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The role of sectoral FDI in promoting agricultural production and improving food security

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Abstract:

The aim of this paper is to examine the effects of foreign direct investments (FDI) on food security for 55 developing countries in a panel framework over the period 1995-2009. There are various measures of food security that can be used. Our first contribution is to build a composite indicator that synthesizes the food indicators used by the Food and Agriculture Organization to measure the food availability and food utilization. Second, our empirical study is based on a model composed of a food security equation and an agricultural production equation. Our results show that sectoral FDI have different effects on food security. FDI in the agriculture sector improves food security and FDI in the secondary and tertiary sector increases the food insecurity. We found a significant FDI's spillover through the agricultural production to food security. While the effect is positive with FDI in secondary sector, it is negative for FDI in the tertiary sector.

Keywords: Food security; FDI; agricultural production; developing countries.

JEL classifications: F1, Q1

1. Introduction

Food security is a big challenge to the economic decision-makers in developing countries (DCs) and it is closely linked to social stability in these areas, where poverty can reach very high levels. According to the State of Food Insecurity in the World's report of Food and Agriculture Organization (FAO), World Food Programme (WFP) and the International Fund for Agricultural Development (IFAD) (2013), nearly 842.3 million people (12% of the world population) are chronically undernourished; the vast majority lives in developing countries.

The economic and social potential of developing countries does not necessarily lead to good results in improving food security. In fact, it faces to a global economic context, which is characterized by changes in growth, commodity prices, climate and trade. The World Bank (2008) as well as the FAO, WFP and IFAD (2012) show that agricultural investment plays an important role in promoting agricultural growth, reducing poverty and hunger. Liu (2014) summarizes the results of FAO's case studies on the impacts of foreign agricultural investment on host communities and countries.¹

The recourse to the attraction of foreign direct investments (FDI) can be an alternative for developing countries. The FDI inflows have grown greatly in these countries, from 16.7 % of global inflows in the early 1990s to 52 % in 2012. Among them, the lowest share is directed to Africa and the biggest share is directed to the East and the Southeast of Asia (UNCTAD, 2013).

According to these stylized facts, a positive relationship between FDI inflows and the food supply is expected. In fact, the empirical literature dealing with the impact of FDI on food security dates back to the 1980s. The focus was on the distinction between the dependency and the modernization effects. Indeed, foreign investments could play a positive role via their

effect on agricultural productivity (Hallam, 2011) but they are also a source of economic and political dependency (Jenkins and Scanlan, 2001; Wimberley, 1991). As far as we know, a number of empirical studies have used the aggregated FDI inflows (see Wimberley, 1991; Firebaugh, 1992; Firebaugh and Beck, 1994; Jenkins and Scanlan, 2001). The sectoral approach of FDI is rarely used and when it is, it concerns rather developed countries. In addition, the spillover effect of FDI has been seeing in intra-industry rather than in inter-industry (Vu and Noy, 2009). So, there is a lack in the literature about this relation when we are focusing on sectoral FDI in developing countries. Another limit in the existing empirical works is the neglect of agricultural production, which is the main base of food security.

To our best knowledge, at disaggregated level, only Mihalache-O'Keef and Li (2011) analyzed the direct economic relationship between sectoral FDI and food security in a large sample. Djokoto (2012) investigated the effects of FDI on food security in one particular developing country, Ghana. On the other hand, a large economic literature deals with FDI spillovers. At the sectoral level, we could cite a recent work of Tondl and Fornero (2010) that examined the relationship between FDI and productivity in different economic sectors.

There is no study addressing the transmission channels between FDI and food security, especially through agricultural production channel. This paper tries to fill in this gap. Our contribution is at least twofold. First due to different measures of food security and consequently to a number of criticisms like the possible different typology of countries associated with each measure, we propose a composite indicator of food security². Second, we try to determine the channels by which FDI may affect food security, focusing on the agricultural production. We propose to answer the following questions: Does FDI has a positive impact on food security? Is agricultural production a pass-through from FDI to food security? Is this effect observed for all FDI or only FDI in specific sectors?

To answer these questions we rely on two equations, one for the macroeconomic determinants of food security and the other for the agricultural production determinants. These equations are linked by a simultaneous equation system and tested through three steps least square techniques (3SLS) for an unbalanced panel of 55 developing countries during the period 1995-2009. Our work confirms that the sectoral FDI do not all have the same effects, which supports the argument of Vu and Noy (2009) to use the sectoral FDI rather at its aggregated level.

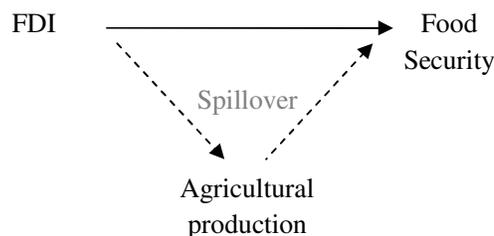
In this perspective, our work is organized as follows. In the next section, a review of literature is proposed. Section 3 describes the data and the methodology we adopted. The results are then discussed in section 4 and section 5 concludes.

