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Do FDI inflows and energy price affect the food import dependency in developing countries? Evidence from panel VAR Models

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Abstract:

The ability of a country to import food depends on several factors. Considering food security as a priority issue, we focus in this paper on the FDI inflows and the energy price as determinants of food import dependency. Indeed, on the one hand FDI as a substitute/complement to trade flows could impact the depending nation. On the other hand, energy price affects production and transport costs, thereby impacting international trade in food productions. To investigate this relationship, we follow the methodology of Love and Zicchino (2006) by estimating a panel vector autoregressive model (PVAR) of 40 developing countries for the period between 1990 and 2012. The panel is split into two sub-samples. We found that FDI inflows explain food import dependency in low and lower middle-income countries and the energy price proxy influences food import dependency in upper-middle income countries. The impulse response functions' results are close to those from panel VAR, where an increase in FDI inflows or in energy price leads to more food import dependency in low and lower-middle income countries or in upper-middle income countries, respectively.

Keywords: FDI, energy price, food security, Panel VAR, developing countries, food import dependency

JEL classifications: F1, Q4, O1

Les flux entrants d'IDE et le prix d'énergie affectent-ils la dépendance en importations alimentaires des pays en développement ? Analyse à partir d'un modèle VAR en données de panel

Résumé :

La capacité d'un pays à importer des produits alimentaires dépend de plusieurs facteurs. Considérant la sécurité alimentaire comme une question prioritaire, nous nous concentrons dans cet article sur les flux d'IDE et le prix de l'énergie comme deux facteurs déterminants de la dépendance des importations alimentaires. En effet, l'IDE est substituable ou complémentaire au commerce international et donc il peut avoir une relation de dépendance en termes d'importations alimentaires. D'autre part, le prix de l'énergie affecte la production et les coûts de transport, affectant ainsi le commerce international des produits alimentaires. Pour étudier cette relation, nous avons suivi la méthodologie de Love et Zicchino (2006) par l'estimation d'un modèle vectoriel autorégressif en données de panel (PVAR) pour 40 pays en développement sur la période 1990-2012. L'échantillon est divisé en deux sous-groupes de pays. Nous avons constaté que les flux entrants d'IDE influencent la dépendance alimentaire dans les pays à revenus faibles et moyens alors qu'une baisse du prix de l'énergie (approximé par l'indice de prix à la consommation) cause la dépendance dans les pays à revenus moyens-supérieurs. Les fonctions de réponse estimées confirment ces résultats.

Mots-clés : IDE, prix de l'énergie, sécurité alimentaire, Panel-VAR, pays en développement, dépendance en importations alimentaires

Classification JEL : F1, Q4, O1

Do FDI inflows and energy price affect the food import dependency in developing countries? Evidence from panel VAR Models

1. Introduction

International trade plays an important role in economic growth and development. However, it can become problematic if it leads to dependency on imports (Rakotoarisoa *et al.* 2011) and more problematic if this dependency affects food security. A growth driven by exports improves balance of payments and generates foreign exchange for food imports (Breisinger *et al.* 2012). Indeed, after the international food crisis of 2007-2008 caused by higher agricultural and food prices, the vulnerability's issue of developing countries (DCs) to the volatility of international markets has risen to the surface of the economic debates. In fact, it appeared that this increase has affected the ability of countries to import, which makes several questions about the factors that may boost or reduce dependency on food imports.

Improving food availability through imports can be a solution to the decline in local food production (Diaz-Bonilla *et al.* 2000), but developing countries do not have the same imports' capabilities and preferences on imported products. So the degree of dependency is different between countries; for example, many Middle East countries spend a large part of their foreign exchange earnings on food imports (Hoering 2013).

DCs need resort to imports because it appears the only solution at short-run to recover the food gap between local demand and local production and at the end to improve food availability. The recourse to the international market is relatively expensive for those countries because they pay their imports in foreign currency. However, it is necessary to differentiate between national food security and food security for the poorest population because enough food availability doesn't mean that the poorest have access to food. So when we speak about food import dependency, we are interested with the national food insecurity. In fact, upset food insecurity for the poorest population requires several factors such as better distribution of national wealth, which improves the infrastructure, income, and subsequently facilitates food distribution and finally access to food (Hoering 2013).

Nowadays, the economic environment is characterized by a growth in foreign direct investment (FDI) inflows and outflows to/from DCs and volatility in prices of agricultural, food and energy products in international markets. So, our first line of researches has examined the relationship between FDI and food import dependency. Indeed, the major

interest of DCs to improve their ability to import food in case of higher food prices is the increase of local food demand. In brief, attracting FDI would enhance food and this seems to be an important policy to increase the stock of foreign currency. The theoretical literature on the relationship between FDI and international trade is extremely abundant. The empirical literature is divided between studies that analyze the relationship between trade and FDI outflows, which is usually treated in the case of developed countries, and between trade and FDI inflows in the cases of DCs.

According to the empirical literature, we can distinguish the works, which use time series (Liu *et al.* 2002; Pacheco-López 2005; Wang and Wan 2008) from those using panel data (Liu *et al.* 2001; Tekin 2012). From a methodological point of view, all these works use the same econometric techniques such as cointegration and Granger causality.

However, technological development has made the world more dependent on energy use and thus more sensitive to higher energy prices via the high demand. Also, high-yield varieties of food require more energy use and intensive fertilizer irrigation and in the final this raises production's cost and prices (Steinfeld *et al.* 2006; Kamara *et al.* 2009). Thus, our second line of researches examines the relationship between energy price and food import dependency. The literature is increasingly suggesting that energy prices affect the trade flows inter-country, more specifically between importer and exporter energy countries. Another transmission channel can be mentioned here, the growth of the biofuel industry, which affects the availability of cereals in the international market and thus may lead to higher food import prices.

The third line of researches is the relationship between FDI and energy price. In previous works, it appears that FDI don't affect the energy demand in DCs (Sadorsky 2010). In another work, Mielnik and Goldemberg (2002) noticed that more FDI inflow increase, the energy intensity decreases. This is a good thing for energy net importer countries that FDI contribute to weaken the local energy demand. But other works have demonstrated the opposite. For example, according to Tang (2009), Malaysia is an energy dependent country where FDI inflows are positively related to electricity consumption and this made the energy importer countries more vulnerable to energy price volatility.

However, our research focuses on the first relationship mentioned above, because our objective is to investigate from the existing economic literature the transmission channels by which the food import dependency is affected and to answer empirically the following

questions: How FDI influence the dependency on food imports in DCs? What role can be played by the energy price in this relationship?

In fact, we are aware of the existence of other channels that may affect the food import dependency. But, according to data availability in our hand, we focus on the major factors which have nowadays influenced the international trade and more specifically the food import dependency.

Despite dependency is an old concept, existing work has not exceeded the descriptive analyzes. Our first contribution is to address the weakness of the existing literature about food import dependency by identifying some important factors, which can influence it. Here, we provide evidence on the existence of links between FDI inflows, energy price and international trade and consequently affecting food security. Our second contribution is the use of panel vector autoregressive (VAR) methodology. This choice is justified by the following criteria and is coherent with the aims of our work. i) The panel VAR methodology is useful in the specification of a model with a limited theoretical background; ii) it has the capacity to address the endogeneity problem between variables; iii) it takes into account the country fixed effects and it allows to register the dynamic effects between variables and present the reaction of one variable to a shock of another variable (Grossmann *et al.* 2014). Finally, this paper distinguishes data by countries' groups (e.g. based on income level). Ours results can provide recommendations on trade and economic policy to be followed by DCs to resist to the food insecurity problem.

The remainder of the paper is organized as follows. In the next section, we propose a state of art of food import dependency according to the countries. Section III gives theoretical and empirical evidences of the links between food import dependency and its determinants. Section IV discusses the data used in this paper. Section V describes the methodology and section VI presents the main results of the dynamic relationship between variables and the impulsion response functions. In the last section, we conclude.

