of our findings. First, food security is a wide and complex concept characterised by multiple dimensions (availability, affordability, utility and stability) and different levels of definition, either at national, local, household or individual level. As food security indicators, we consider consumption outcomes analyzing the issue of food supply but leave aside the questions of obesity and low nutritional security. We limit our study to some macro-variables that affect national food security in the long run, so we do not consider the full range of variables that might also affect food security. This selection of the food security drivers is related to the second limitation. We are not able to include country fixed effects in the estimation of the model to control the omitted variables bias. This is due to the little variation of gini index over time within-countries. A derived shortcoming is that the coefficients in the models may be overestimated. The third limitation relates to data availability. Due to missing values in income distribution variables we interpolate several values for several years and countries. Despite these limitations, the analysis contributes to the knowledge about the drivers of food security in developing countries and therefore to improving the targeting and formulation of development policies.

In the article we discuss the impact of income inequality on food security, and we find that that income inequality negatively influences the food security. The next step is to find how to reduce income inequality and improve food security. In this sense, there is an evidence of success from the conditional cash transfers programmes in raising household consumption (Rawlings and Rubio, 2005; Marshall and Hill, 2014). The cash transfer programmes have a relevant role in explaining the fall in inequality in Brazil (IPC, 2006).

3.7 Conclusions

We use a regression model with panel data comprising time series (1995-2010 period) and cross sectional components (48 developing countries). We propose three baseline models according to different food security variables as dependent variables. We use two nutrition status variables (average protein supply and average energy supply) and a food distribution variable (depth of food deficit). We analyze two different measures of income distribution: Gini index and the ratio between the income share held by the highest quintile and the income share held by the lowest quintile. We also consider, as control variables, the long-term drives of food supply and food demand that impact on food security.

Our statistical panel analyses give support to several conclusions. Firstly, income inequality is key to the persistence of hunger. Income distribution has a negative impact on the three food security indicators considered in the study. As income inequality decreases the average protein and calorie consumption increases and, in a greater extent, depth of hunger decreases. These results emphasize the importance of addressing inequality to reduce hunger among more vulnerable people. Due to the little variation over time of gini index, we qualify these results by highlighting that the relation between level of income and inequality is also relevant. Our analysis confirms that there is a trade-off between development and inequality. Inequality increases until a stage of development is reached, defined by Barro (2008) at around US$2,000 (referred to year 1985). Beyond this point, inequality begins decreasing. Hence, although inequality is detrimental for food security, in those countries where the development is accompanied by a decrease of inequality, indicators reveal a better food security situation than in those where inequality is increasing.

Secondly, our results confirm the findings of previous studies focusing on the impact of agricultural exports on food security. Primary export dependence is detrimental to food security over the long term. Export oriented production policies do not necessarily meet national consumption needs unless they are accompanied by measures that facilitate smallholders to participate in exports or reach the main consumption markets. Food price increases in the long run increase poverty because the poor spend large share of their incomes on food and many of them are net buyers. Thirdly, we identify that depth of food deficit is more sensitive to changes in income, its distribution and agricultural exports than national average supply variables. Average consumption hides the undernourished of the most vulnerable population. This conclusion offers a relevant research focus for further studies that address the problem of food security. It is thus recommended to take into account food distribution variables, not only nutritional status variables.

This article points to the need to broaden the discussions of food security beyond the common concerns of rising incomes, agricultural production or investment. Rising average incomes alone is not sufficient for reducing hunger, unless growth makes societies more egalitarian. Hunger is also a distributional problem. Policies to combat hunger and malnutrition should put the income distribution goal in the set of priorities.

4 How important is economic growth to improve food security in developing countries?

Abstract

There is a debate in the literature about the importance of economic growth in resolving the problem of undernourishment. This chapter looks at the speed of annual change of undernourishment rates and tests whether greater economic growth accelerates reductions in undernourishment in developing countries. The analysis is carried out with the data spanning 22 years (1991–2012) and covering 35 developing countries, using panel data analysis. We identify different undernourishment trends based on the countries` speed of response to food insecurity. Results reveal that accelerations in annual economic growth leads to higher annual improvements in nourished population. The positive impact of sustained economic growth on food security is greater than the impact of economic growth in the short term. The positive impact of improvements in access to improved water is higher than the impact of income growth. Conclusions suggest that food policies attempting to reduce undernourishment can be accelerated through increased income growth, but even in a greater extent through sustained growth and increased access to improved water.

Keywords: economic growth, prevalence of undernourishment, rate of change

JEL: O4, I3, 01

4.1 Introduction

According to the Global Hunger Index, hunger has fallen 40% since 1990 (IFPRI, Welthungerhilfe, and Concern Worldwide, 2014). There are substantial differences in the rate of change of food security indicators across developing countries. The percentage of people suffering hunger in Nicaragua decreased a 31% from 1990 to 2009, while the fall in Ecuador was 4.9% over the same period (Willaarts *et al.,* 2014). What explains these disparities in the rate of change? Some studies found that economic growth is a major prerequisite for improving nutrition in developing countries (Ravallion, 1990; Pritchett and Summers, 1996; Smith and Haddad, 2002). Other authors claim that income growth is necessary but not sufficient to combat undernourishment, being the investments in public health, sanitation, education also essential (Wolf and Behrman, 1983; Timmer, 2000; Alderman *et al.*, 2003; Suri *et al.*, 2011; Ruel and Alderman, 2013). The main goal is to test if greater economic growth accelerates reductions in undernourishment in developing countries.

To address this research question, this article uses a panel data from 35 developing countries over the period 1991-2012 to explore the relationship between income per capita growth and the rate of change of undernourishment prevalence. We first review the literature about economic growth and human development. The literature provides evidence of the two-way relationship between economic growth and human development. This simultaneity in the causal relationship highlights the importance of endogeneity problems using econometric models. We then analyze in the third section the trends of the prevalence of undernourishment in developing countries. We identify five different types of possible trends and we classify and analyze countries according to these trend types. In section 4 a preliminary analysis of the patterns of the growth of GDP per capita and the prevalence of undernourishment is presented. In section 5, we present a preliminary cross-sectional analysis that sheds some light in understanding the relationship between undernourishment and its explanatory variables. With a view to delve into the analysis of causality, in section 6 we present a second modeling framework based on first differences and on a dynamic panel estimation. In this section, we summarize and discuss the results. In section 7, we present the main conclusions.

4.2 Relevant literature about economic growth and human development

Human development has taken a center stage in the study of developing economies. According to the first Human Development Report, human development is the process of broadening people's choices. The three essential ones are for people to lead a long and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living (UN, 1990). Human development is closely linked to economic growth. Several studies have addressed the two-way causality relationship between them (Ranis *et al.,* 2000; Suri *et al.,* 2011). Economic growth permits improving human development, and improving human development enhances economic growth opportunities. In the first causality direction, the argument is that economic growth improves incomes. As income per capita grows, people tend to invest more in human capital. They increase their access to health-promoting goods and services, leading to improved health and nutritional status (Ravallion, 1990; Pritchett and Summers, 1996; Smith and Haddad, 2002; Alderman *et al.*, 2003). Case *et al.* (2001) find that also children's health is positively related to household income. The reverse causality, from human development to economic growth, is explained by the link between health and productivity. If a worker is healthier, he or she will be more productive and command higher earnings (Strauss and Thomas, 1998; Zon and Muysken, 2003; Schultz, 2005; Cole and Neumayer, 2006). Other authors also emphasize the role of education in promoting income growth (Krueger and Lindahl, 2001).

Although income growth is considered a major prerequisite to improve health and nutrition in developing countries, there are studies that conclude that economic growth has no automatic effect in reducing undernourishment. Subramanyam *et al.* (2011) and Kumar (2007) conclude that the reductions in childhood undernourishment in India did not depend on economic growth but on direct investment in health services. Subramanyam *et al*. (2011) expose the causes that explain the weak association between economic growth and undernourishment. Economic growth has to be accompanied by increases in incomes and greater household wealth, public services investments and provision of clean drinking water and health care (Anand and Ravallion, 1993; Suri *et al.,* 2011). Second, the impact of economic growth on human development will depend on the share of poor people that see their income grow. There are differences in how much the poor share in aggregate growth (Ravallion, 2001; Foster and Székely, 2001, Storm and Naastepad, 2007; Wuyts, 2011). According to Timmer (2005) agricultural growth tends to be much more pro-poor than growth in industrial or service sectors. Third, there are countries (mainly from East and Southeast Asian) where, even with relatively low levels of income per capita, government interventions have enhanced food security situation (Timmer, 2000).

4.3 Analysis of the prevalence of undernourishment trend

Recent global scenarios are focused on the drivers of food security. Food security is a wide and complex concept characterized by multiple dimensions (availability, affordability, utility and stability) and different scopes, at national, local, household or individual level. Each food security dimension is commonly analyzed using different food security indicators. Availability is measured with indicators of calorie availability. Food prices are used to trace access. Approaches to analyze stability include food stocks, distribution of wealth and government policy. The most common indicators of food utilization are child malnutrition and undernourishment (Dijk and Meijerink, 2014). This study is focused on food security at national level, measured by the prevalence of undernourishment, which is defined as the percentage of population whose food intake is insufficient to meet dietary energy requirements continuously. It is based on a comparison of usual food consumption expressed in terms of dietary energy with certain energy requirement norms (Naiken, 2002).

According to the last state of food insecurity report, over the last decade, the prevalence of undernourishment has fallen from 18.7 to 11.3 percent globally and from 23.4 to 13.5 percent for the developing countries (FAO, IFAD and WFP, 2014). The rate of change has been different across countries. According to this report, the prevalence of undernourishment fell from 33% to 23.8% in Africa Sub-Saharan, in Asia from 23.7% to 12.7%, and from 15.3% to 6.1% in Latin America and the Caribbean. The purpose in this section is to analyze the patterns of this fall. Specifically we check whether the national prevalence of undernourishment has decreased at a steady rate or else whether the rate of change has increased or decreased over the period.

We analyze the trend of the prevalence of undernourishment of 35 developing countries over the period 1991-2012. This sample is representative of low-income and some middle-income countries (Table 4.1). There are countries of four geographical regions, South Asia (4 countries), East Asia (5 countries), Latin America (13 countries) and Sub-Saharan Africa (13 countries). The availability of high-quality nationally representative undernourishment data is one of the limitations of inclusion of countries. We do not include developing countries whose prevalence of undernourishment is lower than 5% and has not varied over the studied period.