2. Review of literature

Agriculture is a pivotal crucial sector for developing countries: it represents an important weight in the developing countries' economy. One of the best ways to prevent food crises in the long-run is to invest in agricultural productivity. Indeed, improving agricultural productivity is an important step towards the growth of food production, the reduction in food prices on local markets and the increase in farm income, which improves the poors' access to food. Productivity is sensitive to the state of health of the population (Timmer, 2010). In fact, hunger affects the health and leads to reduced productivity of people. According to FAO (2006a), this problem hinders economic development and the potential of entire societies. In later publication, the FAO (2009) showed the important role of the agricultural sector in developing countries and especially poor ones. It can be a buffer to the economic and employment during periods of crisis.

Our work is at the crossroads of three fields of the literature, the relationship between FDI and food security, FDI and agricultural production, and food security and agricultural production as represented by the Figure 1.

Figure 1: The relationships between FDI and food security



From these relations, we seek the two effects of FDI on food security. The first effect is determined by testing the effect of FDI on the food security directly and the indirect effect is determined by spillover of FDI on agricultural production, the latter being important in the improvement of food security. But first of all, we must remind the food security's concept and measurement.

2.1. Food Security: Concept and measurements

Food security is an old concept which was born in the mid-1970s at the world food summit in 1974. In the mid-1980s, food security was defined by the World Bank (1986) "*as access by all people at all times to enough food for an active, healthy life*". This definition has evolved over the years. In 1996, the World Food Summit defined the food security in its declaration by: "*Food security exists 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*" (FAO, 2006b).

The FAO identified four dimensions for food security. First, the food availability is "*the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports*". Second, the food access is "*the access by individuals to adequate*

resources (entitlements) for acquiring appropriate foods for a nutritious diet". Third, the food use is the "utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met". Finally, the food stability or food secure is "a population, household, or individual who must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity)".

Food security is measured by several indicators related to nutrition and hunger as the per capita per day intake of calories, protein and fat. These indicators allow the follow-up of the food situation of a country. The FAO and the World Health Organization (WHO) measure undernutrition of the individuals by energy requirements in terms of caloric intake, protein intake and fat intake. These requirements constitute the essential nutritive elements in food. Several empirical studies have used the per capita per day calories and protein intake as an indicator of food security like Wimberley (1991), Wimberley and Bello (1992), Firebaugh and Beck (1994), Mihalache-O'Keef and Li (2011) and Djokoto (2012).

The literature also shows several indicators like the ratio of total exports to food imports (Díaz-Bonilla et al., 2000). This indicator is commonly used to measure the macro-level of food security. It enables to know whether a country can achieve food security by generating foreign exchange through exports, which could allow financing food imports. In a descriptive analysis, Breisinger et al. (2010) used the inverse of this traditional index to test the vulnerability of the country to secure food import. This indicator is considered by the FAO as an indicator of food stability. Authors have also used other indicators, like food production per capita to assess the agricultural potential, and hunger index to evaluate the famine.

There are also the Millennium Development Goals (MDGs) that present eight goals which the poverty's eradication is one of it (United Nation, 2000). In this context, Gentilini and Webb

(2008) proposed a composite indicator labeled the poverty and hunger index. It is a multidimensional index that combines five official indicators of the MDGs: the proportion of population living on less than US\$1/day, the poverty gap ratio, the share of the poorest quintile in national income or consumption, the prevalence of underweight children (under five years of age) and the proportion of population undernourished.

There are many other indicators of food security discussed in the literature (see DeHaen et al. (2011), Masset (2011)). Some of them are linked to the four pillars of food security and others are from the Millennium Development Goals. This diversity of indicators justifies the complexity of food security's concept. At the empirical level, it is preferable to contain this diversity by the construction of our composite indicator that must be in harmony with the focus of the paper. This composite indicator, as described below in section 3, relies on four indicators used by the FAO and is based on Principal Component Analysis Techniques.

2.2. FDI and Food security

In the early 1980s, studies on the relationship between FDI inflows and food security have emerged. The focus was on two contradictory theories: the dependency theory and the modernization theory.

The post-World War II period was characterized by large FDI inflows to DCs, specifically into the extractive sector. In fact, the multinational corporations (MNCs) were on the research of natural resource, cheap labor, and profit. So they penetrated into the most dynamic sectors in DCs, and in consequence, leads the host countries towards improper development (Amirahmadi and Wu, 1994).

Accordingly to this theory, the FDI's effects are potentially destructive, if the MNCs manipulate the prices of goods to avoid taxes, repatriate profit to origin country, influence local politics and economic conditions by controlling the means of production, in addition to

adverse effect on growth and the distribution of income (Dixon and Boswell, 1996; Heo and Hahm, 2007; Adams, 2009). In this regard, the dependency on foreign investment has negative effects on DCs.

Supporters of the modernization theory focus on internal and external sources of economic development. Internal sources come from domestic investment, growth and education by creating industrialization and cultural modernization, and finally provide social welfare (Jenkins and Scanlan, 2001). External sources come from FDIs, which bring technology, organizational capability, management skills and marketing know-how. FDI inflows provide easy access to international markets and diffuse new skills and knowledge in the host economy (Kumar and Pradhan, 2002). The technology transfer and know-how lead to productivity gains and improved efficiency of allocation of resources (Graham, 1995; Tambunan, 2005). But the technology transfer has also some adverse effects. On one side, its learning processes is costly. On the other side, the managerial and technical capacities and the ability to finance the adoption of advanced technology are not the same across local firms (Liu, 2008). The adverse effect is found in Zambia when the presence of foreign firms has reduced the productivity of local firms (Bwalya, 2006).