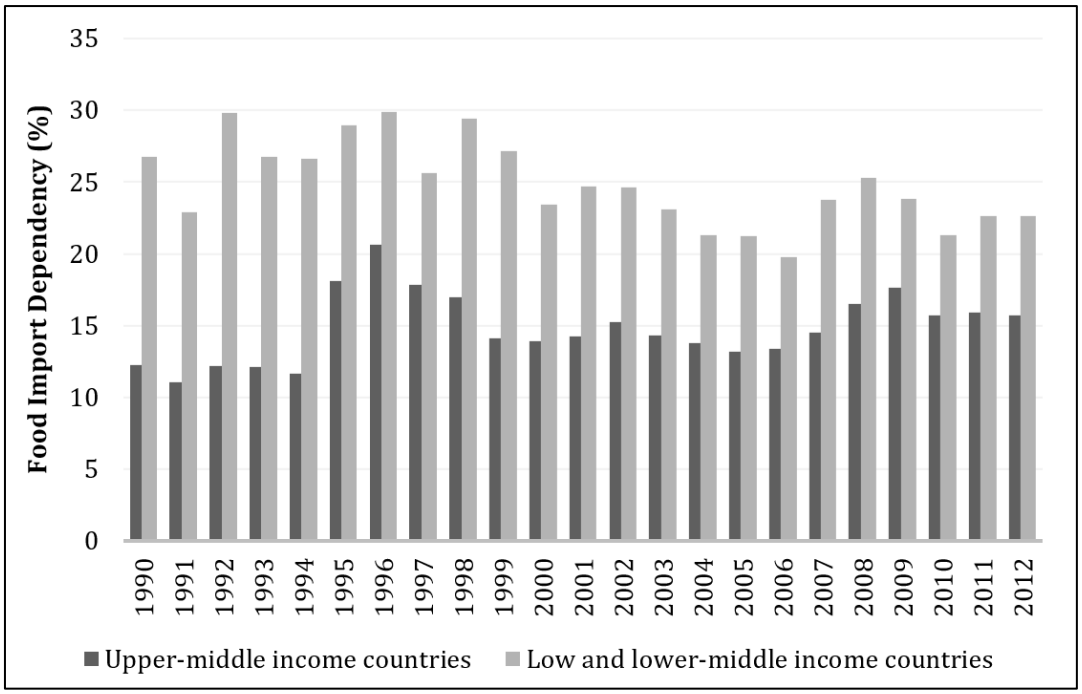
2. Food import dependency: a state of art

There are several ways to present the concept of food security. Diaz-Bonilla *et al.* (2000) have used this concept to analyze the dependency from an international trade point of view. Their objective was the measurement of the ability of countries to finance their food imports out of total export incomes. Many years before, Siamwalla and Valdés (1980) used the same

concept. They used the average of food imports to total export incomes for the period 1965-1977 in DCs. They found only four countries such as Bangladesh, India, Sri Lanka and Egypt with a ratio greater than 15%. Their results confirmed that Asian countries are more dependent than the other regions. By contrast, Farzin (1988) analyzed the food supply situation of some DCs by using a different measurement because his question was how food imports are dependent on local food consumption. Farzin (1988) followed just a descriptive analysis and found that the food aid was a source of dependence in Somalia's economy: about 51.7% of food imports for the period between 1980 and 1984.

A new descriptive data analysis is here proposed and based on 40 developing countries divided in two groups: the group A composed of 23 low and lower middle-income countries, and the group B with 17 upper middle-income countries. For the period 1990 to 2012 in Figure 1, the share of food imports over total merchandise exports displays a dependency ratio not lower than 19% and 11% for low and lower middle-income countries and upper middle-income countries, respectively. For the same period, we can see that the low and lower-middle income countries are more dependent on food imports than the upper middle-income countries.

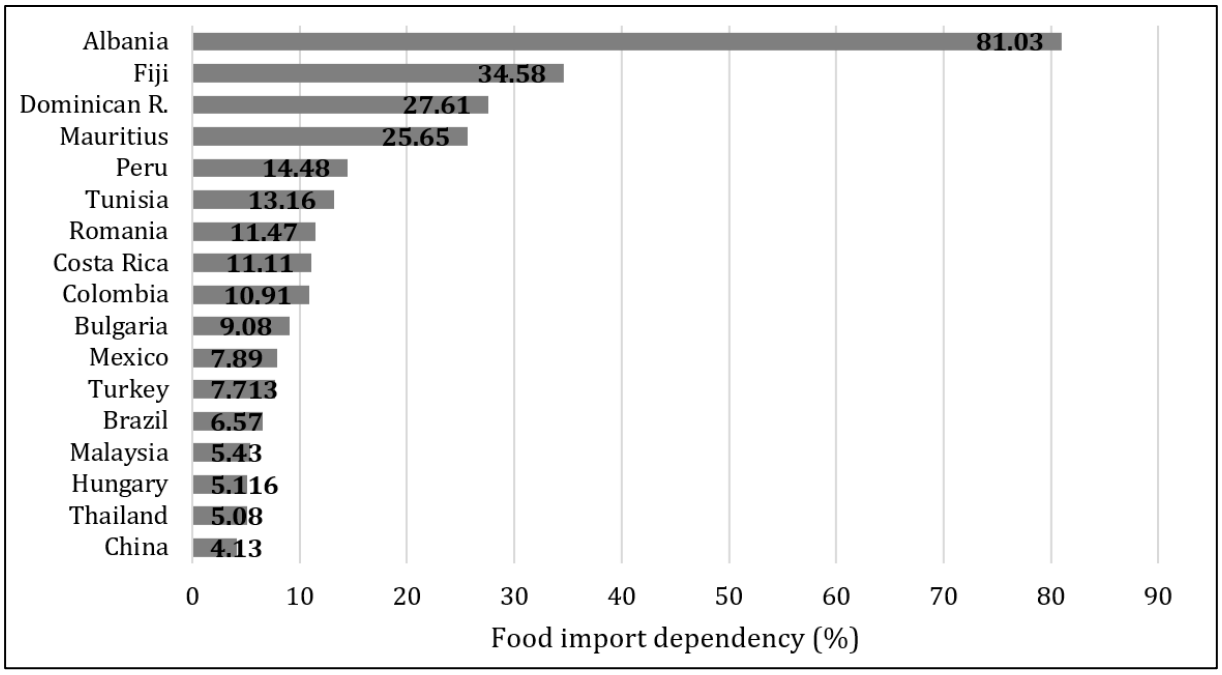
Figure 1: The average of food import dependency in 40 developing countries:



Source: Authors' calculations based on world development indicators (WDI) database

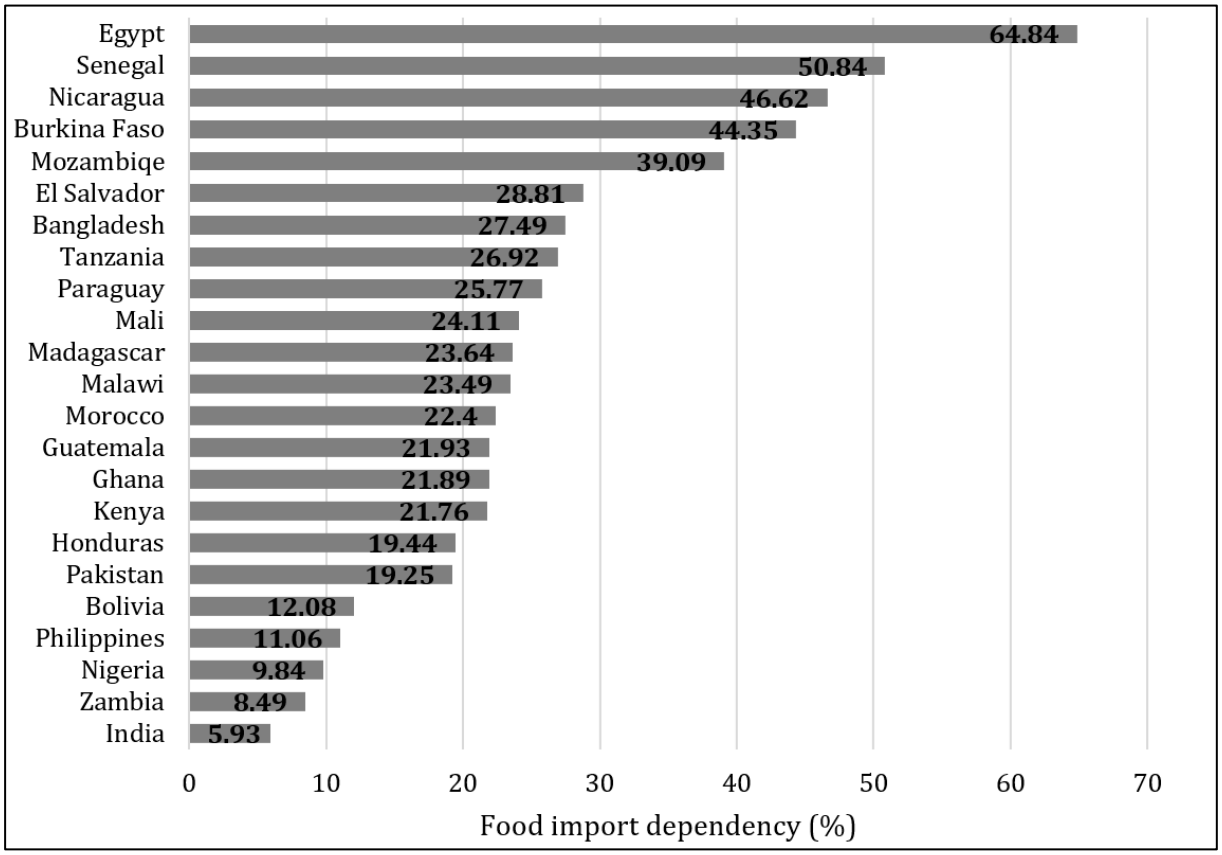
Figures 2 and 3 show the average of food import dependency based on World Bank's income classification (see Table A1 in Appendix). In Figure 2, Albania is very dependent to food imports with a ratio of 81%, which explains in part the deficit of its trade balance. Then, there are three island countries with a ratio higher than 25%. For instance, in the period of 1991-2001, Fiji's food production per capita has declined with a rapid rate of rural-urban migration, which explains the higher import dependency (Sharma 2006). The lowest dependent country to food import is China with a ratio of 4%. This reflects in part the trade policy of China before its accession to the World Trade Organization (WTO) in 2001. It has set a trade policy aimed on exports incentives and limiting imports. This policy has allowed China to have the largest foreign-exchange reserve in the world (Liu *et al.* 2012).