Table 4.1. Sample of developing countries

Asia	Africa		Latin America	
Bangaldesh	Benin	Swaziland	Bolivia	Paraguay
China	Burkina Faso	Tanzania	Brazil	Peru
India	Cameroon	Uganda	Chile	Uruguay
Indonesia	Cote d´Ivorie	Yemen	Colombia	Venezuela
Pakistan	Gabon		Ecuador	
Philippines	Kenya		El Salvador	
Sri Lanka	Morocco		Guatemala	
Thailand	Mozambique		Honduras	
Vietnam	Senegal		Nicaragua	

We fitted linear and quadratic country-specific trends, and used the adjusted R-squared to identify the trend type that is more significant. The significance of the coefficients estimated may be affected by error serial correlation, since significant trend can be found even though the trend is not significant but only an autocorrelation model with one lag (AR1). We use Durbin-Watson statistic to detect the presence of autocorrelation in the residuals of each country's model (Durbin and Watson, 1951). The Durbin-Watson statistic is close to 0 in all countries' regressions. This result indicates that there is evidence of positive serial correlation in the specification tested. We address autocorrelation using Prais Winsten estimator (Prais and Winsten, 1954), which uses generalized least-squares method to estimate de parameters in a linear regression model in which the errors are serially correlated (AR1).

Linear trends are studied with linear regressions for each country considering the prevalence of undernourished in year *t* as the dependent variable (Y_t) and year as the independent one (x_t):

$$Y_t = \alpha_0 + \alpha_1 x_t + \varepsilon_t \qquad [1]$$

where, α_0 is the intercept and ε_t is the error term.

Quadratic trends were studied with two-order polynomial regressions for each country, considering the prevalence of undernourished (Y_t) in year *t* as the dependent variable and year (x_t) and its squared (x_t^2) as the explanatory ones:

$$Y_t = \alpha_0 + \alpha_1 x_t + \alpha_2 x_t^2 + \varepsilon_t \qquad [2]$$

In polynomial regressions the coefficient of the quadratic term (α_2) indicates which way the curve is bending. The linear coefficient (α_1) indicates the direction of the curvature. If α_1 is positive the linear trend is positive and hence undernourishment increases over the period.

In the quadratic model, there is a high correlation between year (linear term) and its square (quadratic term). To deal with multicollinearity, we mean-center the independent variable (Marquardt, 1980). This allows the linear coefficient to better reflect the linear relation. By taking deviations from the mean ($\bar{x}$), we obtain a new variable ($x_t' = x_t - \bar{x}$) and we create its square ($x_t'^2 = (x_t - \bar{x})^2$).

$$Y_{it} = \alpha_0 + \alpha_1 x_t' + \alpha_2 x_t'^2 + \varepsilon_t \qquad [3]$$

As Table 4.2 shows, the adjusted R-squared of polynomial regressions in 27 out of 35 countries is greater or equal than the adjusted R-squared of linear models[7]. The coefficient of the quadratic term is significant. These results show that the evolution of undernourished population in most of our developing countries follows a quadratic trend. Reductions of undernourishment prevalence follow a linear trend in eight

[7] Adjusted R-squared of the linear regression of Burkina Faso, Uganda and Yemen is greater than quadratic´s one, but the linear coefficient is not significant.

countries: Bolivia, Ecuador, India, Kenya, Morocco, Philippines, Senegal and Sri Lanka.

Table 4.2. Adjusted R-squared, sign and significance of coefficients in linear and quadratic trend models of undernourished rates evaluated at national level

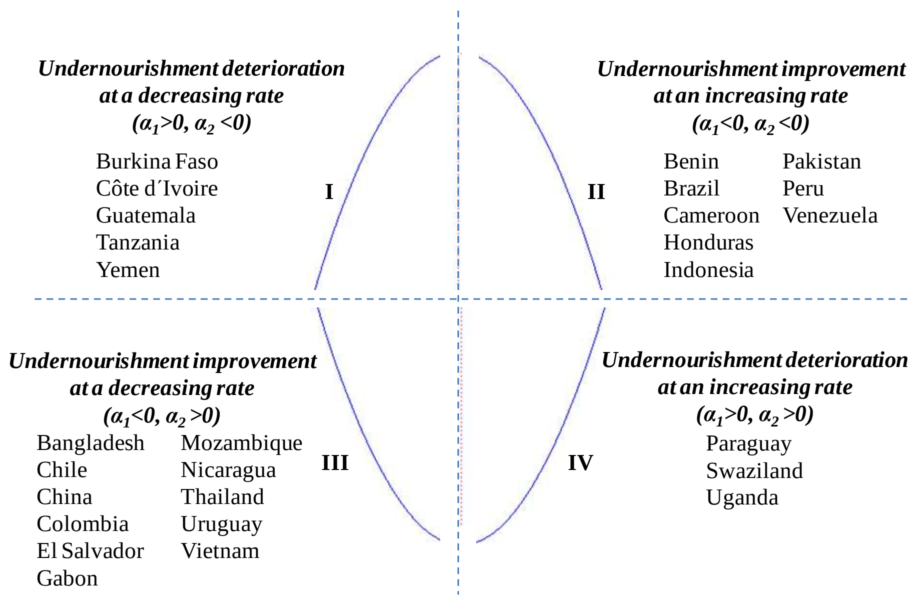
		Linear trend		Exponencial trend		
Country	Observations	Adjusted R-squared	Linear Coefficient (α_1)	Adjusted R-squared	Exponencial Coefficient (α_2)	Linear Coefficient (α_1)
Bangladesh	22	0.63	(-)**	0.89	(+)***	(-)***
Benin	22	0.95	(-)***	0.98	(-)**	(-)***
Bolivia	22	0.86	(-)***	0.74	(-)*	(-)***
Brazil	22	0.95	(-)***	0.96	(-)*	(-)***
B.Faso	22	0.68	(+)	0.56	(-)**	(+)***
Cameroon	22	0.92	(-)***	0.97	(-)**	(-)***
Chile	22	0.67	(-)**	0.84	(+)***	(-)***
China	22	0.83	(-)***	0.92	(+)***	(-)***
Colombia	22	0.86	(-)***	0.86	(+)***	(-)***
Côte d´Ivoire	22	0.43	(+)**	0.72	(-)**	(+)***
Ecuador	22	0.75	(-)**	0.26	(+)	(-)**
El Salvador	22	0.72	(-)	0.74	(+)***	(-)***
Gabon	22	0.8	(-)***	0.8	(+)***	(-)***
Guatemala	22	0.34	(+)***	0.9	(-)***	(+)***
Honduras	22	0.98	(-)***	0.98	(-)***	(-)***
India	22	0.88	(-)***	0.81	(+)	(-)***
Indonesia	22	0.78	(-)***	0.78	(-)***	(-)***
Kenya	22	0.84	(-)***	0.76	(-)*	(-)***
Morocco	22	0.78	(-)***	0.81	(+)	(-)***
Mozambique	22	0.91	(-)***	0.93	(+)***	(-)***
Nicaragua	22	0.91	(-)***	0.99	(+)***	(-)***
Pakistan	22	0.9	(-)***	0.9	(-)**	(-)***
Paraguay	22	0.32	(+)	0.93	(+)***	(+)
Peru	22	0.89	(-)***	0.89	(-)*	(-)***
Philippines	22	0.92	(-)***	0.88	(-)	(-)***
Senegal	22	0.55	(-)	0.42	(-)	(-)***
Sri Lanka	22	0.95	(-)***	0.93	(-)	(-)***
Swaziland	22	0.18	(+)**	0.58	(+)**	(+)***
Tanzania	22	0.44	(+)	0.78	(-)***	(+)**
Thailand	22	0.83	(-)***	0.99	(+)***	(-)***
Uganda	22	0.75	(+)	0.31	(+)**	(+)
Uruguay	22	0.49	(-)	0.52	(+)***	(-)**
Venezuela	22	0.33	(-)	0.86	(-)***	(-)***
Vietnam	22	0.76	(-)***	0.98	(+)***	(-)***
Yemen	22	0.85	(-)	0.73	(-)***	(+)***

Note: *, **, *** denote statistical significant level at 10%, 5% and 1%

Source: Own elaboration based on World Development Indicators (World Bank, 2014b)

We can classify our sample of countries in five groups according to the quadratic and linear coefficients of the polynomial regressions. Two first groups are differentiated: countries with prevalence of undernourishment following a linear trend, and countries with prevalence of undernourishment following quadratic trends. Countries with prevalence of undernourishment following quadratic trends are classified in four additional subgroups (Figure 4.1): Countries where prevalence of undernourishment worsens at a decreasing rate (I) or an increasing rate (IV), and those countries where prevalence of undernourishment improves at an increasing rate (II) or a decreasing rate (III).

Figure 4.1. Classification of countries according to the prevalence of undernourishment quadratic trend. Period 1991-2012



Source: Own elaboration based on World Development Indicators (World Bank, 2014b)

4.4 Relationship between economic growth and food security improvement

We identify different patterns of the growth of GDP per capita and prevalence of undernourishment across the defined groups of countries. We perform a frequency analysis with 140 observations on growth rates and changes in undernourishment rates (Table 4.3). These observations are the average annual changes of GDP per capita and prevalence of undernourishment over the following periods: 1991-1996, 1996-2001, 2001-2006, 2006-2011.

Table 4.3. Frequency Analysis of Average annual change of GDP per capita versus average annual change of undernourished population, periods 1991-1996, 1996-2001, 2001-2006, 2006-2011.Countries are classified according to their prevalence of undernourishment trend

Group II (Undernourishment improvement at an increasing rate) (8 countries)

▽△Undernourishment rate change \ ▽△Economic rate change	Rate<0%	0-5%	5.01%-10%	
Rate>0%	3	1	0	4
-5% - 0%	1	15	0	16
-10 %- -5.01%	0	10	2	12
	4	26	2	32

Group III (Undernourishment improvement at a decreasing rate) (11 countries)

▽△Undernourishment rate change \ ▽△Economic rate change	Rate<0%	0-5%	5.01%-10%	
Rate>0%	0	4	2	6
-5% - 0%	4	15	5	24
-10 %- -5.01%	1	8	5	14
	5	27	12	44

Linear trend Group (8 countries)

△▽Undernourishment rate change \ ▽△Economic rate change	Rate<0%	0-5%	5.01%-10%	
Rate>0%	3	5	0	8
-5% - 0%	1	19	2	22
-10 %- -5.01%	0	2	0	2
	4	26	2	32

Group I and IV (Undernourishment deterioration) (8 countries)

△▽Undernourishment rate change \ ▽△Economic rate change	Rate<0%	0-5%	5.01%-10%	
Rate>0%	4	16	0	20
-5% - 0%	3	7	0	10
-10 %- -5.01%	0	2	0	2
	7	25	0	32

Source: Own elaboration based on World Development Indicators (World Bank, 2014b)