Both theories have been adopted to explain the impact of foreign investments on welfare. A selected list of papers dealing with the relationship between FDI and food security is provided in Table 1.

Table 1: Selected empirical findings on FDI-food security nexus

Authors	Countries Period	Methodology	Type of FDI data	Empirical results
Wimberley (1991)	60 DCs 1967-1985	Lagged panel	Penetration of transnational corporations	(-)
Wimberley and Bello (1992)	59 DCs 1967-1985	Lagged panel	Penetration of transnational corporations	(-)
Firebaugh and Beck (1994)	62 DCs 1965-1985	- Difference-of-logs model - Difference model	FDI stock as share of GDP	(+) (-)
Jenkins and Scanlan (2001)	88 DCs 1970-1990	Lagged panel	FDI stock over total capital stock ratio	(-)
Mihalache-O'Keef and Li (2011)	56 DCs 1981- 2001	- Lagged panel - Simultaneous equations - Difference model	- Primary FDI; - Secondary FDI - Tertiary FDI	(-) (+) (+) and (-)
Djokoto (2012)	Ghana	ARDL Model	Agricultural FDI	(-)

Note: (-) and (+) are negative and positive effect respectively.

Theoretically, primary FDI affects food security negatively due to the increase in unemployment, changes in the use of agricultural land, and negative environment and demographic externalities. In contrast, FDI in the secondary sector improve food security by raising employment and wages, technology and knowledge spillovers. However, tertiary FDI has an ambiguous impact partitioned between unskilled and skilled labor. According to Todaro (1969), Evans and Timberlake (1980) and Mihalache-O'Keef and Li (2011), the unskilled labor is affected by tertiary FDI when this latter spurs rural labors to migrate to urban slums for jobs with high incomes, thus subsistence agriculture declines, and therefore migrants pay higher prices on urban markets which reduce their access to food. However, the skilled labor is affected by tertiary FDI flows when the latter improve the individual income, which is favorable to the satisfaction of basic nutritional needs.

2.3. FDI and agricultural production

The literature review suggests that the impact of FDI in the agricultural sector can be positive or negative. Some case studies show the FDI's positive side. For instance, in Ghana, the investments by one transnational company contributed to an increase in total production of

palm oil and in Uganda, companies such as Tilda (U) Ltd contributed to the growth of rice production, which has almost doubled in the last decade after the introduction of a new variety of rice called Nerica (Gerlach and Liu, 2010). In terms of positive spillovers, the example of Poland is the most appropriate to be cited here, where the vertical and horizontal FDI inflows have positively affected the dairy sector (Dries and Swinnen, 2004). Moreover, spillovers in terms of technology transfers and know-how have improved agriculture production in Ghana (Djokoto, 2012). In fact, the technology transfers can lead to greater domestic productivity, increase in production and employment in addition to a reduction in domestic prices, but this can have both negative and positive environmental effects (Hallam, 2011). In this context, the Uganda's government has adopted friendly production methods to the environment, i.e. investment in floriculture (Gerlach and Liu, 2010). Empirically, the pollution-haven argument can be put forward to explain the potential negative effect of FDI on the environment and households' health. FDI damage the environment, especially when the activity is in the mining industry. For instance, according to Akabzaa and Darimani (2001), the mining industry has weakened and polluted the water table in the Tarkwa mining region in Ghana and this pollution has affected the households' health.

At the sectoral level of FDI, very few works exist on this topic. The sectoral level reveals two directions of the FDI effects. First, the effect is direct from agriculture FDI to agricultural production. Second, the effect is indirect from spillovers of FDI in the rest of economic sectors to agricultural production. This can be seen in the case of Latin America where FDI in agriculture has a positive and significant effect on agricultural productivity and a positive spillover effect from manufacturing FDI and services FDI. The indirect effects may be explained by the presence of foreign capital in agri-food industries, which requires more efficiency in agricultural production. Regarding the spillover effect from FDI in services, the

agricultural sector can be beneficial by enhanced productivity in the transport sector (Tondl and Fornero, 2010).

To our best knowledge, there is no study that analyzes the link between sectoral FDI and the agricultural production. However, the use of food security indicators on explaining the effect of nutrition on farm productivity was tested by Strauss (1986) and Deolalikar (1988). The first used a household-level data from Sierra Leone and he found that nutrient intake has increased the productivity of agricultural labor. Deolalikar (1988) found practically the same results in a sample from the rural south of India. He found that the average daily calorie intake and the weight-for-height lead to improve the agricultural production's growth.

To conclude the literature review, the theory is in favor of a relationship between foreign direct investment and food security, but according to the empirical analysis, there is a lack of evidence on the way FDI may influence food security, in particular at disaggregated level.

3. Data and Methodology

3.1. Data

This work is based on an unbalanced panel of 55 developing countries (see Table A1 in the appendix) over the period 1995-2009. Tables A2 and Table A3 in the Appendix report the definitions and the descriptive statistics. Most of the data were extracted from the World Development Indicators database of the World Bank. Other data are collected from UNCTAD, FAOSTAT, Polity IV and national sources.