Figure 2: The average of food import dependency for the period 1990-2012 in upper middle income countries



Source: Authors' calculations based on world development indicators (WDI) database

Figure 3: The average of food import dependency for the period 1990-2012 in low and lower middle income countries



Source: Authors' calculations based on world development indicators (WDI) database

Figure 3 confirms the difference in terms of dependency between the two groups of countries. The dependency reached the 20% level in two thirds of the sample. Egypt and India have the highest and the lowest dependency ratio (65% and 6%), respectively. In addition to the weak development, low and lower middle income countries are, with some exception, the most vulnerable to food imports. These developing economies are unable to meet local demand and supply of food. For instance, United Republic of Tanzania imposes export bans on key food items to reduce food exports (Liu *et al.* 2012).

In a report on the search of an alternative to food import dependency for Global Policy Forum, Hoering (2013) considered the dependency as a harmful for DCs. The author justified that by the experience of India and South Africa with the United States, where the last refused in 1960 to send food to India under the program PL480 because of some political reasons and in 2002, it insisted to send Genetically Modified maize (GM-maize) as food aid to South Africa. In fact, many factors can affect the vulnerability of the country beyond people and government like market forces on the loose of sovereignty (Hoering 2013). There is a natural

factor like adverse weather conditions which affects the agricultural crops. Some monetary and financial factors also exist like dollar's depreciation, financial crisis, and a higher speculative demand on food commodity futures markets provoked by the low international stock level. In addition, the energy plays an important role in this issue when the high fuel prices increase transportation cost and food production cost, especially for energy importing countries. Finally, a trade policy such as export bans and price controls on cereals may push producers to reduce their supply to the world market and this increases the international prices (Kamara *et al.* 2009). All these factors are the main determinants of food price rises in international markets and affect the vulnerability of DCs.

3. FDI, energy price and trade: Theoretical and empirical evidences

From a theoretical viewpoint, FDI and trade have a substitution and complementary relationship. In fact, the link between FDI and trade depends in part on the organization of firm activity (Caves 1982) and to unobserved factors like infrastructure, transport costs, high tariffs to imports, depreciation of host countries' currency, the institutional characteristics, the size and income of host countries (Gastanaga *et al.* 1998; Fontagné 1999).

When DCs receive FDI, two scenarios may exist. Firstly, FDI may lead to an increase in local production, and thus an increase in local demand of inputs. Such scenario allows the reduction of imports and enhances exports (Fontagné 1999; Wang and Wan 2008). Here, FDI substitute imports and the host country is beneficiary because a decrease of imports contributes to the improvement of trade balance. Nevertheless, firms do not have the same strategy for delocalization. The second scenario is that FDI may increase the imports of host economy by increasing demand for foreign inputs. As consequence, the trade balance of home country will be improved and that of host country will be deteriorated (Fontagné 1999).

Based on the existing empirical studies, the relationship between FDI and trade is always controversial. In the case of Mexico during the period between 1970 and 2000, Pacheco-López (2005) found firstly a bidirectional causality between FDI and exports explained by the fact that Multinational corporations (MNCs) begin by trading because it is easier and less risky than locate in a foreign country. After acquiring experience and knowledge of the host economy situation, MNCs locate to the host country (Liu *et al.* 2001) to produce and deliver goods locally and overseas, thus increasing exports. Secondly, they found a bidirectional causality between FDI and imports, which means that the attraction of FDI increases imports

of inputs. Liu *et al.* (2002) have argued that FDI and exports have bidirectional causality in China by the use of quarterly data from 1981 to 1997. However, they found unidirectional causality from FDI to imports. In other words, FDI inflows are determinant on the import growth, while imports are not a FDI attractiveness factor. Chinese trade policy encourages the exports more than the imports by adopting an import policy depending on planning import and tariff and non-tariff barriers. But it should be noted that this policy is before the accession of China to the WTO. To complete these country studies, Table 1 provides results of causal relationships between FDI and trade from two recent empirical works focusing on a broader sample of countries.

Table 1: Summary of recent empirical studies on the FDI-Trade nexus

Authors	Sample	Causal relationship	Countries
Ahmed, Cheng and Messinis (2011)	Five countries from Sub-Saharan	Bidirectional causality	Ghana, Kenya and Nigeria
		Unidirectional causality from FDI to Exports	South Africa
		Unidirectional causality from exports to FDI	Zambia
Tekin (2012)	18 African developing countries 1970 and 2009	Bidirectional causality	--
		Unidirectional causality from FDI to Exports	Benin, Chad, Haiti, Mauritania, Niger, Togo and Yemen
		Unidirectional causality from exports to FDI	Haiti, Madagascar, Mauritania, Malawi, Rwanda, Senegal and Zambia

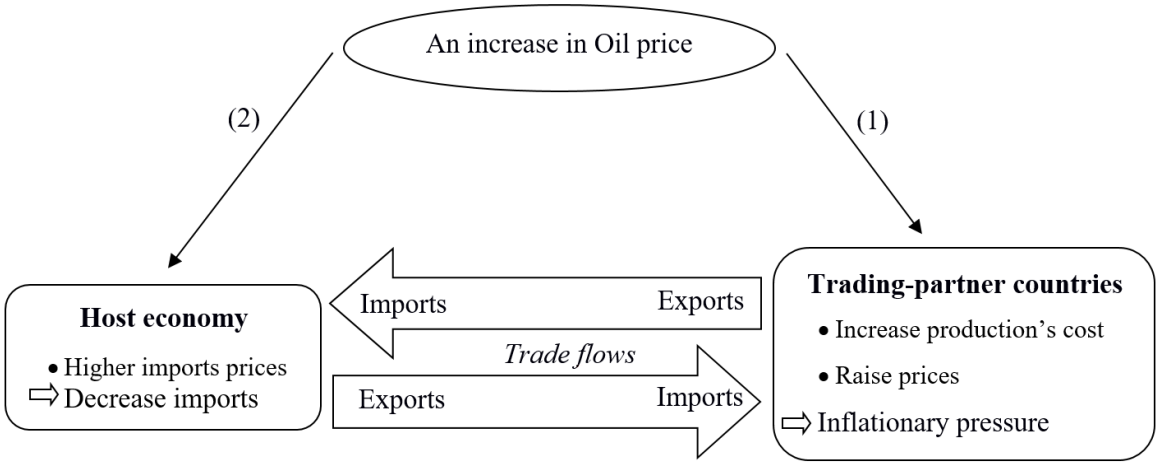
While most empirical studies consider the trade taking the exports and imports separately, Wang and Wan (2008) used the ratio of trade balance expressed by the ratio of imports to exports in value. They examine whether FDI inflows and outflows, real exchange rates, Chinese income and the income of the world are determinants for the trade balance of China over the period 1979 to 2007. Their results showed that FDI outflows have no effect on the trade balance. However, FDI inflows contribute to enhance the exports and thus to improve the trade balance.