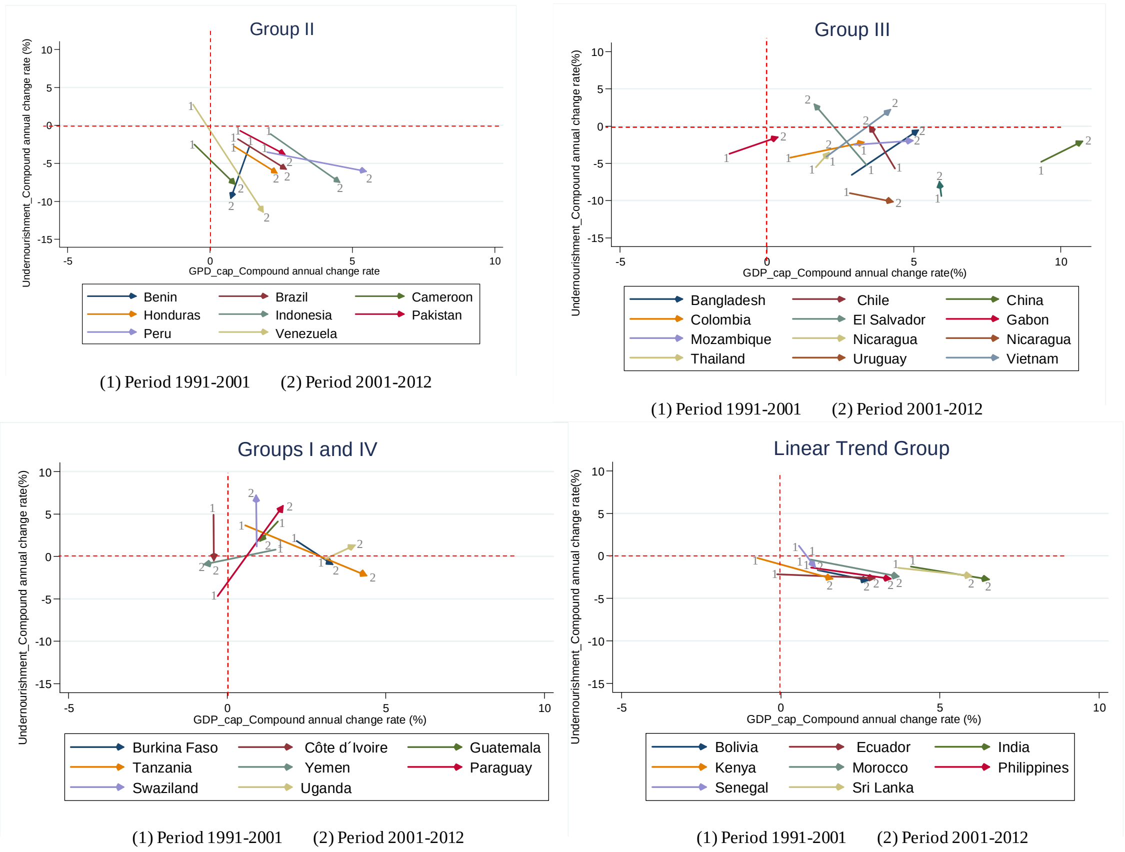
As Table 4.3 shows, countries of Group III (with undernourishment improving at a decreasing rate) exhibit the highest growth rates. Growth rates exceed 5% in 12 out of 44 observations, mainly performed by south-east Asian countries (China, Thailand and Vietnam). 27 out of 44 observations show growth rates between 0 and 5%. In this group, growth rates are accompanied mainly by undernourishment reductions lower than 5% (24 out of 44 observations) and between 5%-10% (14 out of 44).

Economic growth rates in Group II (with undernourishment improving at an increasing rate) are similar to those in Group I (undernourishment deterioration at a decreasing rate), Group IV (undernourishment deterioration at an increasing rate) and linear trend group. Most of GDP per capita growth rates are between 0 and 5% in each sample (25-26 out of 32 observations in each group). The difference among these four groups lies on the performance of undernourishment. Having similar growth rates, the highest reductions in prevalence of undernourishment are performed by countries of group II (12 out of 32 observations are reductions between 5-10%). In the linear group, most of reductions in prevalence in undernourishment stand between 0- 5% (26 out of 32). But countries of groups I and IV show increments in their undernourishment values (20 out of 32 observations).

This preliminary analysis offers three distinguishable patterns of the changes of income per capita and prevalence of undernourishment. Economic growth rates between 0 and 5% are more frequently accompanied by 0-5% reductions in the prevalence of undernourishment (56 out of 104 observations). Growth rates over 5% are also accompanied by reductions in the rate of undernourishment over 5% in the prevalence of undernourishment (7 out of 16 observations). Negative growth rates are accompanied simultaneously by 0-5% reductions (9 out of 20 observations) and increases (10 out of 20 observations) in the prevalence of undernourishment.

To support these results, Figure 4.2 shows the comparison of the paired data of the change of GDP per capita and undernourishment in two time periods. We calculate the accumulated annual change rate of GDP per capita and undernourishment, considering two periods: 1991-2001 and 2001-2012.

Figure 4.2. Compound annual change of GDP per capita versus compound annual change of undernourished population, periods 1991-2001, 2001-2012. Countries are classified according to their prevalence of undernourishment trend



Source: Own elaboration based on World Development Indicators (World Bank, 2014b)

Based on the different trends of undernourishment, as is expected, countries of Group II show higher reductions in undernourishment in the second period than in the first one. On the contrary, the highest reductions of undernourishment in Group III take place in the first period. In both cases, most of the reductions of the undernourishment rate are accompanied by similar income growths between 0% and 5%. The countries of the linear group exhibit a different pattern. The improvements of the undernourishment rate in period 1 are very similar to those in period 2, although there have been higher income growths. Finally, the countries of the groups I and IV show deteriorations in their undernourishment rates in periods of economic growth. Hence, Figure 4.2 shows that higher income growths are accompanied by different changes on the undernourishment rate.

4.5 Preliminary cross-sectional analysis

The conceptual framework that guides the empirical analysis on food security classifies the causes of malnutrition in three levels, immediate, underlying and basic causes (Engle *et al.*,1999). Inadequate dietary intake and disease are immediate causes that operate at individual level. Underlying causes are household food insecurity, inadequate care and insufficient health services and unhealthy environment. These factors cause undernourishtment at household and community levels. Basic causes are insufficient education, human economic and organizational resources, socio-cultural, socio-political and socio-economical factors (Engle *et al.*, 1999; Smith and Haddad, 2000; Reinhard, 2002). Empirical studies use as explanatory variables of undernourishment the following variables: population with access to safe water, female secondary school enrollment rate, the ratio of female-to-male life expectancy, dietary energy supply per capita, gross domestic product (GDP) per capita, and an index of democracy (Smith and Haddad, 2000; Alderman *et al*., 2003). Arcand and Béatrice (2004) also analyze the impact of trade openness and exchange rates on undernourishment. Analyzing human development, Suri *et al.* (2011) also propose primary enrollment rate, gini coefficient, poverty headcount and public education and health expenditures. All these models do not consider direct interventions (micronutrient supplementation, food fortification or diet supplementation for pregnant women), that although they do not rely on increased income, they have reduced undernourishment (Allen and Gillespie, 2001).

Based on the explanatory variables proposed in previous studies, we present the following cross national regression. We consider two types of error components models, random effects and fixed effects. In random effects approach, unobserved heterogeneity is consider to be random error:

$$Y_{it} = \alpha + \sum_{k=1}^{4} \beta_k X_{kit} + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma_i^2) \qquad [4]$$

where Y_{it} is the prevalence of undernourishment (%) in country *i* (35 developing countries), in year *t* (1991 to 2012), α is a scalar, β is a K×1 vector of parameters, X_{kit} are the K explanatory variables: Gross Domestic Product (GPD) per capita (current $/cap), population with access to improved water (% population), the health expenditure (% of GDP) and literacy rate (% population) and ε_{it} is the error term.

In the fixed effect approach, unobserved heterogeneity is considered to be fixed and different for each country (Allison, 2009). The country fixed effect model is as follows:

$$Y_{it} = \alpha + \sum_{k=1}^{4} \beta_k X_{kit} + (\beta_i + \varepsilon_{it}), \quad \varepsilon_{it} \sim N(0, \sigma_i^2) \qquad [5]$$

where the β_i is the unobservable country- specific, time-invariant effects and ε_{it} is the error term. The equation is obtained by transforming the observations on each variable into deviations from the country- specific averages:

$$Y_{it} - \bar{Y}_i = \sum_{k=1}^{4} \beta_k (X_{kit} - \bar{X}_{ki}) + (\beta_i - \bar{\beta}_i) + (\varepsilon_{it} - \bar{\varepsilon}_i) \qquad [6]$$

Since the β_i are invariant, $(\beta_i - \bar{\beta}_i) = 0$, and the terms drop out of the model.

Table 4.4 summarizes the measures and statistics for the variables included in the specifications.

Table 4.4. Measures and descriptive statistics for variables included in the models

Explanatory variables	Measure	Source(*)	Mean	Std.Dev	Min	Max	Obs	Missing Values
Prevalence of undernourishment	% population	WDI	20.88	10.411	5	60.3	770	
GDP per capita	current $/cap	WDI	2,031	2,383	136	15,245	770	
Improved water (access to)	% population	WDI	76.9	14.7	34.1	99.5	762	8
Health expenditure	% of GDP	WDI	10.40	4.34	3.24	25.17	630	140
Literacy rate	% of population	WDI	74.18	21.4	12.85	98.65	534	236

(*) WDI: World Development Indicators (World Bank, 2014b)

Smith and Haddad (2002) consider in their study the impact of GPD per capita on the rest of the basic causes that explain undernourishment situation. They find that per capita income growth leads to improvements in health environment and education and indeed income growth leads to reductions in undernourishment. They conclude that economic growth was responsible for about half of the reduction in child undernourishment and approximately half of this effect of economic growth was through increased food availability and the rest due to access to safe water, female secondary school enrollments, female to male life expectancy ratio and per capita dietary energy supply. Considering these results, we propose six different models that are summarized in Table 4.5. From column 1 to 3, GDP per capita is one of the explanatory variables in the regression model. From column 4 to 6, GDP per capita is removed and health expenditure and literacy rate are added as explanatory variables. We use panel corrected standard errors (PCSE) for panel data (Beck and Katz, 1995). We compare the results of the estimations with random effects (columns 1 and 4), country fixed effect (columns 2 and 5) and region fixed effect (columns 3 and 6). Variables are transformed in logarithms in all models.