First of all, a correlation analysis is performed between all variables (Table A4 in the Appendix). We observe that the correlation is low between variables, but it is high between the values of agricultural production, capital stock and labor force in agriculture and the arable land. This high correlation reflects the combination between these variables to achieve the production process.

Different measures of food security were proposed by FAO. The most known one is the per capita per day supply of calories. According to the FAO, this indicator referred to the total amount of food available per day for human consumption divided by the total of population during the reference period. This indicator is used in some empirical works to measure the nutritional status of individuals and to present the food availability, but the literature reveals that this indicator has several weaknesses due to the low responsiveness to shocks. For example, the decrease of income leads poor people to switch from high value calorie sources to low ones. Consequently, the food expenditure decreases but not the calorie consumption (Jensen and Miller 2010; Headey and Ecker 2012). The calorie intake is used in some works like Mihalache-O'Keef and Li (2011). The same authors have used also the protein intake as an indicator to compare results with the calorie intake's results. There is no utility to use these two indicators because the calories are a measure of the energy provided by proteins, fats and some others nutrients³. Otherwise, the calorie intake includes more information about the nutritional status than protein intake. Additionally, the calories alone are not enough to describe the food availability. To deal with the weakness of calories we have chosen the most important indicators from FAOSTAT, which are linked to the agricultural production and food supply. First, we have chosen the average dietary energy supply adequacy as an indicator of adequacy of the food supply in terms of calories. It is calculated as a percentage of the average dietary energy requirement. Second, the average value of food production per capita provides a measure of the economic size of the food production sector and the food availability for everyone in a country. These two indicators describe the first pillar of food security, food availability, and they are calculated on three years averages by FAO to correct errors in the measure. Third, we consider the access to improved water sources, which is the percentage of the population with an access to an adequate amount of water. Finally, the access to improved sanitation facilities is taken into account; it is expressed by the percentage

of the population with at least adequate access to good sanitation. This choice is justified by the fact that people need to utilize food properly to avoid health issues, for example intestinal parasites from unsanitary water (Tweeten, 1999). In addition, the access to water is essential for agriculture and food, and the improved sanitation reduces the pollution caused by human waste. Taken separately, the four indicators mentioned provide a fragmented and sometimes contradictory picture: they tell little about net progress towards reaching the overall goal. A composite index can assemble the information provided by individual measures.

Our analysis will also shed light on the importance of sectoral FDI inflows presented by (i) FDI in agriculture, hunting, forestry and fishing (ii) FDI in mining, quarrying and oil and gas extraction⁴, (iii) FDI in the secondary sector and⁵ (iv) FDI in the tertiary sector in addition to other factors such as economic development, government expenditure, agricultural production, trade openness, political regime.

The economic development is measured by GDP per capita: we expect a positive effect from this variable (Wimberley and Bello, 1992; Jenkins and Scanlan, 2001; Mihalache-O'Keef and Li, 2011). The government expenditure is measured by the annual growth of the general government final consumption expenditure. This variable is to control the government's role to address food security concerns and a positive impact is expected.

To test for the impact of trade openness, we use the sum of exports and imports of goods and services as a share of GDP. We attend to find a positive impact from trade openness on food security because imports provide the needed complement if the domestic food production is not sufficient (Diaz-Bonilla et al., 2000; 2003). In addition, the exports generate foreign exchange revenues used to import food.

The political regime is measured by POLITY2 indicator. This indicator is a modified version of POLITY which varies between 10 (highly democratic) and -10 (very autocratic)⁶. In fact, democratic governments are more likely to provide nutrition to their people than the less

democratic or autocratic countries (Sen, 1999; Mihalache-O'Keef and Li, 2011). We finally consider the value of agricultural production. The main determinants are capital, labor and land. They are measured respectively by the stock of capital in agriculture, the labor force in agriculture and the area of arable land. We have added the rural population growth as a measure of the population structure to examine if the rural population growth improves the agricultural production. We expect a positive effect on agricultural production as found by Binswanger et al, (1987) that an increase in population density leads to agricultural growth.

3.2. Methodology

First, we build a composite indicator for food security. Then we specify the equation of macroeconomic determinant of food security and the equation of agricultural production.

3.2.1. Construction of a composite index for food security

In this paper, four indicators of food security are used to build a composite indicator using the principal component analysis (PCA). The indicators are the average dietary energy supply adequacy, the average value of food production per capita, access to improved water sources and access to improved sanitation facilities. The objective of the PCA method is to reduce the number of indicators by the transformation of a set of correlated variables into a new set of uncorrelated variables entitled principal components⁷. The method consists in the capture of the maximum variance between variables, which gives for every principal component a linear transformation as follow:

$$PC^p = \delta_1^p X_1^p + \delta_2^p X_2^p + \dots + \delta_n^p X_n^p \quad (1)$$

With, PC^p is the P th principal component. X_n^p is the value of the n th variable for the P th component and δ_n^p is the regression coefficient for the n th variable of the P th component and it is the eigenvector of the covariance matrix between the variables.

Return to our data, there is a high correlation between our four indicators (see Table 2), so the PCA method can be used here. The literature of PCA method reveals many extensions to this method. One of the extensions is the correction of outlying in the data. We believe that the four indicators are different between DCs and to avoid this problem we followed the methodology of Verardi (2009) to do a robust analysis of the principal component.