To put it in a nutshell, there are many proofs from trade literature that FDI inflows and trade are linked. For this reason, we believe that FDI inflows may influence food security through the trade channel, specifically the food import dependency. But first, let us examine the role of the energy market. In the context of food security, the energy plays an important role in the supply and demand of food. Several studies have shown that instability in the international

energy market affects international trade. The rising price of energy increases the cost of production of goods and services (Turhan *et al.* 2013), and consequently, leads the increase in the prices of tradable commodities. At the same time, the price of energy affects the cost of transport, which promotes trade of cheaper products. In this context, it will be more profitable for an importing country to divert its trade flows to nearest countries and, in this case, gains are benefited by this country because of the minimization of the cost of transport, but a loss of well-being will be supported by it (Bridgman 2008; Kousnetzoff *et al.* 2008; Mirza and Zitouna 2009). However, an increase in energy price can take two forms. An increase caused by an energy supply shock, leading to a decline in international trade flows, and an energy demand shock gives rise to an increase in the international trade flows (Chen and Hsu 2012). Theoretically, the beneficiaries from these two shocks are the energy-exporter countries and the losers are the energy-importer countries.

The literature distinguished a trade and a financial transmission channel by which a rise in energy price affects the current account (Le and Chang 2013). By focusing on the trade channel, we illustrate the transmission channel by which an increase in oil price affects the international trade in Figures 4 and 5.

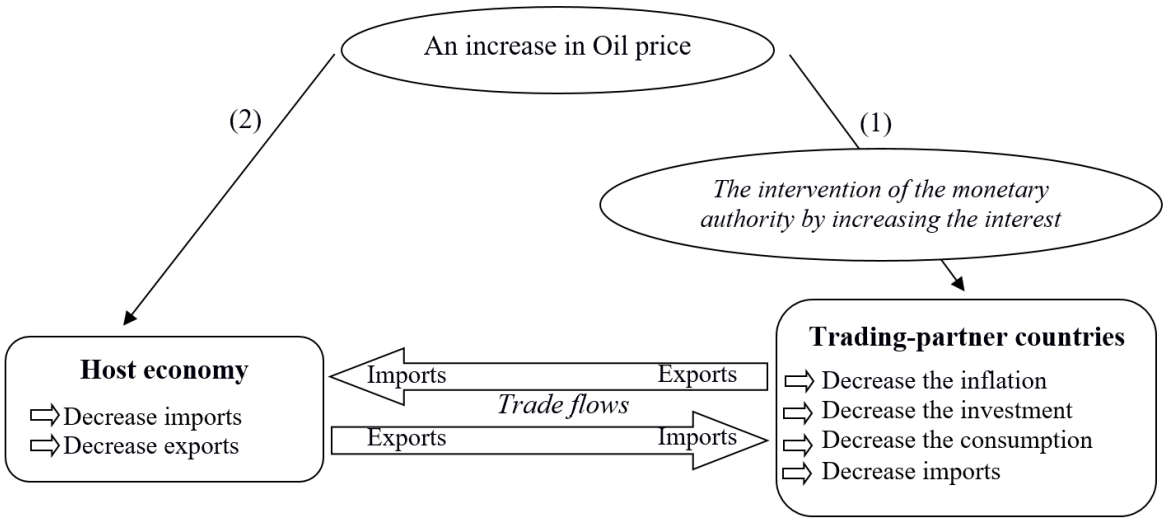
Figure 4: The effects of oil price on international trade before the intervention of the monetary authority in trading-partner countries



We present in Figure 4 a host economy, which trades with several other countries named here trading partner countries. An increase in oil price potentially causes inflationary pressure in several countries, leading to raise the import prices in host economy. As a result, the monetary

authorities in trading partner countries interfere to curb inflation by increasing the interest rate (see Figure 5). This monetary policy leads to reduce the inflation, to decline the investment and consumption, and thus to decrease imports from the host economy (Korhonen and Ledyaeva 2010; Le and Chang 2013).

Figure 5: The effects of oil price on international trade after the intervention of the monetary authority in trading-partner countries



Secondly, the energy price may play a role due to the fact that food has a competitor which affects its supply. The extraction of biofuel from agricultural products has led to a greater demand for agricultural products for non-food purposes and therefore it contributes to increase their price (FAO, 2008). Biofuel is extracted from cereals and presents around 5% of the world cereal production (UN 2009; Elbehri *et al.* 2013). The rise of biofuel production has increased the transmission of energy price volatility into agricultural commodity price variation (Hertel and Beckman 2011). Starting from the idea that high energy price affects the trade flows between countries, we examine if the vulnerability of DCs to import food can be affected.

To resume, the impact of FDI inflows on the food import dependency is related to the nature of the relation between FDI and trade, and the increase in energy price seems to be a brake to international trade. So we expect to find at minimum a response of food import dependency to a shock on FDI inflows and energy price.

4. Data

This paper focuses on the study of 40 developing countries for the period between 1990 and 2012. FDI inflows data as a share of GDP are collected from the World Development Indicators (WDI) database of the World Bank. Dependency on food imports is here measured by the ratio of food imports over total merchandise exports; it is collected from the WDI and we named it FMX:

$$FMX = \frac{Value\ of\ food\ imports}{Value\ of\ total\ merchandise\ exports} \quad (1)$$

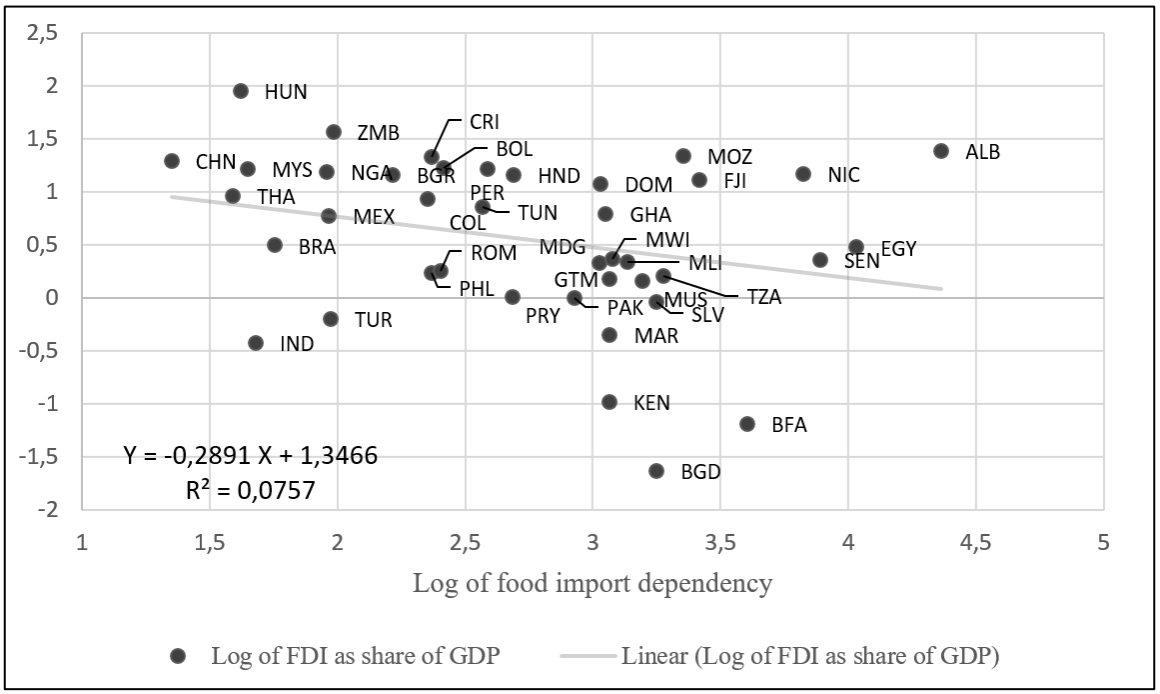
The energy price is proxied here by the consumer price index (CPI). Data comes from WDI database. Our choice is justified, first, by the lack of energy prices data. The second argument is that residents and industries in many countries don't pay the same price of energy because it is subsidized by government. For instance, Mahadevan and Asafu-Adjaye (2007) presented these arguments to justify the use of the consumer price index (CPI) as a proxy of energy prices to examine the relationship between energy consumption, energy price and economic growth in developed and developing countries.1 In addition, the correlation test shows that there is a high correlation of 0.81 between the oil price index in international market and the CPI in our sample, and as illustrated in the previous section, the oil price influences the inflation, so we expect that the CPI reflects the variation in energy prices. All variables are used in the natural logarithm form.2

The relationship between the natural logarithm of FDI inflows and energy price with food import dependency (FMX) can be observed from figures 6 and 7, which represent the averaged variables from 1990 to 2012 (See Table A1 in the appendix for the list of countries). FDI seem to be negatively associated with FMX, but this is not the case for energy price where the correlation seems to be positive. The linear correlation suggests that FDI can be a reducer for the food import dependency, but the energy price can be an amplifier.