Table 4.5. Results of regression with panel data corrected errors approach

Dependent variable: Prevalence of undernourishment

	1	2	3	4	5	6
	Models with GDP_cap as explanatory variable			Models without GDP_cap as explanatory variable		
	PCSE Random effects	PCSE country fixed effect	PCSE regional fixed effect	PCSE Ramdom effects	PCSE country fixed effect	PCSE regional fixed effect
GDP_cap ($/cap), 1991-2012	-0.33*** (0.008)	-0.27*** (0.02)	-0.32*** (0.01)			
Improved water (%), 1991-2012	-0.48*** (0.04)	-0.21* (0.12)	-1.15*** (0.08)	-1.65*** (0.03)	-0.39** (0.14)	-2.43*** (0.07)
Health Expenditure (%), 1995-201				-0.11*** (0.02)	-0.08* (0.04)	-0.12*** (0.04)
Literacy (%), 1991-2012				-0.09*** (0.02)	-0.31*** (0.07)	-0.18*** (0.05)
Region						
South Asia (4 countries)			0.07*** (0.02)			0.18*** (0.01)
Latin America (13 countries)			0.10*** (0.02)			0.01 (0.02)
Africa Subsaharian (13 countries)			-0.21*** (0.04)			-0.46*** (0.05)
Intercept	7.29*** (0.17)	5.56*** (0.49)	9.28*** (0.37)	10.66*** (0.13)	6.05*** (0.35)	14.59*** (0.59)
R^2	0.51	0.87	0.62	0.41	0.92	0.5
N	762	762	762	473	473	473

Notes:
Figures in parentheses are the coefficients standard errors
*, **, *** denotes significance at 10%, 5% and 1% level
In model 2 and model 5, there is a significant difference among 36 and 34 countries repectevily
Ommited region is East Asia (5 countries)

As expected, GDP per capita, population with access to improved water, health expenditure and literacy rate have negative and statistically significant coefficients in all models. This indicates that improvements in the levels of each of these variables lead to reductions in the undernourished population level. These results are consistent with those obtained in previous studies (Smith and Haddad, 2000; Smith and Haddad, 2002; Alderman *et al.*, 2003; Arcand and Béatrice, 2004; Suri *et al.*, 2011). Health and food security are closely interrelated. There are diseases that are caused or aggravated by inadequate nutrition, and illness is an impediment to utilize the nutrients contained in the food consumed. Food security requires the combination of sufficient food intake and a healthy environment. Inadequate water and sanitation are associated with considerable risks of diarrheal disease and other several illness (Cairncross *et al.,* 2010; Wolf *et al.,* 2014). Diarrhea leads to malabsorption of nutrients (Humphrey, 2009) and stands among the main contributors to global child mortality (Liu *et al.,* 2012).

Education policies are also relevant for food security. Better education facilitates a better knowledge about food production, household management and nutrition issues. In this sense, the literature highlights the education for girls and women, and gender equity and its positive effects on food utilization and household food security (Quisumbing *et al.,* 1995; Smith and Haddad, 2000; Hyder *et al.,* 2005). Sex education, and policies strengthening women's social and economic position play a key role to control the rapid population growth, which is endangering the capacity of population to attain food security (Bokelon *et al.,* 2005).

Columns 2 and 4 show the results of the model including country fixed effects. The explanatory variables of the model in column 2 are the income per capita and population with access to improved water. In model 4 the explanatory variables are population with access to improved water, health expenditure and the literacy rate. As R-squared values show, the potential of this type of error components models to explain the evolution of prevalence of undernourishment across time is higher than in the rest of the models. In these two models the estimated coefficients are smaller than in the case of random effect models (columns 1 and 3). Including country fixed effect corrects the overestimation caused by omitted variables bias. This implies that there are time invariant omitted variables that are related with malnutrition, biasing up the estimates. We apply the Hausman test, finding that the specification is adequately modeled by a fixed-effects model due to the difference in country coefficients is systematic (Hausman, 1978).

Finally, the regional dummies included in models in columns 3 and 6, show that the prevalence of undernourishment in African countries is higher than in the other regions. Latin American countries have on average lower undernourishment rates. The results in columns 4 to 6 do not change even though they are fitted using fewer observations. When we include health expenditure and literacy rate in the model, the number of observations drops to 473. This is because we have health expenditure data only since 1995 and there are several missing values in literacy rate data (Table 4.4).

4.6 Causal empirical analysis

4.6.1 Model specification

Endogeneity is one of the most complex challenges in investigating causality relationships with econometric models. According to the literature, there is two- way causality between human development and economic growth. There are many specific invariant effects that explain the food security situation in each country that are not included in the econometric models. So endogeneity is a concern for our modeling approach. Alderman *et al.* (2003) propose country fixed effect regressions to address the endogeneity. Smith and Haddad, 2002 undertake instrumental variables applying two-stage least squares regression analysis and Arcand and Béatrice (2004) use the Generalized Methods of Moments of Arellano-Bond. Following Smith and Haddad (2000) we address endogeneity formulating a model in first differences (Wooldridge, 2002). We test the null hypothesis that higher economic growth promotes greater improvements in food security situation in developing countries. We start from the following expression:

$$Y_{it} = \alpha_0 + \sum_{k=1}^{K} \alpha_k X_{kit} + (\beta_i + \varepsilon_{it}) \quad [7]$$

where Y_{it} is the prevalence of undernourishment (%) in country *i* (35 developing countries), in year *t* (1991 to 2012), α_0 is a scalar, α_k is a K × 1 vector of parameters, X_{kit} are the K explanatory variables, β_i is the fixed effect and ε_{it} is the error term. The explanatory variables are those presented in model [4] (Table 4.4). The model in first differences is given by:

$$\Delta Y_{it} = [\alpha_0 + \sum_{k=1}^{K} \alpha_k X_{kit} + (\beta_i + \varepsilon_{it})] - [\alpha_0 + \sum_{k=1}^{K} \alpha_k X_{kit-1} + (\beta_i + \varepsilon_{it-1})]$$

$$= \sum_{k=1}^{K} \alpha_k \Delta X_{kit} + \Delta\varepsilon_{it} \quad [8]$$

where, ΔY_{it} is the annual change of prevalence of undernourishment (%) $\alpha_k \Delta X_{kit}$ are the percentage annual changes of the *K* explanatory variables and $\Delta \varepsilon_{it}$ is the change in error term. The explanatory variables are annual percentage change in GDP per capita (constant values referred to 2005), the annual percentage change in population with access to improved water, the annual percentage change in health expenditure and the annual percentage change in literacy rate. Annual percentage changes are obtained by taking first difference of variables in logarithms.

We have made two assumptions to facilitate the interpretation of the results. The first one is related to the fact that in our study ΔY_{it} shows a negative sign (reductions in prevalence of undernourishment) and Δx_{kit} moves in the opposite direction (improvements in *K* explanatory variables). In order to ensure that the prevalence of undernourishment annual changes has the same sign (positive) as the explanatory variables, we analyze the prevalence of undernourishment in a positive mode (100 – prevalence of undernourishment (%). We call this new variable, Nourished Population (NP). Second, because the aim of the chapter is to analyze the speed of improvements in food security, the econometric model is only run on positive changes in nourished population. Negative changes in nourished population are not included in the analysis. This assumption involves leaving out 214 observations of the undernourishment evolution from 735 to 521. Most of the removed observations (92 observations) correspond to the eight countries that show undernourishment deterioration over the period (Groups I and IV in Figure 4.1). In each country of these groups, about half of the observations have been removed. In the rest of countries, the number of removed observations is lower as it is detail in Appendix 4.1.

Table 4.6 summarizes the measures and statistics for the variables included in the models of first differences. The average annual growth of GDP per capita is 3.53% in the sample of 35 countries in period 1991-2012. The five subsamples of countries show an average annual growth of GDP per capita similar to this rate. The average annual growth of population with access to improved water and of literacy rate is near to 1%. It can be seen that the average growth of these two variables is near 0 in group I and about 3% in group IV. The average annual growth of health expenditure is 0.5% in the whole sample. Again, this rate drops to 0% in group I. This variable shows annual sharp changes between -51% and 67%.

Table 4.6. Measures and descriptive statistics for variables in percentage annual changes

Explanatory variables	Measure	Source	Obs	Mean	Std.Dev	Min	Max
Sample: 35 countries							
Nourished population	(%)	WDI	735	78.93	10.41	39.70	95.00
GDP per capita annual growth	(%)	WDI	770	3.53	0.11	2.70	3.88
Access to improved water annual growth	(%)	WDI	761	1.02	0.93	-1.43	4.55
Literacy rate annual growth	(%)	WDI	505	0.96	0.02	-0.05	0.16
Health expenditure annual growth	(%)	WDI	595	0.42	13.54	-51.34	66.88
Group I: Undernourishment deterioration at a decreasing rate (5 countries)							
Nourished population	(%)	WDI	105	72.92	7.29	58.70	86.70
GDP per capita annual growth	(%)	WDI	110	3.50	0.11	2.70	3.69
Access to improved water annual growth	(%)	WDI	110	0.01	0.01	-0.01	0.04
Literacy rate annual growth	(%)	WDI	74	0.02	0.04	-0.05	0.16
Health expenditure annual growth	(%)	WDI	85	0.00	0.13	-0.29	0.67
Group II: Undernourishment improvement at an increasing rate (8 countries)							
Nourished population	(%)	WDI	168	81.61	7.13	60.30	95.00
GDP per capita annual growth	(%)	WDI	176	3.51	0.12	2.87	3.88
Access to improved water annual growth	(%)	WDI	171	0.83	0.50	0.00	2.08
Literacy rate annual growth	(%)	WDI	119	0.61	1.51	-5.06	8.23
Health expenditure annual growth	(%)	WDI	136	0.47	14.43	-36.71	60.55
Group III: Undernourishment improvement at a decreasing rate (11 countries)							
Nourished population	(%)	WDI	231	81.22	13.97	39.70	95.00
GDP per capita annual growth	(%)	WDI	242	3.56	0.11	3.02	3.82
Access to improved water annual growth	(%)	WDI	238	0.88	0.66	0.00	3.13
Literacy rate annual growth	(%)	WDI	166	0.93	1.50	-1.85	11.41
Health expenditure annual growth	(%)	WDI	187	0.26	13.79	-51.34	50.64
Group IV: Undernourishment deterioration at an increasing rate (3 countries)							
Nourished population	(%)	WDI	63	78.11	6.82	64.50	89.10
GDP per capita annual growth	(%)	WDI	66	3.51	0.08	3.27	3.76
Access to improved water annual growth	(%)	WDI	66	2.73	0.90	0.00	4.55
Literacy rate annual growth	(%)	WDI	47	0.69	0.97	-1.35	3.02
Health expenditure annual growth	(%)	WDI	51	0.70	14.25	-44.62	28.95
Linear trend Group (8 countries)							
Nourished population	(%)	WDI	168	77.15	8.14	61.80	94.90
GDP per capita annual growth	(%)	WDI	176	3.53	0.09	3.18	3.75
Access to improved water annual growth	(%)	WDI	176	1.04	0.45	0.00	2.31
Literacy rate annual growth	(%)	WDI	99	0.65	1.77	-1.97	8.69
Health expenditure annual growth	(%)	WDI	136	0.57	12.18	-42.83	32.13

(*) WDI: World Development Indicators

We apply the Wooldridge test (Wooldridge, 2002) to identify serial correlation in the idiosyncratic error term of equation [8]. In linear panel-data models, serial correlation biases the standard errors and causes the results to be less efficient. In our database, the hypothesis of no serial correlation is rejected. Another common problem is the heteroskedasticity. To test this presence we apply Wald statistic for groupwise heteroskedasticity (Fox, 1997). The null hypothesis of homocedasticity is rejected. Thus, we use a generalized least squares regression with correction of heterocedasticity and autocorrelation (Beck and Katz, 1995).