Table 2: Correlation test between the food security indicators

	(1)	(2)	(3)	(4)
(1) average dietary energy supply adequacy	1			
(2) average value of food production per capita	0.4373	1		
(3) access to improved water sources	0.6071	0.4701	1	
(4) access to improved sanitation facilities	0.5873	0.5169	0.8673	1

Source: authors' calculations

The number of principal components is chosen based on two criteria. It is chosen according to (1) the cumulative variance of which at least 60 to 70% of the total information is explained and (2) the Kaiser criterion (Kaiser, 1960) which is used to keep the principal components that have an eigenvalue more than one.

Table 3: Total variance of principal components

Component	Eigenvalue	Proportion of information	Cumulative of information
PC1	2.61424	65.36%	65.36 %
PC2	0.748148	18.70%	84.06 %
PC3	0.537943	13.45%	97.51%
PC4	0.0996734	2.49%	100%

Source: authors' calculations

The results in Table 3 show that the choice of the first component (PC1) is most appropriate because 65% of the total information is accounted by it. In addition, its eigenvalue is greater than one.

Table 4: the eigenvectors of each component.

	PC1	PC2	PC3	PC3
average dietary energy supply adequacy	0.3766	0.9037	-0.1968	-0.0524
average value of food production per capita	0.4983	-0.0130	0.8532	0.1536
access to improved water sources	0.5453	-0.2853	-0.4405	0.6535
access to improved sanitation facilities	0.5589	-0.3190	-0.1982	-0.7393

Source: authors' calculations

Since we have choose the first component, then we choose the first eigenvector from Table 4. For a given year, multiplying each indicator by the square of the coefficient of the first eigenvector that corresponds to it, leads to a score. In turn, this score is our composite indicator and can be decomposed as follow:

$$\begin{aligned} \text{FSI} = & 0.137 \times \text{average dietary energy supply adequacy} \\ & + 0.229 \times \text{average value of food production per capita} \\ & + 0.303 \times \text{access to improved water sources} \\ & + 0.331 \times \text{access to improved sanitation facilities} \end{aligned}$$

3.2.2. Estimated model

We estimated two equations. However, the specific effect on the estimation can be fixed or random. To avoid this problem, we used the specification of Hausman (1978). The Hausman test's null hypothesis is that the preferred model is random effects and the alternative is fixed effects, and the result suggested the fixed effects model. To find a way around the heteroscedasticity and autocorrelation, we follow Mihalache-O'Keef and Li (2011) and we use Huber-White robust standard error, clustered over countries.

As an initial step, we test the relationship between sectoral FDI and food security (equation 2). We estimate a fixed effect model as follow:

$$\begin{aligned} \text{FSI}_{it} = & \alpha_0 + \alpha_1 \text{FDI}_{agri}_{it} + \alpha_2 \text{FDI}_{minig}_{it} \\ & + \alpha_3 \text{FDI}_{secondary}_{it} + \alpha_4 \text{FDI}_{tertiary}_{it} \\ & + \alpha_5 \ln_prodagr_{it} + \alpha_6 \text{Openness}_{it} \\ & + \alpha_7 \text{Ln_GDP_percapita}_{it} + \alpha_8 \text{Gov_exp}_{it} + \alpha_9 \text{polity2}_{it} \\ & + \gamma_i \text{FE}_i + \delta_t \text{FE}_t + \varepsilon_{it} \end{aligned} \quad (2)$$

Where i and t refer to countries and years, respectively; α_k are the estimated coefficients and ε_{it} is the error term. FDI_{agri} , FDI_{mining} , $\text{FDI}_{secondary}$, $\text{FDI}_{tertiary}$ represent

agricultural, mining, secondary and tertiary foreign direct investments respectively, $\ln_prodagr$ is the logarithm of agricultural production value, $Openness$ is the trade openness, $\ln_GDP_percapita$ is the logarithm of GDP per capita, Gov_exp is the annual percentage growth of general government final consumption expenditure and $Polity2$ is the political regime. FE_i are the country fixed effects and FE_t represent time fixed effects.

In a second step, we consider the determinant of the agricultural production as a fixed effect model. Empirically, the agricultural production is widely treated by the estimation of Cobb-Douglas production function or a translog production function. Nevertheless, the purpose of our analysis has no interest to the partial elasticities of inputs variables or the exam of the inputs substitution, so a simple agricultural production can be used in our case. Further, the Cobb-Douglas agricultural production function (Cobb and Douglas, 1928) is largely used in the economic literature without a theoretical framework. Some authors have added other factors to explain the agricultural production. e.g. to investigate the effects of infrastructure, investments in agricultural research and education (Antle, 1983), to test the effects of transportation infrastructure and electricity on the agricultural production (Felloni et al., 2001), to examine the effect of governance quality (Lio and Liu, 2008) and to check the impact of climatic change on the agricultural production (Barrios et al., 2008).