[1] Asafu-Adjaye (2000) and Odhiambo (2010) used also the same proxy CPI to energy prices.

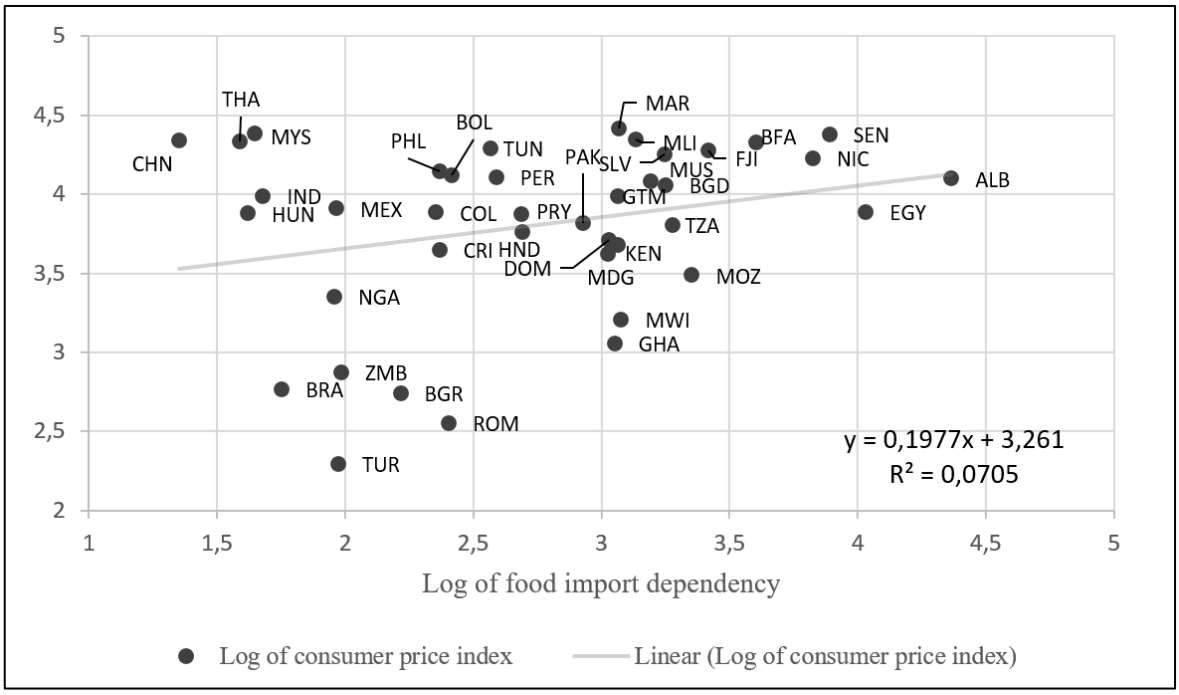
[2] A correlation analysis is performed between all variables (Table A2 in the Appendix). We found a low correlation between variables.

Figure 6: Linear correlation between FDI inflows (% of GDP) and food imports dependency ratio (FMX)



Source: Authors' calculations based on WDI

Figure 7: Linear correlation between the proxy of energy price index and food import dependency ratio (FMX)



Source: Authors' calculations based on WDI

In fact, it's not possible to confirm this intuition with just a linear correlation test between variables. The dynamic relationship between the variables is not taken into account and therefore these relations are currently lacking additional information. So in the next section we deepen the analysis of such relationships. In a first step, we apply a panel unit root test to our variables. We use the Cross-sectionally Augmented Dickey-Fuller (CADF)3 test of Pesaran (2007) to take into account the correlation across sections in series. The optimal lag length is selected by Schwarz's criteria. Null hypothesis assumes that all series are non-stationary. The results of Pesaran's CADF unit root test are reported in Table 2. We proceed by testing the unit root at level with constant and next with constant and trend. The results show that in most specifications, FDI and CPI are stationary at level and only FMX seems to be stationary at first difference.

Table 2: Results of CADF Unit root test

	At level				At first difference	
	with constant		with constant and trend		with constant	
variables	lags	Standardized Z[t-bar] statistics	lags	Standardized Z[t-bar] statistics	lags	Standardized Z[t-bar] statistics
All sample						
FMX	1	-0.562	1	0.936	1	-8.193***
FDI	1	-4.325***	1	-1.534*	1	-10.786***
CPI	1	-4.194***	2	-4.077***	1	-8.831***
Group A						
FMX	1	-0.757	1	1.425	1	-5.206***
FDI	1	-2.645***	1	-0.467	1	-8.255***
CPI	1	-2.624***	1	1.265	2	-3.537***
Group B						
FMX	1	-1.211	1	-0.151	1	-5.663***
FDI	1	-3.216***	1	-1.584*	1	-7.177***
CPI	1	-1.467*	1	-2.203**	1	-3.921***

Notes: ***, **,* denote test statistic significance at the 1%, 5% and 10% levels.

We have split our sample into two groups, the group A includes low and lower middle-income countries and the group B concerns upper middle-income countries. Unit root tests lead to the same conclusions than for the whole sample. The three variables are integrated at different level, which means they do not share a common trend, so they are not cointegrated. This allows us to estimate a VAR model in panel framework.

[3] Our test of unit root is implemented in Stata 13 using the procedure described by Lewandowski (2006). It enables to take into account the possible cross-sectional dependence.

5. Methodology

In the literature many econometric studies have used the VAR (Vector Autoregressive), the VEC (Vector Error Correction) and Autoregressive Distributed Lag models. Some models are used in time series framework while others are used in panel framework. According to the literature and to our CADF test used in the previous section, the appropriate technic is a panel vector auto regressive (PVAR)4 model proposed by Love and Zicchino (2006). The first-order VAR model is given by:

$$Z_{it} = \Gamma(L)\ Z_{it-1} + f_i + d_t + e_{it} \tag{2}$$

where Z_{it} is the vector of dependent variables (ΔFMX, CPI, FDI); Z_{it-1} is a vector of lagged dependent variables and $\Gamma(L)$ is a matrix polynomial in the lag operator 5; f_i is a vector of country-pair fixed effects; d_t are time dummies; and e_{it} is a vector of idiosyncratic errors.

The specificity of this model is that it allows for individual heterogeneity in the levels of variables by introducing fixed effects. However, in the presence of lagged dependent variables, the estimation will be biased due to the correlation with country fixed effects. To avoid this issue, we follow Love and Zicchino (2006) by applying the forward mean-differencing6 procedure. The objective is to transform all variables of the model in deviations from forward means to remove the fixed effects. A detailed explanation for this procedure is given by Boubtane *et al.* (2013).

Let z_{it}^m and e_{it}^m denote a variable and an error term, respectively in two vectors:

$$Z_{it} = (z_{it}^1, z_{it}^2, \dots, z_{it}^M)' \qquad \text{and} \qquad e_{it} = (e_{it}^1, e_{it}^2, \dots, e_{it}^M)'$$

The means obtained from the future values of z_{it}^m and e_{it}^m are equal to

$$\bar{z}_{it}^m = \sum_{s=t+1}^{T_i} \frac{z_{is}^m}{(T_i - 1)} \tag{3}$$

and

$$\bar{e}_{it}^m = \sum_{s=t+1}^{T_i} \frac{e_{is}^m}{(T_i - 1)} \tag{4}$$

[4] A Stata program, built by Love and Zicchino (2006) allows the estimation of Panel VAR model and the calculation of impulse-response functions. In this paper we use an improved version (Abrigo and Love 2015).

[5] The matrix polynomial can be written as $\Gamma(L) = \sum_{n=1}^{p} \Gamma_n L^n$.

[6] It is also known by the Helmert's procedure (see Arellano and Bover, 1995)

Where T_i is the last period of data available for a given country series.