To control the bias in the estimated coefficients, we also use lagged variables as instruments variables. Lagged dependent variables have been used in regression analysis as a robust strategy to eliminate autocorrelation in the residuals. In general, regressions that do not include the lagged dependent variable often result in larger coefficient estimates for independent variables, compared to regressions that include it. Dynamic regression models use lagged dependent variables to model processes where current values of the dependent variable are a function of its prior values (Keele and Kelly, 2005; Beck and Katz, 2011). Smith and Haddad (2000) include the lagged dependent variable as a regressor in their analysis of child malnutrition. In time series data, lagged explanatory variables are valid instruments since lagged explanatory values are correlated with lagged dependent variables but not with the error term (Shumway and Stoffer, 2006)[8].

4.6.2 Results and discussion

The results of the regression model are shown in Table 4.7. The first column (1) details the results of the baseline model considering the total sample. Columns 2, 3 and 4 summarize the results of the models for different groups of countries proposed according to the prevalence of undernourishment trend (Figure 4.1). The columns from 5 to 7 show the results including lagged explanatory variables in the model.

As column 1 shows, the results confirm the initial hypothesis that higher per capita income growth contributes to generate higher increments in nourished population. The coefficient of GDP per capita annual growth is positive and statistically significant across all models´ specifications. Since the analysis is performed on rates of change the magnitude of the coefficients is small. An acceleration in the economic growth of 1% generates an acceleration of 0.02% in the nourished population (column 1). We run the

[8] All data, results and STATA code for programming are available from the authors.

model on the subsamples of Group II (undernourishment improvement at an increasing rate), Group III (undernourishment improvement at a decreasing rate) and linear trend group (Figure 4.1)[9]. It can be seen that the coefficient of economic growth remains positive, statistically significant with value around 0.02%. According to the R-squared, the model with the best fit is obtained with group III (column 3). Furthermore, the coefficient of income growth in group III model is higher than the estimated income growth coefficients in Group II and the linear group trend. The higher income growth coefficient indicates that the impact of economic growth acceleration on food security is higher in countries of group III than the rest. According to the analysis of the undernourishment trends, countries of group III have reduced their prevalence of undernourishment more intensively over the early years of the period. Frequency analysis of economic growth showed in section 4.4, also suggests that these countries have recorded the highest frequency of income growths between 5-10% over the period. Descriptive statistics shown in Table 4.6 indicate that the average annual growth of Group III is higher than the rest of the groups. We conclude that higher income growths have enabled these countries not only to have greater improvements in food security but do so in a shorter period of time during the first years of the considered period. The higher impact of economic growth on food security in the countries of the group III may explain why these countries show a faster response to the challenge of reducing hunger than those countries where the impact of economic growth is lower.

One step further in the analysis of the economic growth is reported in columns 5, 6 and 7. The positive and significant sign of the lagged economic growth in model 5 shows that higher economic growth in the previous period generates a higher improvement in nourished population in current year. The coefficient is similar to the economic growth coefficient in model 1. If we analyze longer time periods of economic growth, we realize that the impact of annual average economic growth of several previous years on actual nourished population improvements is higher than the impact of annual economic growth. We include in the specification the five-year moving average (column 6) to

[9] We do not show the results of the group I and IV´s regressions. Data limitation due to the reduced improvements in nourished population in groups I and IV (76 observations) may be the reason why the model do not fit using these samples of countries.

analyze the impact of the average annual rate of income growth in the previous five years on actual increment of nourished population. In the same way, we run another estimation considering the ten-year moving average (column 7). The coefficient of average annual economic growth rate in the previous ten years is the largest comparing to the rest of economic growth coefficients. An acceleration of 1% of economic growth in ten years period generates an acceleration of 0.045 % in the nourished population (more than double than in model 1). As the economic growth term covers more years, the sensitive of food security to changes in economic growth is higher. The positive impact of sustainable economic growth (long run) on food security is greater than the impact of economic growth in the short term.

Table 4.7. Results of first difference and dynamic panel estimation

Dependent variable: Positive annual change of nourished population (%)

	1	2	3	4	5	6	7
Explanatory variables	Baseline Model	Baseline M. Group II	Baseline M. Group III	Baseline M. Linear trend Group	Lagged explanatory variables	5-year Moving Average	10-year Moving Average
GDP per capita annual growth (%), 1991-2012	0.022***	0.016*	0.021***	0.017**			
	(0.003)	(0.006)	(0.004)	(0.008)			
Lagged GDP per capita annual growth (%), 1992-2012					0.019***		
					(0.003)		
5-year moving average GDP per capita growth (%), 1985-2012						0.037***	
						(0.004)	
10-year moving average ten years GDP per capita (%), 1980-2012							0.045***
							(0.005)
Lagged nourished population (%), 1992-2012	-0.016***	-0.011*	-0.016***	-0.012*	-0.013***	-0.028***	-0.034***
	(0.002)	(0.005)	(0.004)	(0.006)	(0.002)	(0.004)	(0.034)
Access to improved water annual growth (%), 1991-2012	0.222**	0.345*	0.653**	0.52**		0.212**	0.162*
	(0.07)	(0.17)	(0.24)	(0.24)		(0.081)	(0.082)
Lagged access to improved water annual growth (%), 1992-2012					0.192*		
					(0.076)		
N	514	138	185	115	514	514	514
R^2	0.52	0.34	0.67	0.31	0.51	0.52	0.52

Notes:
Figures in parentheses are the coefficients´ standard errors
*, **, *** denotes significance at 10%, 5% and 1% level

We consider four control variables in the specification: the lag of nourished population, the annual percentage change in population with access to improved water, the annual percentage change in health expenditure and the annual percentage change in literacy rate[10]. The coefficient of the lagged nourished population is negative and statistically significant. It indicates that as the percentage of nourished population is higher, its improvements slow down, a finding that is common to all models specification. It can be seen that the coefficient of this variable in group III is higher than the coefficients of the other two groups. This may be explained by the trend of the prevalence of undernourishment of the countries of this group, which shows that reductions in prevalence of undernourishment are smaller as undernourishment decreases.

Looking at the population with access to improved water, its estimated coefficient is negative and significant. Higher increases in population with access to improved water contribute to higher improvements in nourished population. This variable, the change of population with access to improved water, has the highest coefficient in all models. An increment of 1% of people with access to improved water generates an acceleration of 0.22% in the nourished population. This confirms the relevance of the access to improved water to achieve the undernourishment goal. This result suggests that, despite the importance of income growth, undernourishment must be combated also with higher investments in improved water and sanitation (Ranis *et al.,* 2000; Timmer, 2000; Alderman *et al.,* 2003). Comparing the results across samples of countries, the Group III shows once more the highest coefficient. Countries that reveal a faster capacity to respond to undernourishment show a major sensitivity to improvements in population with access to improved water.

4.7 Conclusions

Despite the progress made in reducing hunger, the international community continues to face serious challenges of hunger and undernourishment. FAO estimates that about 805 million people are still undernourished in 2012–14 (FAO, IFAD and WFP, 2014). This article focuses on the analysis of the speed of changes in food security situation across

[10] The estimated coefficients of annual changes of health expenditure and literacy rate are not shown because they are not statistically significant. It may be explained because there are several missing data in literacy rate (Table 4.4) and health expenditure shows extreme values in its annual changes pattern (Table 4.6).

developing countries. We contrast the hypothesis of whether accelerations in economic growth promote greater reductions in the prevalence of undernourishment in developing countries. We use a regression model with panel data comprising time series (1991-2012) and cross sectional components (35 developing countries). The analysis is carried out with three economic growth definitions: annual growth, five-year moving average annual economic growth and ten-year moving average annual economic growth. We have analyzed the trends of the prevalence of undernourishment trends and we find that the sample of countries can be grouped based on five types of trends: Countries with prevalence of undernourishment following a linear trend, countries where prevalence of undernourishment improves at an increasing rate or decreasing rate, and countries where prevalence of undernourishment worsens at a decreasing rate or an increasing rate. This classification helps us to estimate the impact of economic growth on food security.

Our statistical panel analyses gives support to several conclusions. First, results confirm that accelerations in annual economic growth leads to higher annual improvements in nourished population. Comparing the results of the analysis considering the different economic growth definitions, we find that as the economic growth covers more years in a sustained manner, the impact of changes in economic growth on food security is higher. The positive impact of sustained economic growth on food security is greater than the impact of economic growth in the short term. The impact of economic growth on changes in nourished population is studied considering the nourished population baseline level. Annual changes in nourished population depend on the baseline food security situation. It appears that as the rate of nourished population grows the annual change of nourished population decreases. Secondly, consistent with previous studies we find that, in addition to income growth as a factor in reducing the prevalence of undernourishment, growth needs to be accompanied by investments in health, sanitation and education to meet the goal of reducing undernourishment. Thirdly, we have performed the same analysis on the subsamples of countries classified according to their prevalence of undernourished trend. The results show that the impact of economic growth and population with access to improved water differs from one subsample to another, and this difference may explain why developing countries do not show the same recovery trend of the undernourishment rate. Countries with a greater sensitivity to economic growth and access to improved water show a faster response to the challenge of reducing hunger.

This study also concludes that reductions in undernourishment can be accelerated through increased income growth but in a greater extent through increased access to improved water services. So even if economic growth falters, sustained improvements in the access o drinking water and sanitation may still push for reductions in the percentage of undernourished people.