The equation of the agricultural production is given by:

$$\begin{aligned} \ln_prodagr_{it} = & \beta_0 + \beta_1 \ln_K_{it} + \beta_2 \ln_L_{it} + \beta_3 \ln_land_{it} & (3) \\ & + \beta_4 FDI_agri_{it} + \beta_5 FDI_mining_{it} \\ & + \beta_6 FDI_secondary_{it} + \beta_7 FDI_tertiary_{it} \\ & + \beta_8 FSI_{it} + \beta_9 Rural_pop_{it} \\ & + \gamma_i FE_i + \delta_t FE_t + \theta_{it} \end{aligned}$$

Where β_t are the estimated coefficients and θ_{it} is the error term. \ln_K , \ln_L and \ln_{land} are the main inputs of the agricultural production and they represent the capital stock, labor force in agriculture and arable land respectively. FSI and $Rural_{pop}$ are our food security index and the rural population growth respectively. As shown in the equation, we test for the impact of the sectoral FDI on the agricultural production. We integrate the composite indicator as a measure of individual energy intake and food availability because the lack of a person's energy nutrition with access to food, water and good sanitation reduces its ability to produce, which means that more workers are malnourished, less labor productivity is provided for agricultural production.

In a third step, we determine whether there is a relationship among variables between equations (2) and (3). Therefore, we tested for the endogeneity between the food security composite indicator and the agricultural production with the Durbin-Wu-Hausman endogeneity test⁸. The results suggest that endogeneity is significant. Thus, we estimated a simultaneous equations model with fixed effects (by year and by country) by using the three-least squares (3SLS) method. The use of 3SLS method is validated by the Breusch-Pagan Lagrange Multiplier Diagonal Covariance Matrix Test under the null hypothesis that ordinary least square (OLS) method is consistent⁹.

4. Estimation results' of the simultaneous equations models

Table 5 reports the estimated results of simultaneous equations using 3SLS. First, we estimate the system three times. In Model 1, GDP per capita, government consumption and political regime are dropped from the food security's equation, and rural population growth is dropped from the production equation. In Model 2, we added the GDP per capita and finally in model 3 we include the rest of variables. All models contain time and country fixed effects.

Table 5: estimation's results of simultaneous equations:

	Model 1		Model 2		Model 3	
	FSI	Ln_prodagr	FSI	Ln_prodagr	FSI	Ln_prodagr
FDI_agr	0.156*** (3.41)	-0.0438 (-0.867)	0.123*** (2.75)	0.0141 (0.53)	0.155*** (3.24)	-0.00732 (-0.25)
FDI_min	-0.0199* (-1.68)	0.00712 (0.958)	-0.0148 (-1.28)	0.00164 (0.293)	-0.00865 (-0.738)	0.000341 (.0613)
FDI_secondary	-0.0221* (-1.94)	0.0186*** (3.05)	-0.0221** (-1.99)	0.0202*** (3.94)	-0.0216* (-1.89)	0.0174*** (3.25)
FDI_tertiaryper	-0.0054 (-1.1)	-0.00128 (-.378)	-0.00845* (-1.75)	-0.00459** (-2.12)	-0.0101** (-2.09)	-0.00389* (-1.82)
Ln_prodagr	1.29*** (7.28)		1.35*** (7.89)		1.2*** (6.68)	
Openness	0.00136 (1.46)		0.00147** (2.09)		0.0018** (2.49)	
Ln_GDP_percapita			0.535*** (5.04)		0.46*** (4.57)	
Gov_exp_					0.00165** (2.19)	
Polity2					0.000544 (0.162)	
FSI		0.424** (2.42)		0.181*** (2.63)		0.226*** (3.36)
Ln_K		0.191 (.964)		0.357*** (3.66)		0.293*** (3.04)
Ln_L		0.155*** (3.42)		0.256*** (5.68)		0.277*** (6.12)
Ln_Land		0.0809 (1.01)		0.133*** (2.93)		0.121*** (2.66)
Rural_pop						0.0117* (1.75)
Constant	-7.42*** (-3.09)	5.53*** (4.83)	-12*** (-5.02)	5.24*** (7.02)	-9.36*** (-3.79)	5.34*** (7.23)
Observation	353		353		332	
Countries	55		55		51	
Overall R ²	0.8509		0.8512		0.7634	
Overall R-adjusted	0.8106		0.8106		0.6965	
Lagrange Multiplier Test	169.08683***		284.52870***		159.06136***	

Note: t-statistics in parentheses. ***, **, * Significant at the 1%, 5 % and 10 % respectively.

Our first finding is that our composite indicator and agricultural production have positive and significant coefficients. Beginning by Model 1, we found the composite food security indicator and labor force in agricultural sector have positive and significant coefficients. However, only the FDI in secondary sector affects agricultural production with a positive and

significant coefficient. This means that there is a spillover effect from manufacturing FDI on agricultural production, and therefore on food security. In the food security equation, only tertiary FDI and trade openness are not significant. FDI in agricultural and agricultural production affect positively the food security, however, FDI in mining and in secondary sectors have a negative impact significant at the level of 10%.

After the addition of GDP per capita in Model 2, the trade openness becomes significant with the expected positive sign. FDI in tertiary sector also becomes significant but with negative sign. FDI in mining is no more a statistically significant factor. In the agricultural production's equation, the negative sign of FDI in tertiary sector and the positive signs of capital and arable land become significant.

Finally, in Model 3 we added the rest of variables and we have found that government expenditure is an important determinant to explain the improvement of food security and the rural population growth to explain the increase on agricultural production. Other variables have the expected signs. Finally, the coefficient associated to the political regime is positive but not significant.