The transformed variable and error term can be written as:

$$\tilde{z}_{it}^{m} = \delta_{it}(z_{it}^{m} - \bar{z}_{it}^{m}) \quad (5)$$

and

$$\tilde{e}_{it}^{m} = \delta_{it}(e_{it}^{m} - \bar{e}_{it}^{m}) \quad (6)$$

$$\text{where } \delta_{it} = \sqrt{\frac{T_i - t}{T_i - t + 1}}$$

However, the last year of data cannot be calculated, because there are no future values for the construction of the forward means. The transformed model becomes:

$$\tilde{Z}_{it} = \Gamma(L)\,\tilde{Z}_{it} + \tilde{e}_{it} \quad (7)$$

where $\tilde{Z}_{it} = (\tilde{z}_{it}^{1}, \tilde{z}_{it}^{2}, \dots, \tilde{z}_{it}^{M})'$ and $\tilde{e}_{it} = (\tilde{e}_{it}^{1}, \tilde{e}_{it}^{2}, \dots, \tilde{e}_{it}^{M})'$

This transformation is in fact an orthogonal deviation, each observation being expressed as a deviation from average future observations. This technique allows use of lagged values of regressors as instruments and we estimate the transformed model (7) as a system of three equations by the Generalized Method of Moments (GMM). Nevertheless, our goal is to determine how food import dependency responds to changes in FDI inflows and energy price, so we will only focus on the equation where the ratio of food import dependency is the dependent variable.

In a next step, we compute the impulse-response functions which describe the reaction of one variable to the innovations in another variable in the system. So we identify the orthogonal shocks of independent variables by using the Cholesky decomposition (see Love and Zicchino 2006).

6. Empirical results

6.1 Panel VAR and Granger causality test

Following the methodology of Love and Zicchino (2006), the results are presented in Tables 3, 4 and 5 for bivariate and trivariate panel VAR models. The choice of the best lag length is important in any VAR model. The check of lag order avoids us the loss of degrees of freedom and over-parameterization. According to the Schwartz information criteria the appropriate lag is here one period.

In Table 3, we have estimated first the panel of 40 countries in a bivariate and trivariate panel VAR model. For all three models, we have not found any significant effect from FDI and CPI to FMX.

Table 3: Panel VAR's results for 40 developing countries

	Dependent variables		
	(1)	(2)	(3)
Independent variables	*ΔFMX*	*ΔFMX*	*ΔFMX*
ΔFMX_{t-1}	-0.154***	-0.161	-0.162***
	(-3.27)	(-3.36)	(-3.38)
FDI_{t-1}	0.19	--	0.017
	(1.05)	--	(1.23)
CPI_{t-1}	--	0.029	0.012
	--	(1.12)	(0.4)

Notes: Heteroskedasticity adjusted z-statistics are in parentheses
***, **,* denote test statistic significance at the 1%, 5% and 10% levels, respectively.

Second, we estimated the panel VAR model for only low and lower middle-income countries (See Table 4). In model (1), results show that FDI inflows have a positive and significant effect at the level of 5%. In model (2), CPI has a negative but not statistically significant effect. Model (3) shows the same results than in the previous models: FDI have a positive and significant effect and CPI kept the negative and no significant coefficient. These results show that FDI increase the dependency of low and lower income countries to food import and the energy price doesn't have any effect.

Table 4: Panel VAR's results for Group A (low and lower middle income countries)

	Dependent variables		
	(1)	(2)	(3)
Independent variables	*ΔFMX*	*ΔFMX*	*ΔFMX*
ΔFMX_{t-1}	-0.188***	-0.194***	-0.201***
	(-3.08)	(-3.16)	(-3.27)
FDI_{t-1}	0.044**	--	0.034**
	(2.25)	--	(2.16)
CPI_{t-1}	--	-0.005	-0.042
	--	(-0.19)	(-1.18)

Notes: Heteroskedasticity adjusted z-statistics are in parentheses
***, **,* denote test statistic significance at the 1%, 5% and 10% levels, respectively.

Third, we focus on the upper middle-income countries. The results are different from the previous ones. Only CPI affects positively FMX (see Table 5). This result confirms our intuition that energy price has an adverse effect on international trade and specifically food import dependency.

Table 5: Panel VAR's results for Group B (upper middle income countries)

	Dependent variables		
	(1)	(2)	(3)
Independent variables	*ΔFMX*	*ΔFMX*	*ΔFMX*
ΔFMX_{t-1}	-0.063	-0.117	-0.125
	(-0.99)	(-1.22)	(-1.15)
FDI_{t-1}	0.057	--	-0.021
	(-1.17)	--	(-0.61)
CPI_{t-1}	--	0.0862**	0.107*
	--	(2.06)	(1.81)

Notes: Heteroskedasticity adjusted z-statistics are in parentheses
***, **,* denote test statistic significance at the 1%, 5% and 10% levels, respectively.

Then, to test the causality between variables, we have applied a bivariate and trivariate Granger causality test and results are reported in Table 6. The unidirectional causality is found running from FDI to FMX only on group A and from CPI to FMX only on group B.

Table 6: Bivariate and trivariate Granger causality test

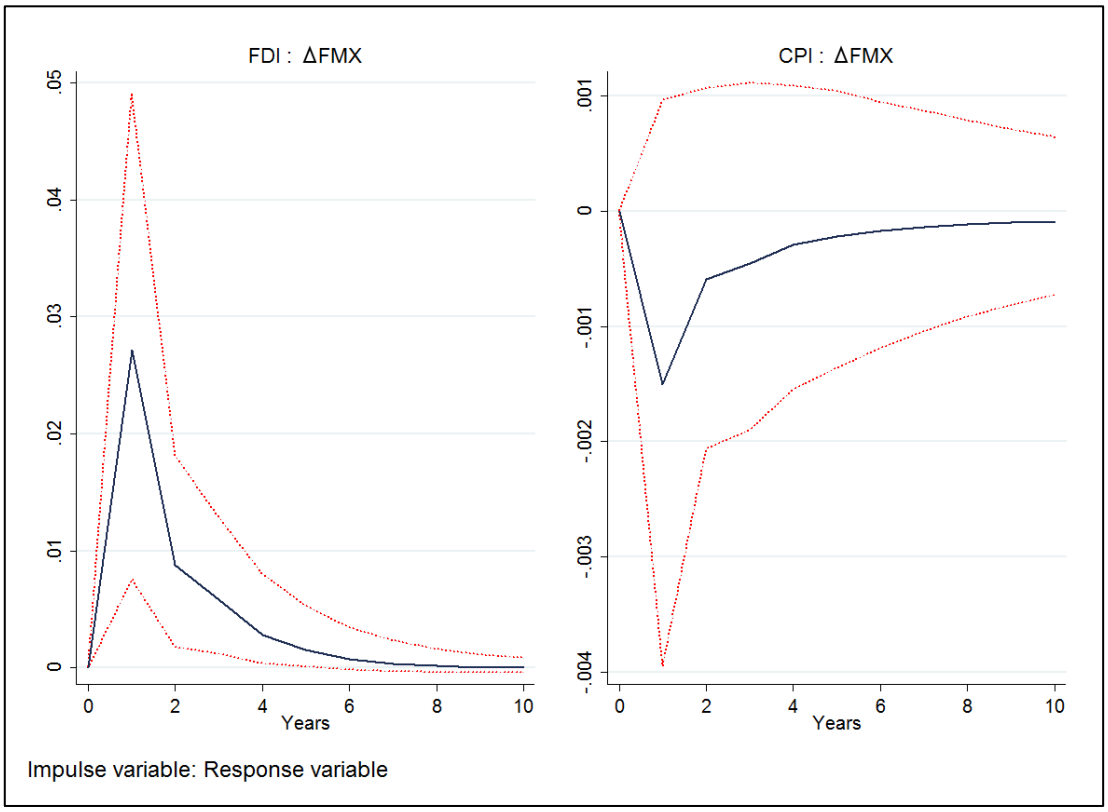
	All sample			Group A			Group B		
	ΔFMX			*ΔFMX*			*ΔFMX*		
FDI	1.095	--	1.501	5.042**	--	4.667**	1.360	--	0.371
CPI	--	1.254	0.161	--	0.035	1.402	--	4.249**	3.291*

Notes: ***, **,* denote test statistic significance at the 1%, 5% and 10% levels, respectively.

6.2. Impulsion response functions

Figures 8 and 9 present the impulse-response functions with a standard error of 95% confidence; errors are generated by Monte-Carlo with 1000 replications. Figure 8 reports the impulse responses for group A, while figure 9 reports the impulse responses for group B. The objective here is to check the expected reaction in the future of the capacity of importing food in case of shocks.