There are some limitations of our findings. First the analysis deals only with improvements in food security situations. It fails to take into account countries where hunger has been exacerbating during part of the period of analysis, as it happened in Burkina Faso, Côte d Ívoire, Guatemala, and Paraguay. Second, because food security is a wide and complex concept characterized by multiple dimensions (availability, affordability, utility and stability) and different levels of definition, we do not cover other dimensions which do not correlate perfectly with the indicator used in the study. We limit our study to macro-variables that affect national food security in the long run, so we do not consider the full range of variables that might also affect food security. Neither do we consider the micro dimension of food security. We analyze food security evolution analyzing the trend of one food security indicator, the prevalence of undernourishment. This indicator has limits to adequately cover the utilization dimension, because it is estimated at a highly aggregate level on the basis of macro-level relationships and, therefore omit household and demand level factors, which are key determinants of food utilization. Third, the chapter does not analyze new approaches about *hidden hunger*. And finally, we do not consider many direct interventions that have proved essential to reducing undernourishment in the last years, such as micronutrient supplementation, food fortification or diet supplementation for pregnant women.

5 Final conclusions

5.1 Main conclusions and research contributions

The Millennium Development Goal of halving the percentage of people suffering from hunger by 2015 appears to be within reach (UN, 2013). Despite this significant accomplishment, still one in eight people in the world today remains chronically undernourished and one in four children shows signs of being stunted. This thesis has tried to identify the impact of several key driving factors responsible for hunger persisting at still unacceptable levels. It analyzes the impact of globalization and economic growth on several food security indicators. This investigation has carried out an empirical analysis of food security drivers in developing countries from a macro level perspective and long-term horizon. The sample analyzed covers 52 countries and the period from 1991 to 2012. It is a representative sample of the developing world and includes countries with different level of income (from least developed countries to upper middle income countries) in four geographical regions, East and South Asia, Europe and Central Asia, North Africa and Near East, Sub-Saharan Africa and Latin America.

Four research questions were formulated at the beginning. In the following points, I present the main conclusions drawn from answering the research questions.

5.1.1 Do public-private investments in infrastructure promote agricultural exports in developing countries?

The first conclusion, that answers this question, is that public-private investment in infrastructure contributes positively to enhancing agricultural exports in developing countries. Infrastructure investments promote the development of the agricultural sector by improving access to inputs, technology, timely information, and national and international markets. The analyzed database reveals that the public-private investment in infrastructure has increased over the last years, though it is mainly focused on middle and upper-middle income countries. Similar trends can be seen in the analysis of the agricultural exports. Middle and upper-middle income countries have increased the agricultural exports in a much larger extent than low-income countries.

The thesis provides a second conclusion that appears to explain why foreign private investor remains uninterested in the least developed countries. The impact of public-private investment in infrastructure does not seem to perform equally well across the countries analyzed. The intensity of the positive impact of the public-private investment on agricultural exports is stronger in higher income countries than in lower income countries. The fact that the same amount of public-private investment in infrastructure generates higher agricultural exports in higher income countries explains why the private investors are focusing on them. These two first conclusions contribute to define the process of the Post-2015 Development Agenda and the role of private sector in the future global development framework. Promoting private investment in infrastructure in the least developed countries should be a major priority for enhancing export growth, as is currently happening in middle and upper-middle income countries. The contribution of public sector is essential to create a enabling environment that reduces risks and impediments to investment (legal, policy, regulatory and financial framework), sharing risks and aligning private sector incentives with public goals.

The third conclusion is that trade tends to reduce poverty if exporting earnings are reinvested in high value productive sectors and, hence, the dependence of the national economy on trade decreases. This conclusion qualifies the relevance of trade openness as a development strategy. Results show that the capacity for exporting agricultural products of a country increases as the participation of agriculture in the national economy decreases. The sample of countries was classified according to the level of trade openness. By grouping countries this way, results permit concluding that countries with higher share of trade on the economy are those with lower income, little investment in infrastructure and less developed export capacity compared to countries with lower share of trade in the economy. The contribution of trade to achieve the development goals will depend on the ability of the recipient country to invest the export earnings in economic sectors unrelated to natural resources and reducing the technological gap. The controversial impact of trade on poverty leads to the next research question addressed in the thesis.

5.1.2 What is the impact of agricultural exports on food security in developing countries?

The second research question of the thesis was aimed at assessing the impact of agricultural exports on food security in developing countries. The answer to this question brings about the fourth conclusion that establishes that agricultural exports may have a negative impact on food security. As posed by other authors, growth based on agricultural exports faces several challenges: 1) It may entail a competition between cash crops and food crop production; 2) The production structure does not necessarily meet local consumption needs; 3) Small farmers may lose their land, their ability to meet their own food needs and, as a result, they might become marginally employed with low and unstable wages; and 4) Poor farmers may become more vulnerable to price instability in global food markets because they are net food buyers and they spend a large shares of their income on food. Export oriented production policies do not seem to contribute to improve food security in exporting countries unless they are accompanied by measures that facilitate smallholders become competitive in markets. Further development strategies should prioritize measures that protect the property rights on land, strength the institutional support (legal framework, investments, insurance, finance), and enhance investments in education, labor skills and labor markets.

5.1.3 How important is income equity to improve food security indicators in developing countries?

The third research question poses if the income distribution matters to improve food security. The answer to this question is that income inequality matters and it is detrimental to food security. To reach this conclusion, a previous analysis about the intensely discussed relationship between inequality and economic growth has been carried out. The results obtained support the Kuznets hypothesis that claims that inequality increases until a stage of development is reached. Beyond this point, inequality begins decreasing. This finding gives support the fifth conclusion whereby in those countries where the income increment is accompanied by a decrease of inequality, indicators reveal a better food security situation than in those where inequality is increasing. This conclusion points to the need to broaden the food security discussions beyond the common concerns of rising incomes, agricultural production or investment, and to consider that hunger is also a distributional problem. Rising average income alone seems to be not sufficient for reducing hunger, unless growth helps deal with extreme poverty. Policies to combat hunger and malnutrition should put the participation of poor people in economic growth in the set of priorities. Growth policies should prioritize measures oriented to improve education and technical skills, reduce the inequality in labor markets and design adequate taxes and cash transfers systems.

5.1.4 To what extent is economic growth necessary to improve food security?

The fourth research question addressed the debate on the relevance of economic growth to accelerate the improvements in food security. The answer to this question results in two additional conclusions. The sixth conclusion is that accelerations in annual economic growth leads to higher annual improvements in nourished population, but it needs to be accompanied by investments in health, sanitation and education to meet the goal of reducing undernourishment. Reductions in undernourishment can be accelerated through increased income growth but in a greater extent through increased access to improved water. So even if economic growth falters, sustained improvements in the access to drinking water may still push for reductions in the percentage of undernourished people.

The seventh finding reveals that the impact of economic growth and access to improved water on food security improvements does not show the same intensity in all the countries analyzed. It may explain why developing countries do not show the same path towards reducing the undernourishment trend. Countries with a greater sensitivity to economic growth and access to improved water show a faster response to the challenge of reducing hunger. Further, the pace of future nourished population improvement depends on the current food security situation. As the status of food security is better, the improvements are slower. This indicates that there is non-linear path toward improving food security. And it might explain why countries that have exhibit significant progress in the last fifteen years (Colombia, Nicaragua, Bangladesh or Peru), still have significant percentages of people suffering malnutrition.

The eighth and last conclusion is related to the horizon of economic growth. It appears that long-term sustainable economic growth generates a greater impact on food security that a short- medium term economic growth. Growth strategies should focus in reaching not only income increments but also that the increments are sustained in the long run. The positive impact of the sustained growth over ten years on food security doubles the positive impact of the annual economic growth.

The eight conclusions share a common denominator. It seems that development policies should prioritize the investment in human development to reach the global goal of hunger eradication. This requires investing in health, improved water and sanitation, education, labor skills, together with improvements in labor markets and institutional support.

5.2 Limitations and future paths for research

There are numerous limitations of the research results. Focusing on the most relevant, I shall comment four. The first one is related to the quality of the data analyzed. Despite the significant improvements in the methodology to measure food security, better data and additional indicators are needed to generate a more holistic assessments of food security. This requires stronger commitment by international agencies to support the statistical capacity of developing countries.

The second one is related to the complexity of addressing food security challenges. As mentioned in the introduction of the thesis, food security is a wide concept characterized by multiple dimensions, different levels and time horizons. The research has focused only on the availability and access dimensions from a macro perspective but leaves aside the utilization and stability dimensions and nutritional security. Its scope does not cover household and individual food security or short-term impacts on food security. The study does not analyze the other burden of malnutrition, overweight, obesity and hidden hunger. At world level, this might be a more serious problem than undernourishment.

Thirdly, econometric analyses have to face the challenging obstacle of the endogeneity that arises as a result of the presence of two-way causality relationship between socio-economic variables and omitted variables bias. These features pose important empirical challenges, as failure to control for them generally leads to biased and inconsistent estimators if unobserved individual heterogeneity is present. The estimation procedures tackled this issue combining cross-sectional data and time series data, applying fixed effects estimations and first difference models. Although these techniques are intensively applied in empirical analyses, there are some other procedures, such as the Arellano-Bond estimator and two-stage least squares (2SLS) with instrumental variables that it would be interesting to apply at least to check the robustness of the conclusions and results.

Finally, the cross sectional analysis shows results and supports conclusions for the developing countries as a group. Certain exceptional food security situations have been identified in the research, referred to some countries where undernourishment is increasing as in Burkina Faso, Côte d´Ivore, Guatemala or Paraguay. These countries should be analyzed individually and more in depth.

Despite the recognized limitations, this thesis presents a coherent integrated framework for the assessment of food security that contributes to the knowledge about food security drivers in developing countries, and therefore improving the targeting and formulation of development policies. These limitations also facilitate the identification of the future research questions. Among the clearest paths for future research stand the following: 1) The analysis of food security from a micro-level approach and considering country´s case studies; 2) The investigation of the utilization and nutrition dimension (obesity and hidden hunger); 3) This thesis reveals that the impact of economic growth on food security depends on the country. A new path of research could be the study of the factors explaining the variability among countries; and 4) The application of further econometric techniques need to be undertaken to avoid the endogeneity problem.

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Appendices

Appendix 1.1: Economic, social and food security indicators of the countries of the sample.