In terms of growth, we interpret the increase of one independent variable while all other variable in the model are held constant. A 1% increase in the share of secondary FDI to GDP leads to 1.74% increase in agricultural production, while 1% in tertiary FDI declines the agricultural production about 0.4%. A unit increase in food security indicator is associated with an average of 22% increase in agricultural production. At the same time, a 1% increase in the agricultural production and agricultural FDI, respectively, is associated with 0.155 and 0.012 units increase in the food security's composite indicator. However, an increase of 1% in secondary and tertiary FDI is followed by a decrease about 0.022 and 0.01 units, respectively.

In sum, our results give importance to agricultural FDI, agricultural production, trade openness and economic development in improving food availability and food utilization. In

addition, our results highlight the adverse effects of FDI in secondary and tertiary sectors. These effects are lower comparing to the positive one from FDI in agriculture. This negative impact is a result of industrial development's pollution that affects environment and access to water, and thus the food availability and utilization. However, the positive effect from secondary FDI provides employment and spillover effect in term of technology transfer and know-how that are useful in improving agricultural production, the access to water and improved sanitation.

5. Conclusion

In recent decades, food security has taken more attention from policy makers in the developing world and FDI inflows became one of the main factors of development and growth in these countries. FDI inflows are expected to have some effects in DCs, specifically in food security context.

The sectoral FDI inflows' effects can shed new light on how the transmission takes place. In this paper, we treat the macroeconomic dimension of food security by the use of an unbalanced panel data of 55 developing countries for the period 1995-2009. The review of literature shows that the relation between FDI and food security is being discussed empirically as a direct relationship with the neglect of agriculture's role. Our work proposes an extension: we take into account the indirect effect through the agricultural production.

As shown in this paper, empirical research on the contribution of FDI in improving food security remains ambiguous and needs more work on it. Following a number of studies showing that FDI inflows affect food security, we found that the direct effects come from FDI in agriculture and the indirect effects come from FDI spillovers in the other economic sectors. Our results have confirmed that FDI improves directly food availability and utilization by increasing food supplies, and access to water and improved sanitation. Food availability has a

direct link with the agricultural production. If the DCs increase their agricultural production, the calorie supply and food production rise. This is an important step to decrease food prices. In addition, when the agricultural production increases, sellers will expand their radius of sale, which may be beneficial for people in less favorable areas of the nation.

Agricultural FDI contributes to the improvement of food security thanks to the increase in agricultural production, which is the main source of food. The benefits for agriculture due to agricultural FDI are in terms of know-how, R&D and technology transfer. The secondary FDI creates employment, increases the individual's income, and therefore improves access to food. In contrast, negative spillovers from tertiary FDI on agricultural production and food security could be explained by the argument that FDI creates jobs in urban areas with higher wages which encourages workers in rural areas to migrate. Thus, the increase in demand in urban areas will increase the price paid by migrants and therefore reduces their access to food (Todaro, 1969; Evans and Timberlake, 1980; Mihalache-O'Keef and Li, 2011). Another negative effect from secondary on food availability and utilization can be explained by the pollution produced during manufacturing process.

Our findings have important implications. They give importance to FDI in increasing agricultural production and thus improving food security. However, we should not neglect that the host country must have the ability to absorb technology transfer and know-how. The discussion of the appropriate local policies needed for improving food security has to be deepened.

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Appendix

Table A1: List of countries

1	Albania	12	Colombia	23	India	34	Mauritius	45	Russian Federation
2	Argentina	13	Costa Rica	24	Indonesia	35	Mexico	46	Saudi Arabia
3	Armenia	14	Croatia	25	Kazakhstan	36	Moldova	47	Thailand
4	Bangladesh	15	Ecuador	26	Kyrgyz Republic	37	Morocco	48	Tunisia
5	Bolivia	16	Egypt	27	Lao PDR	38	Mozambique	49	Turkey
6	Bosnia and Herzegovina	17	El Salvador	28	Latvia	39	Nicaragua	50	Ukraine
7	Brazil	18	Ethiopia	29	Lithuania	40	Pakistan	51	Tanzania
8	Bulgaria	19	Fiji	30	Macedonia	41	Panama	52	Uruguay
9	Cambodia	20	Guyana	31	Madagascar	42	Paraguay	53	Vanuatu
10	Chile	21	Honduras	32	Malawi	43	Peru	54	Zambia
11	China	22	Hungary	33	Malaysia	44	Philippines	55	Romania

Table A2: Variables definitions

Variable	Definition	Source
average dietary energy supply adequacy	the dietary energy supply as a percentage of the average dietary energy requirement in each country	FAOSTAT
average value of food production per capita	The total value of annual food production, in International Dollars divided by the total population	
access to improved water sources	The percentage of the population with access to an improved water source	
access to improved sanitation facilities	the percentage of the population with access to improved sanitation facilities	
FSI	The composite indicator of food security	Authors' calculation
FDI_agri	Agriculture, hunting, forestry and fishing FDI inflows as share of GDP (%)	National source and UNCTAD
FDI_mining	Mining, quarrying, oil and gas FDI inflows as share of GDP (%)	
FDI_secondary	Secondary FDI inflows as share of GDP (%)	
FDI_tertiary	Tertiary FDI inflows as share of GDP (%)	
Openness	The sum of exports and imports of goods and services as a share of GDP	World development indicator (WDI)
Ln_GDP_percapita	The logarithm GDP per capita million at constant 2000 prices	WDI
Gov_exp	The annual growth of the general government final consumption expenditure	WDI
polity2	Political regime	Polity IV
Ln_prodagr	The logarithm of agricultural production, measured by the value of agricultural production in millions of dollars at constant 2005 prices	FAOSTAT
Ln_K	The logarithm of capital stock in agriculture millions at constant 2005 price	FAOSTAT
Ln_L	The logarithm of labor force in agriculture in thousand people	UNCTAD
Ln_land	The Logarithm of arable land in hectares	WDI
Rural_pop	The annual growth of the rural population	WDI