Figure 8: Impulse responses of FMX to shocks in FDI and CPI for group A

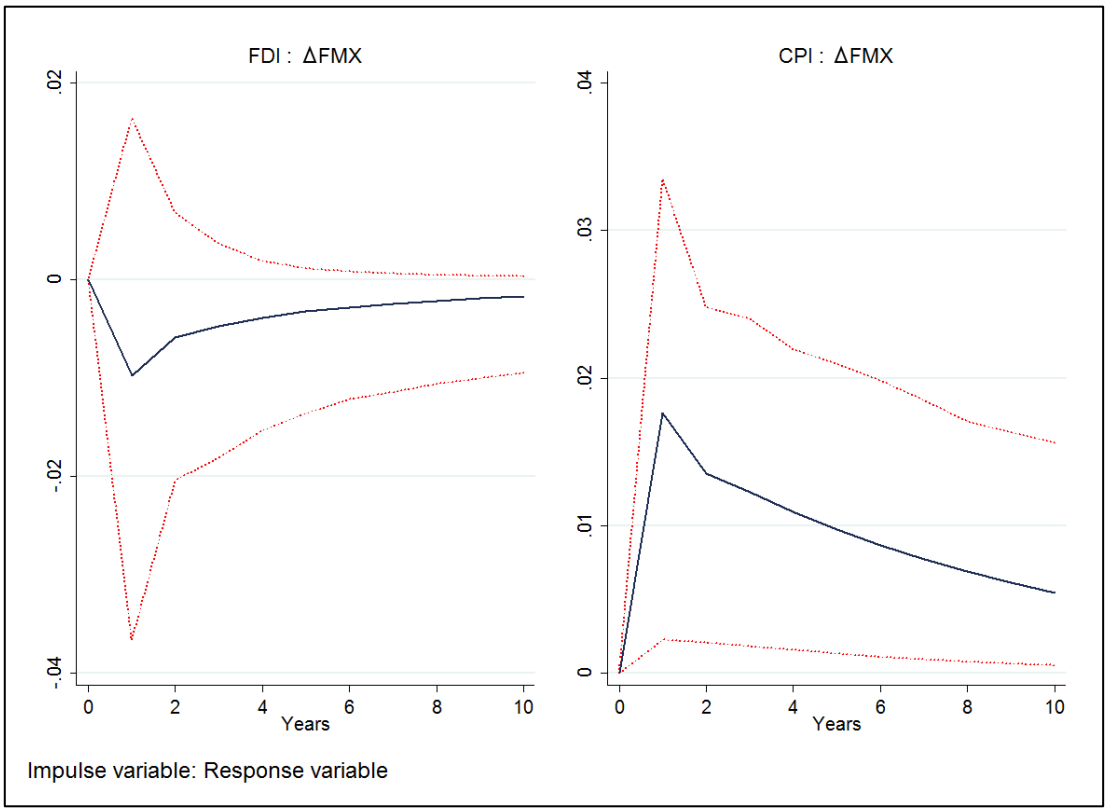


Note: The errors are 5% on each side generated by Monte-Carlo simulation with 1000 reps.

In Group A, we found that FMX responds positively to the FDI inflows increase with a peak in the first year before a decrease. After six years, the response becomes quite weak, close to zero all the time (see figure 8). In contrast, the respond of FMX to the price impulse is completely the reverse for the same period. The influence magnitude of one standard deviation from CPI on FMX first decreases. Low and lower middle-income countries have a positive food import dependency's response to FDI inflows; the FDI inflows are probably not able to boost exports.

Let move to the analysis of group B. In Figure 9, we observe that FMX has a negative short-term response to a shock in FDI, and a positive short-term response to a shock in CPI. It seems that upper middle-income countries are more vulnerable to shocks in prices than in FDI inflows. Moreover, the response is the opposite than that observed for countries of group A. This means, therefore, that low and lower middle-income countries are more sensitive to shocks in FDI inflows.

Figure 9: Impulse response of FMX to shocks in FDI and CPI for group B



Note: The errors are 5% on each side generated by Monte-Carlo simulation with 1000 reps.

7. Discussion and conclusion

In this paper, the causal relationship between FDI inflows, energy price and food import dependency is examined for 40 countries using a panel VAR model. We split the sample on two groups, the first corresponds to the developing countries with low income and lower middle income and the second is composed of the developing countries with upper middle income, over the period 1990-2012.

Our paper reveals some interesting findings regarding the food stability in developing countries. We provide empirical evidence of the causal links from FDI inflows and energy price to food import dependency. However, it seems that FDI inflows increase dependency in low and lower middle-income countries. Otherwise, FDI inflows are unable to improve the capacity of these countries to import food. This result may be explained by the fact that these countries haven't the ability to absorb the all benefits of FDI and they are more vulnerable to access to the international food markets. On the other hand, a rise in prices increases food import dependency in upper middle-income countries and therefore their ability to import food deteriorates.

Our paper has highlighted the transmission mechanism by which the vulnerability of developing countries to import food responds to a FDI or energy price shock. We found theoretical evidence for the existence of indirect links about the direction of the response of food import dependency. In addition, our research reveals that food import dependency response depends on the income level of the country. The impulse response function results show that the responsiveness of the food import dependency is positive in low and lower-middle income countries in case of a FDI shock and is positive in upper middle-income countries following a price shock.

This research has some emerging policy implications. It is strategically important for low and lower income countries to change their trade policy, specifically in the food sector. Firstly, these countries must seek to attract export oriented FDI and it is recommended to minimize their exports of local produced food. Secondly, these countries must invest on their ability in absorbing the FDI's spillovers because it can be a way to acquire skills and technology, to innovate new marketing strategies and managerial practices, to find new methods and channels of distribution and thus to access to international markets. For upper middle-income countries, we recommend the use of renewable energy to reduce their access to international energy market.

References

Abrigo, M. R. M., Love, I. (2015). *Estimation of Panel Vector Autoregression in Stata: a Package of Programs*. Working paper. University of Hawaii. http://paneldataconference2015.ceu.hu/Program/Michael-Abrigo.pdf

Ahmed, A. D., Cheng, E., Messinis, G. (2011). The Role of Exports, FDI and Imports in Development: Evidence from Sub-Saharan African Countries. *Applied Economics* 43 (26): 3719-3731. doi:10.1080/00036841003705303.

Arellano, M., Bover, O. (1995). Another Look at the Instrumental Variable Estimation of Errorcomponents Models. *Journal of Econometrics* 68: 29–52. doi:10.1016/0304-4076(94)01642-D

Asafu-Adjaye, J. (2000). The Relationship between Energy Consumption, Energy Prices and Economic Growth: Time Series Evidence from Asian Developing Countries. *Energy Economics* 22 (6): 615-625. doi:10.1016/S0140-9883(00)00050-5.

Boubtane, E., Coulibaly, D., Rault, C. (2013). Immigration, Growth, and Unemployment: Panel VAR Evidence from OECD Countries. *LABOUR* 27 (4) : 399–420. doi: 10.1111/labr.12017

Breisinger, C., Ecker,O., Al-Riffai, P., Yu, B. (2012). *Beyond the Arab Awakening: Policies and Investments for Poverty Reduction and Food Security*. Washington DC: IFPRI. doi:10.2499/9780896295452

Bridgman, B. (2008). Energy Prices and the Expansion of World Trade. *Review of Economic Dynamics* 11(4): 904-916. doi: 10.1016/j.red.2008.07.006

Caves, R. E. (1982). *Multinational Enterprise and Economic Analysis*. Cambridge: Cambridge University Press.