		Average Protein Supply (gr/day/cap)	Prevalence of Under - nourishment (% population)	Depth of the food deficit (kcal/day/cap)	Dietary Energy Supply (kcal/day/cap)	GDP (million US$)	Gini Index	Population (thousands)	Urban (% population)	Agriculcuture value added (% PIB)	Agricultural raw materials (% merchandise exports)	Food import (% merchandise imports)	Access to improved water (% population)
		2008-10	2011-13	2011-13	2011-13	2013	2008-2010	2013	2013	2013	2013	2013	2012
	Belarus	90.00			3,510	71,710	27.53	9,466	75.88	9.11	1.64	9.23	99.60
	Benin	64.00	6.10	34.00	2,890	8,307		10,323	43.09	36.52	49.14	31.33	76.10
	Burkina Faso	80.00	25.00	178.00	2,630	11,583	39.71	16,935	28.19		44.37	12.05	81.70
	Cameroon	62.00	13.30	85.00	2,550	29,568		22,254	53.25	22.89			74.10
	Cote d'Ivoire	54.00	20.50	133.00	2,670	31,062	41.50	20,316	52.77	22.28	10.23	14.58	80.20
	Gabon	82.00	5.60	35.00	2,760	19,344		1,672	86.66				92.20
Sub Saharan Africa	Kenya	60.00	25.80	166.00	2,180	55,243		44,354	24.78	29.51			61.70
	Mozambique	43.00	36.80	269.00	2,180	15,630	45.66	25,834	31.67	28.99	3.74	10.66	49.20
	Senegal	62.00	21.60	142.00	2,320	14,792	39.19	14,133	43.08	17.52			74.10
	South Africa	84.00	<5	13.00	3,180	350,630	63.85	52,982	63.79	2.39	1.90	6.55	95.10
	Swaziland	58.00	35.80	262.00	2,100	3,791	51.40	1,250	21.34				74.10
	Tanzania	55.00	33.00	221.00	2,210	33,225	37.58 [(1)]	49,253	30.20	28.39	7.13	7.85	53.20
	Uganda	49.00	30.10	192.00	2,290	21,494	44.02	37,579	15.44	24.54	5.91	11.45	74.80
	Yemen, Rep.	55.00	28.80	188.00	2,140	35,955		24,407	33.45		0.16	28.71	54.90

[(1)] Referred to 2007

Source: World Development Indicators (World Bank, 2014b) and Food security Indicators (FAO, 2014)

		Average Protein Supply (gr/day/cap)	Prevalence of Under - nourishment (% population)	Depth of the food deficit (kcal/day/cap)	Dietary Energy Supply (kcal/day/cap)	GDP (million US$)	Gini Index	Population (thousands)	Urban (% population)	Agriculcuture value added (% PIB)	Agricultural raw materials (% merchandise exports)	Food import (% merchandise imports)	Access to improved water (% population)
		2008-10	2011-13	2011-13	2011-13	2013	2008-2010	2013	2013	2013	2013	2013	2012
Latin America	Argentina	94.00	<5	23.00	2,920	609,889	45.63	41,446	91.45	6.98	0.92	2.31	98.70
	Bolivia	61.00	21.30	140.00	2,310	30,601	56.29	10,671	67.70	13.32	0.47	6.70	88.10
	Brazil	90.00	6.90	56.00	3,260	2,245,673	54.88	200,362	85.17	5.71	3.53	4.88	97.50
	Chile	90.00	<5	23.00	2,960	277,199	52.02	17,620	89.18	3.44	5.82	7.70	98.80
	Colombia	69.00	10.60	70.00	2,810	378,415	56.60	48,321	75.88	6.12	2.64	9.99	91.20
	Costa Rica	75.00	8.20	57.00	2,710	49,621	49.80	4,872	74.96	5.64	2.16	10.45	96.60
	Ecuador	57.00	16.30	106.00	2,350	94,473	49.77	15,738	63.30	9.37	3.99	7.30	86.40
	El Salvador	72.00	11.90	78.00	2,580	24,259	47.54	6,340	65.78	10.84	0.93	15.23	90.10
	Guatemala	61.00	30.50	201.00	2,240	53,797	55.89 (2)	15,468	50.66	11.31	3.95	13.25	93.80
	Honduras	67.00	8.70	46.00	2,890	18,550	59.14	8,098	53.54	13.39			89.60
	Mexico	91.00	<5	2.00	3,220	1,260,915	47.72	122,332	78.69	3.48	0.36	6.58	94.90
	Nicaragua	66.00	21.70	144.00	2,570	11,256		6,080	58.15	16.92	0.72	17.23	85.00
	Paraguay	65.00	22.30	157.00	2,460	29,009	51.84	6,802	59.17	21.59	1.70	7.97	93.80
	Peru	71.00	11.80	76.00	2,670	202,350	48.71	30,376	77.95		1.24	9.84	86.80
	Uruguay	81.00	6.20	42.00	2,720	55,708	45.96	3,407	94.98	9.96	8.08	11.28	99.50
	Venezuela, RB	83.00	<5	14.00	3,100	438,284	44.77 (2)	30,405	88.89				

(2) Referred to 2006

Source: World Development Indicators (World Bank, 2014b) and Food security Indicators (FAO, 2014)

		Average Protein Supply (gr/day/cap)	Prevalence of Under - nourishment (% population)	Depth of the food deficit (kcal/day/cap)	Dietary Energy Supply (kcal/day/cap)	GDP (million US$)	Gini Index	Population (thousands)	Urban (% population)	Agriculcuture value added (% PIB)	Agricultural raw materials (% merchandise exports)	Food import (% merchandise imports)	Access to improved water (% population)
		2008-10	2011-13	2011-13	2011-13	2013	2008-2010	2013	2013	2013	2013	2013	2012
East and South Asia	Bangladesh	55.00	16.00	118.00	2,470	149,990	32.34	156,595	32.75	16.28			84.80
	China	94.00	11.40	76.00	3,040	9,240,270	42.35	1,357,380	53.17	10.01	0.44	5.50	91.90
	India	58.00	17.00	121.00	2,390	1,876,797	33.64	1,252,140	31.99	18.20	2.06	3.90	92.60
	Indonesia	58.00	9.10	64.00	2,820	868,346	34.84	249,866	52.25	14.43	5.80	8.78	84.90
	Malaysia	76.00			2,960	313,159	46.16	29,717	73.28	9.31	2.15	7.71	99.60
	Pakistan	64.00	17.20	131.00	2,520	232,287	30.02	182,143	37.86	25.11	1.82	10.29	91.40
	Philippines	61.00	16.20	100.00	2,610	272,067	43.16	98,394	44.63	11.23	1.08	10.35	91.80
	Sri Lanka	58.00	22.80	200.00	2,520	67,182	37.69	20,483	18.30	10.76	2.63	12.10	93.80
	Thailand	62.00	5.80	40.00	3,010	387,252	39.97	67,011	47.94	11.98	4.74	5.48	95.80
	Vietnam	75.00	8.30	63.00	2,890	171,390	35.57	89,709	32.31	18.38	2.38	8.26	95.00

Source: World Development Indicators (World Bank, 2014b) and Food security Indicators (FAO, 2014)

Region	Country	Average Protein Supply (gr/day/cap)	Prevalence of Under - nourishment (% population)	Depth of the food deficit (kcal/day/cap)	Dietary Energy Supply (kcal/day/cap)	GDP (million US$)	Gini Index	Population (thousands)	Urban (% population)	Agriculcuture value added (% PIB)	Agricultural raw materials (% merchandise exports)	Food import (% merchandise imports)	Access to improved water (% population)
		2008-10	2011-13	2011-13	2011-13	2013	2008-2010	2013	2013	2013	2013	2013	2012
Europe and Central Asia	Albania	96			3,000	12,923	34.51	2,774	55.38	22.24	2.30	17.70	95.70
	Azerbaijan	89.00	<5	9.00	3,160	73,560	33.71	9,417	54.10	5.66	0.09	15.74	80.20
	Kazakhstan	103.00	<5	3.00	3,390	231,876	29.19	17,038	53.36	4.93	0.25	9.13	93.10
	Macedonia, FYR	78.00	<5	23.00	2,840	10,195	43.64	2,107	56.98	10.45	0.65	12.72	99.40
	Moldova	69.00			2,420	7,970	34.12	3,559	44.88	15.04	0.68	13.71	96.50
	Ukraine	89.00			3,320	177,431	26.52	45,490	69.27	10.43	1.25	10.34	98.00

Source: World Development Indicators (World Bank, 2014b) and Food security Indicators (FAO, 2014)

Region	Country	Average Protein Supply (gr/day/cap)	Prevalence of Under - nourishment (% population)	Depth of the food deficit (kcal/day/cap)	Dietary Energy Supply (kcal/day/cap)	GDP (million US$)	Gini Index	Population (thousands)	Urban (% population)	Agriculcuture value added (% PIB)	Agricultural raw materials (% merchandise exports)	Food import (% merchandise imports)	Access to improved water (% population)
		2008-10	2011-13	2011-13	2011-13	2013	2008-2010	2013	2013	2013	2013	2013	2012
North Africa and Near East	Egypt, Arab Rep.	97.00	<5	8.00	3,430	271,973	30.77	82,056	43.03	14.51	2.07	17.75	99.30
	Iran, Islamic Rep.	89.00	<5	29.00	3,230	368,904		77,447	72.32				95.90
	Morocco	89.00	5.00	31.00	3,270	103,836	40.88 (1)	33,008	59.20	16.57			83.60
	Syrian A.R.	84.00	6.00	38.00	2,990	40,405 (1)		22,846	56.86				90.10
	Tunisia	95.00	<5	6.00	3,290	46,994	37.13	10,887	66.46	8.61	0.45	10.63	96.80
	Turkey	105.00	<5	5.00	3,770	822,135	39.24	74,933	72.37	8.49	0.45	4.58	99.70

(1) Referred to 2007

Source: World Development Indicators (World Bank, 2014b) and Food security Indicators (FAO, 2014)

Appendix 2.1: Sample of countries.