Table A3: Summary statistics

Variables	Observation	Mean	Std. Dev.	Min	Max
average dietary energy supply adequacy	930	114.972	14.2059	72	163
average value of food production per capita	930	275.6398	156.8022	44	1006
access to improved water sources	914	84.52024	16.22708	20	100
access to improved sanitation facilities	920	69.48891	26.29902	3	100
FSI	892	9.85592	2.03677	3.15264	14.41675
FDI_agri	492	0.1196823	0.3424275	-.646552	2.846407
FDI_mining	445	0.5497982	1.31659	-1.55195	15.9483
FDI_secondary	675	0.8564049	0.9890689	-1.784948	11.48758
FDI_tertiary	688	2.08507	2.750672	-2.125577	32.1708
Ln_prodagr	945	15.08674	1.807903	9.421168	20.07799
Openness	937	80.79348	36.9255	14.93285	220.4068
Ln_GDP_percapita	937	7.363384	1.082748	4.735071	9.875359
Gov_exp	850	4.481702	9.895243	-57.81461	83.22173
polity2	900	4.534444	5.716702	-10	10
Ln_K	819	9.330377	1.78528	3.67097	13.23481
Ln_L	945	7.142199	2.211494	0	13.13469
Ln_land	945	14.7218	2.028449	7.600903	18.90752
rural_pop	945	0.3604173	1.242269	-4.423409	3.482749

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Table A4: Correlation test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) FSI	1.0000												
(2) FDI_agri	-0.0285	1.0000											
(3) FDI_mining	-0.0884	-0.0486	1.0000										
(4) FDI_secondary	0.0193	0.1570	-0.1177	1.0000									
(5) FDI_tertiary	0.1484	0.0437	0.0297	0.3328	1.0000								
(6) Ln_prodiagr	0.0915	-0.1994	-0.0502	0.0279	-0.2568	1.0000							
(7) Openness	0.2488	0.1706	-0.1537	0.3110	0.2641	-0.4075	1.0000						
(8) Ln_GDP_percapita	0.8583	-0.0364	-0.0858	0.0130	0.1426	0.0431	0.1481	1.0000					
(9) Gov_exp	-0.1765	0.1274	-0.0636	0.1602	0.0341	0.0757	-0.0051	-0.1925	1.0000				
(10) polity2	0.2577	0.1053	-0.0635	-0.0219	0.1648	-0.2514	0.1720	0.3088	-0.1578	1.0000			
(11) Ln_K	0.0248	-0.1737	0.0412	-0.0886	-0.2566	0.9357	-0.5372	-0.0095	0.0829	-0.2786	1.0000		
(12) Ln_L	-0.4190	-0.1213	0.0017	-0.0128	-0.2902	0.6744	-0.5208	-0.4237	0.1344	-0.4072	0.6755	1.0000	
(13) Ln_land	-0.1076	-0.1937	-0.0060	0.0033	-0.1924	0.8647	-0.3721	-0.1518	0.0898	-0.3467	0.8771	0.6391	1.0000
(14) rural_pop	-0.6391	0.0411	0.0653	-0.0630	-0.2492	-0.1925	-0.0944	-0.5829	0.1014	-0.1649	-0.1513	0.1663	-0.0902

Footnotes

1- Liu (2014) shows that agricultural investments can generate a wide range of developmental benefits but these benefits are not expected to arise automatically. The case studies suggest that the disadvantages of large-scale land acquisitions may outweigh the few benefits to the local community according to the local rights and the quality of governance in particular.

2- For more information about the various indices and their limits, see De Haen et al. (2011) and Masset (2011).

3- At the nutritional level, one grams of protein provide four calories; one grams of carbohydrate also provides four calories, and one grams of fats provides nine calories (FAO, 2003).

4- In this paper, we regress the agricultural production value (not the value added of primary sector). So for a more accurate result, we use the agricultural FDI and mining FDI separately.

5- The estimation's result can be more specific with data for FDI in agri-food industry, but data isn't available for all countries and it has low number of observation so we used the aggregated FDI in secondary sector.

6- See « Polity IV Users' Manual » viewed at : <http://www.systemicpeace.org/inscr/p4manualv2012.pdf>

7- The use of PCA technic in food security indicators was suggested by Conforti (2013) from FAO STATISTIC DIVISION at the 23rd African Commission on Agricultural Statistics in Morocco.

8- The test is explained by Li and Liu (2005) where they test the endogeneity between FDI and economic growth.

9- We perform this test by the Stata command of Shehata (2012).