Chen, S.S., Hsu, K.W. (2012). Reverse Globalization: Does High Oil Price Volatility Discourage International Trade? *Energy Economics* 34 (5): 1634-1643. doi:10.1016/j.eneco.2012.01.005

Diaz-Bonilla, E., Thomas, M., Robinson, S., Cattaneo, A. (2000). *Food security and trade negotiations in the World Trade Organization*. TMD discussion papers 59. Washington DC: IFPRI. http://www.ifpri.org/cdmref/p15738coll2/id/125376/filename/125377.pdf

Elbehri, A., Segerstedt, A., Liu, P. (2013). *Biofuels and Sustainability Challenge: A Global Assessment of Sustainability Issues, Trends and Policies for Biofuels and Related Feedstocks*. Rome: Food and Agriculture Organization. http://www.fao.org/docrep/017/i3126e/i3126e.pdf

FAO (2008). Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required. Paper presented at the High-level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, Rome, June 3-5. http://www.fao.org/fileadmin/user_upload/foodclimate/HLCdocs/HLC08-inf-1-E.pdf

Farzin, H. Y. (1988). *Food import dependence in Somalia: magnitude, causes, and policy options*. World Bank discussion papers 23. Washington, DC: The World Bank. http://documents.worldbank.org/curated/en/1988/01/437433/food-import-dependence-somalia-magnitude-causes-policy-options

Fontagné, L. (1999). Foreign Direct Investment and International Trade: Complements or Substitutes? OECD Science, Technology and Industry Working Papers 1999/03. Paris: OECD. doi:10.1787/788565713012

Gastanaga, V. M., Nugent, J. B., Pashamova, B. (1998). Host country reforms and FDI inflows: How much difference do they make? *World Development* 26 (7): 1299-1314. doi:10.1016/S0305-750X(98)00049-7

Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica* 37: 424-438. doi:10.2307/1912791

Grossmann, A., Love, I., Orlov, A. G. (2014). The dynamics of exchange rate volatility: A panel VAR approach. *Journal of International Financial Markets, Institutions and Money* 33: 1-27. doi:10.1016/j.intfin.2014.07.008

Hertel, T.W., Beckman, J. (2011). *Commodity price volatility in the biofuel era: an examination of the linkage between energy and agricultural markets*. Working paper 16824, Cambridge, MA: National Bureau of Economic Research (NBER). doi:10.3386/w16824

Hoering, H. (2013). *Alternatives to Food imports dependency*. FDCL Policy Paper. https://www.globalpolicy.org/home/217-hunger/52460-alternatives-to-food-import-dependency.html

Kamara, A. B., Mafusire, A., Castel, V., Kurzweil, M., Vencatachellum, D., Pla, L. (2009). *Soaring food prices and Africa's Vulnerability and Responses: An update*. African Development Bank working paper 97. Tunis: African Development Bank. http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/WORKING%2097.pdf

Korhonen, I., Ledyaeva, S. (2010). Trade Linkages and Macroeconomic Effects of the Price of Oil. *Energy Economics* 32: 848-856. doi:10.1016/j.eneco.2009.11.005

Kousnetzoff, N., Mirza, D., Zitouna, H. (2008). *Oil Prices, Transport Costs and Globalisation*. La lettre du CEPII 282. Paris : CEPII. http://www.cepii.fr/CEPII/fr/publications/lettre/abstract.asp?NoDoc=1128

Le, T.-H., Chang, Y. (2013). Oil price shocks and trade imbalances. *Energy Economics* 36: 78-96. doi:10.1016/j.eneco.2012.12.002

Lewandowski, P. (2006). PESCADF: Stata Module to Perform Pesaran's CADF Panel Unit Root Test in Presence of Cross section Dependence. Statistical Software Components S456732, Boston College Department of Economics.

Liu, X., Burridge, P., Sinclair, P. J. N. (2002). Relationships between Economic Growth, Foreign Direct Investment and Trade: Evidence from China. *Applied Economics* 34 (11): 1433-1440. doi:10.1080/00036840110100835

Liu, P., Koroma, S., Arias, P., Hallam, D. (2012). *Trends and Impacts of Foreign Investment in Developing Country Agriculture: Evidence from case studies*. Rome: Food and Agriculture Organization. http://www.fao.org/docrep/017/i3112e/i3112e.pdf

Liu, X., Wang, C., Wei, Y. (2001). Causal Links between Foreign Direct Investment and Trade in China. *China Economic Review* 12 (2–3): 190-202. doi:10.1016/S1043-951X(01)00050-5

Love, I., Zicchino, L. (2006). Financial Development and Dynamic Investment Behavior: Evidence from Panel VAR. *The Quarterly Review of Economics and Finance* 46 (2): 190-210. doi:10.1016/j.qref.2005.11.007

Mahadevan, R., Asafu-Adjaye, J. (2007). Energy Consumption, Economic Growth and Prices: A Reassessment Using Panel VECM for Developed and Developing Countries. *Energy Policy* 35: 2481–2490. doi:10.1016/j.enpol.2006.08.019

Mielnik, O., Goldemberg, J. (2002). Foreign Direct Investment and Decoupling between Energy and Gross Domestic Product in Developing Countries. *Energy policy* 30 (2): 87-89. doi:10.1016/S0301-4215(01)00080-5

Mirza, D., Zitouna, H. (2009). *Oil Prices, Geography and Endogenous Regionalism: Too Much Ado About (Almost) Nothing*. CEPII Working Paper 2009- 26. Paris: CEPII. http://www.cepii.fr/CEPII/fr/publications/wp/abstract.asp?NoDoc=1635

Odhiambo, N. M. (2010). Energy consumption, prices and economic growth in three SSA countries: A comparative study. *Energy Policy* 38 (5): 2463-2469. doi:10.1016/j.enpol.2009.12.040

Pacheco-López, P. (2005). Foreign Direct Investment, Exports and Imports in Mexico. *The World Economy*, no. 28: 1157–1172. doi: 10.1111/j.1467-9701.2005.00724.x

Pesaran, M. H. (2007). A Simple Panel Unit Root Test in the Presence of Cross-section Dependence. *Journal of Applied Economics* 22 (2): 265-312. doi: 10.1002/jae.951

Rakotoarisoa, M. A., Lafrate, M., Paschali, M. (2011). *Why has Africa become a net food importer? Explaining Africa agricultural and food trade deficits*. Trade and markets division. Rome: Food and Agriculture Organization. http://www.fao.org/docrep/015/i2497e/i2497e00.pdf

Sadorsky, P. (2010). The Impact of Financial Development on Energy Consumption in Emerging Economies. *Energy Polic*y 38 (5): 2528-2535. doi:10.1016/j.enpol.2009.12.048

Sharma, K. L. (2006). *Food Security in the South Pacific Island Countries*. UNU-WIDER Research Paper 2006/68. United Nations University. https://www.wider.unu.edu/sites/default/files/rp2006-68.pdf

Siamwalla, A., Valdés, A. (1980). Food insecurity in developing countries. *Food Policy* 5 (4): 258-272. doi:10.1016/0306-9192(80)90055-X

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C. (2006). *Livestock's long shadow: environmental issues and options*. Rome: Food and Agriculture Organization. ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e00.pdf

Tang, C. F. (2009). Electricity Consumption, Income, Foreign Direct Investment, and Population in Malaysia. *Journal of Economic Studies* 36 (4): 371-382. doi:10.1108/01443580910973583

Tekin, R. B. (2012). Economic Growth, Exports and Foreign Direct Investment in Least Developed Countries: A Panel Granger Causality Analysis. *Economic Modelling* 29 (3): 868-878. doi:10.1016/j.econmod.2011.10.013

Turhan, I., Hacihasanoglu, E., Soytas, U. (2013). Oil Prices and Emerging Market Exchange Rates. *Emerging Markets Finance and Trade* 49 (1): 21-36. doi:10.2753/REE1540-496X4901S102

United Nation (2009). *UN predicts fall in global cereal production as record numbers go hungry*. United Nations News Centre: UN Daily News Issue DH/5338. http://www.un.org/News/dh/pdf/english/2009/12022009.pdf

Wang, Y., Wan, G. (2008). *China's Trade Imbalances: The role of FDI*. UNU-WIDER Research Paper 2008/103, United Nation University.

Appendix

Table A1: Countries list:

low-income economies GNI per capita less than $1,045	Code	Lower middle income economies GNI per capita of more than $1,045 but less than $4,125	Code	Upper middle income economies GNI per capita of more than $4,125 but less than $12,746	Code
Bangladesh	BGD	Bolivia	BOL	Albania	ALB
Burkina Faso	BFA	Egypt	EGY	Brazil	BRA
Kenya	KEN	El Salvador	SLV	Bulgaria	BGR
Madagascar	MDG	Ghana	GHA	China	CHN
Malawi	MWI	Guatemala	GTM	Colombia	COL
Mali	MLI	Honduras	HND	Costa Rica	CRI
Mozambique	MOZ	India	IND	Dominican Republic	DOM
Tanzania	TZA	Morocco	MAR	Fiji	FJI
		Nicaragua	NIC	Hungary	HUN
		Nigeria	NGA	Malaysia	MYS
		Pakistan	PAK	Mauritius	MUS
		Paraguay	PRY	Mexico	MEX
		Philippines	PHL	Peru	PER
		Senegal	SEN	Romania	ROM
		Zambia	ZMB	Thailand	THA
				Tunisia	TUN
				Turkey	TUR

Table A2: Correlation test between all variables

	FMX	FDI	CPI
FMX	1		
FDI	-0.1395	1	
CPI	0.0507	0.3606	1

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