Country	OECD_ Income Classification
Albania	Upper Middle Income Country
Argentina	Upper Middle Income Country
Azerbaijan	Upper Middle Income Country
Bangladesh	Least Developed Country
Belarus	Upper Middle Income Country
Benin	Least Developed Country
Bolivia	Lower Middle Income country
Brazil	Upper Middle Income Country
Burkina Faso	Least Developed Country
Cameroon	Lower Middle Income country
Chile	Upper Middle Income Country
China (People´s Republic of)	Upper Middle Income Country
Colombia	Upper Middle Income Country
Costa Rica	Upper Middle Income Country
Côte d´Ivoire	Lower Middle Income country
Ecuador	Upper Middle Income Country
Egypt	Lower Middle Income country
El Salvador	Lower Middle Income country
Gabon	Upper Middle Income Country
Guatemala	Lower Middle Income country
Honduras	Lower Middle Income country
India	Lower Middle Income country
Indonesia	Lower Middle Income country
Iran	Upper Middle Income Country
Kazakhstan	Upper Middle Income Country
Kenya	Low income country
Malaysia	Upper Middle Income Country
Mexico	Upper Middle Income Country
Moldova	Lower Middle Income country
Morocco	Lower Middle Income country
Mozambique	Least Developed Country
Nicaragua	Lower Middle Income country
Pakistan	Lower Middle Income country
Paraguay	Lower Middle Income country
Peru	Upper Middle Income Country
Philippines	Lower Middle Income country
Macedonia (Former Yugoslav Republic of)	Upper Middle Income Country
Senegal	Least Developed Country
South Africa	Upper Middle Income Country
Sri Lanka	Lower Middle Income country
Swaziland	Lower Middle Income country
Syrian Arab Republic	Lower Middle Income country
Tanzania	Least Developed Country
Thailand	Upper Middle Income Country
Tunisia	Upper Middle Income Country
Turkey	Upper Middle Income Country
Uganda	Least Developed Country
Ukraine	Lower Middle Income country
Uruguay	Upper Middle Income Country
Venezuela	Upper Middle Income Country
Vietnam	Lower Middle Income country
Yemen	Least Developed Country

Source: DAC list of ODA Recipients (2014)
Least Developed Countries and Low Income countries: GNI per capita<= $1,045 in 2013
Lower Middle Income Countries: GNI per capita $1,046-$4,125 in 2013
Upper Middel Incom Countries: GNI per capita $4,126-$12,745 in 2013

Appendix 2.2: Drescriptive statistics for variables included in the models

Variable	Measure	Source	Nº obs	Mean	Std. Dev.	Min	Max
Agri_X	Current million US$	World Development Indicators	834	784	1,598	6	15,807
PPI_Infra	Current million US$	PPI World Bank	748	1,605	4,975	1	68,190
XRT	Local currency per US$	World Development Indicators	879	1,102	3,405	0	25,000
GDP_cap	Current US$ per habitant	World Development Indicators	883	2,583	2,522	141	14,501
WGDP_cap	Current US$ per habitant	World Development Indicators	884	6,808	1,704	5,161	10,201
Inflation	Difference of logharitms	World Development Indicators	883	12	34	-9	99,87
Volatility	Moving standard deviation	World Development Indicators	884	2	2	0	9
Gov_expend	Percent of GDP	World Development Indicators	870	13	4	4	27
Democracy	Index	POLITY IV Project database	867	3	6	-9	10
Agri_sector	Percent of GDP	World Development Indicators	862	16	9	2	56
Agri_prod_cap	Current US$ per habitant	FAO Database	761	327	228	18	1,725

Appendix 3.1: Detail of the interpolated values of Gini Index.

Country	Gini index interpolated values	Country	Gini index interpolated values
Albania	1998-2001, 2003, 2006-2007	Malaysia	1998-2003, 20005-2006, 2008
Argentina		Mexico	1997, 1999, 2001, 2003, 2007, 2009
Azerbaijan	1996-2000, 2002-2007	Moldova	2000
Bangladesh	1997-1999, 2001-2004,2005-2009	Morocco	2000, 2002-2006
Belarus	1997-1999, 2001-2004, 2006-2009	Mozambique	1997-2002, 2004-2007
Bolivia	1998, 2003-2004	Nicaragua	1999-2000, 2002-2004
Brazil	2000	Pakistan	1998, 2000, 2003-2004, 2007
Burkina Faso	1999-2002, 2004-2008	Paraguay	1996-1997, 2000,
Cameroon	1997-2000, 2002-2006	Peru	
Chile	1997, 1999, 2001-2002, 2004-2005, 2007-2008	Philippines	1998-1999, 2001-2002, 2004-2005, 2007-2008
China	1997-1998, 2000-2001, 2003-2004, 2006-2007	Senegal	2002-2004
Colombia	1997-1998	South Africa	1996-1999, 2001-2005, 2007-2008
Costa Rica		Sri Lanka	1997-2001, 2003-2006, 2008-2009
Cote d'Ivoire	1996-1997, 1999-2001, 2003-2007	Swaziland	1996-2000, 2002-2009
Ecuador	1996-1997, 2001-2002, 2004	Tanzania	2001-2006
Egypt	1997-1999, 2001-2004, 2006-2007	Thailand	1997, 2001, 2003-2005, 2007
El Salvador	1997, 2000	Tunisia	1996-1999, 2001-2004, 2006-2009
Guatemala	1999, 2001, 2005	Turkey	
Honduras	2000	Uganda	1997-1998, 2000-2001, 2003-2005, 2007-2008
Indonesia	1997-1998, 2000-2001, 2003-2004, 2006-2007	Ukraine	1997-1998, 2000-2001
Iran		Uruguay	1999
Kazakhstan	1997-2000, 2005	Venezuela	1996-1997, 1999
Kenya	1998-2004	Viet Nam	1999-2001, 2003, 2005, 2007
Macedonia	1999, 2001, 2007	Yemen	1999-2004

Source: Own elaboration

Appendix 3.2: Detail of the interpolated values of income shared by the lowest quintile.

Country	Income shared by the lowest quintile interpolated values	Country	Income shared by the lowest quintile interpolated values
Albania	1998	Malaysia	1996,1998-2003
Argentina		Mexico	1997, 1999, 2001
Azerbaijan	1996-1997,1999-2000,2002-2007	Moldova	
Bangladesh		Morocco	2000,2002-2003,2005-2006
Belarus	1996-1997	Mozambique	1997-2002
Bolivia		Nicaragua	1996-1997,1999-2000, 2004
Brazil		Pakistan	2003-2004
Burkina Faso	1996-1997	Paraguay	
Cameroon	2002-2006	Peru	
Chile	2004-2005, 2007-2008	Philippines	1996,1998-1999,2001-2002,2004-2005, 2007-2008
China	1997-1998,2000-2001	Senegal	1996-1997,1999-2000
Colombia		South Africa	2001-2002, 2004-2005, 2007-2008
Costa Rica		Sri Lanka	1997-1998, 2000-2001
Cote d'Ivoire	1996-1997, 1999-2001	Swaziland	1997-2000,2002-2009
Ecuador	2001-2002	Tanzania	2001-2006
Egypt	2006	Thailand	2001
El Salvador		Tunisia	2006-2007
Guatemala		Turkey	1996-2001
Honduras		Uganda	1997-1998
Indonesia	2000-2001, 2003-2004,2006-2007,2009	Ukraine	1997-198, 2000-2001
Iran	1996-1997,1999-2004	Uruguay	
Kazakhstan		Venezuela	
Kenya	1996,1998-2004	Viet Nam	1996-1997
Macedonia		Yemen	1999-2004

Source: Own elaboration

Appendix 3.3: Detail of the interpolated values of income shared by the highest quintile.

Country	Income shared by the highest quintile interpolated values	Country	Income shared by the highest quintile interpolated values
Albania	1998-2001, 2003, 2006-2007	Malaysia	1998-2003,2005-2006
Argentina		Mexico	1997, 1999, 2001, 2003, 2007, 2009
Azerbaijan	1996-2000, 2002-2007	Moldova	2000
Bangladesh	1997-1999, 2001-2004, 2006-2009	Morocco	2000,2002-2006
Belarus	1996-1997, 1999, 2003	Mozambique	1997-2002,2004-2007
Bolivia	1998, 2003-2004	Nicaragua	1999-2000,2002-2004
Brazil	2000	Pakistan	1998,2000-2001, 2003-2004, 2007
Burkina Faso	1999-2002, 2004-2008	Paraguay	2000
Cameroon	1997-2000, 2002-2006	Peru	
Chile	1997,1999,2001-2002, 2004-20005, 2007-2008	Philippines	1998-1999,2001-2002,2004-2005, 2007-2008
China	1997-1998, 2000-2001, 2003-2004,2006-2007	Senegal	2002-2004
Colombia	1997-1998	South Africa	1996-1999, 2001-2005,2007-2008
Costa Rica		Sri Lanka	1997-2001, 2003-2006, 2008-2009
Cote d'Ivoire	1996-1997, 1999-2001, 2003-2007	Swaziland	1996-2000, 2002-2009
Ecuador	1996-1997-2001-2002,2004	Tanzania	2001-2006
Egypt	1997-1999, 2001-2004, 2006-2007	Thailand	1997, 2001,2003-2005,2007
El Salvador	1997, 2000	Tunisia	1996-1999,2001-2004, 2006-2009
Guatemala	1999, 2001, 2004	Turkey	
Honduras	2000	Uganda	1997-1998,2000-2001, 2003-2005, 2007-2008
Indonesia	1997-1998,2000-2001,2003-2004, 2006-2007	Ukraine	1997-1998, 2000-2001
Iran		Uruguay	1999
Kazakhstan	1997-2000, 2005	Venezuela	1996-1997,2000
Kenya	1998-2004	Viet Nam	1999-2001, 2003, 2005, 2007
Macedonia	1999, 2001, 2006	Yemen	1999-2004

Source: Own elaboration

Appendix 4.1: Detail of removed observations.

Country	Removed observations. Increases in prevalence of undernorishment	Years
Bangaldesh	7	1992-1994, 2007, 2009, 2011-2012
Benin	2	1993,2005
Bolivia	7	1993, 1997-1998, 2003-2005, 2007
Brazil	1	2012
Burkina Faso	8	1996-2001, 2010, 2012
Cameroon	2	1992, 1994
Chile	0	
China	1	2002
Colombia	6	1997,2001, 2003-2006
Cote d´Ivorie	15	1992-1994, 1997-2002, 2007-2012
Ecuador	6	1992, 1999-2003
El Salvador	12	1993-1994, 2003-2012
Gabon	6	1993, 2001-2003, 2007, 2009
Guatemala	13	1992-1993, 1995-1998, 2003-2007,2012
Honduras	0	
India	7	1992-1994, 1999-2001, 2005
Indonesia	4	1997-2000
Kenya	8	1992, 1996-1997, 2001-2003, 2007, 2011
Morocco	6	1992-1993, 1998-2000, 2009
Mozambique	5	1992-1993, 1999, 2006, 2008
Nicaragua	1	2011
Pakistan	5	1996-1997, 2000-2002
Paraguay	9	1999, 2004-2011
Peru	3	1998, 2002-2003
Philippines	6	1992, 1997-1998, 2002, 2009-2010
Senegal	9	1993, 1995-1997, 2001, 2009-2012
Sri Lanka	4	1992, 1996, 2001,2003
Swaziland	14	1992-1997, 2005-2012
Tanzania	11	1992-1996, 1998-2001, 2007, 2009
Thailand	1	2007
Uganda	12	1992-1993, 1995-1996, 2000, 2004-2010
Uruguay	5	1994, 1996, 2010-2012
Venezuela	8	1993-1998, 2001-2002
Vietnam	0	
Yemen	10	1994-1996, 2000-2004, 2007,2008
Total	214	