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

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**ABSTRACT:** Increasing foreign private investment in developing countries explains why the Public-Private Investment (PPI) is becoming a key tool to reach the development goal. This article analyzes the relation between PPI in infrastructure and agricultural exports in developing countries. We use the panel data approach (52 countries and 17 years). Results show that PPI in infrastructure has a positive impact on agricultural exports of developing countries. The impact is greater in developing countries with higher income rates. This suggests that the lower income countries require the intervention of public sector without which private investment cannot help to economic development.

**KEYWORDS:** Agricultural exports, development, panel data, public-private investment in infrastructure.

**JEL classification:** C33, F21, O11, Q17.

**DOI:** 10.7201/earn.2015.02.05.

## El papel del sector privado en el desarrollo: la relación entre la inversión público-privada en infraestructuras y las exportaciones agrarias en los países de desarrollo

**RESUMEN:** La presencia de la inversión privada extranjera en los países en desarrollo explica por qué la Inversión Público-Privada (IPP) se convierte en una herramienta para alcanzar el objetivo del desarrollo. Se analiza la relación entre la IPP en infraestructuras y las exportaciones agrarias en los países en desarrollo, aplicando la metodología de datos de panel (52 países y 17 años). Los resultados muestran que la IPP tiene un impacto positivo en las exportaciones agrarias de los países en desarrollo. Dicho impacto es mayor en aquellos países de mayor renta. Ello sugiere que los países de menor renta requieren de la intervención del sector público, sin la cual la inversión privada no puede contribuir al desarrollo económico.

**PALABRAS CLAVE:** Datos de panel, desarrollo, exportaciones agrarias, inversión público-privada en infraestructura.

**Clasificación JEL:** C33, F21, O11, Q17.

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## 1. Introduction

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

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

Developing countries still face funding constrains to execute their plans to invest in infrastructure. It is estimated that infrastructure spending will have to rise between 1.8 and 2.3 trillion dollars per year by 2020 to meet the needs of developing countries. Traditional transnational corporations (TNCs) remain the largest investors in infrastructure (UNTT, 2013). The Foreign Direct Investment (FDI) has increased from 400 billion dollars in 1995 to 1.450 billion dollars in 2013 (UNCTAD, 2014). Since 1990, developing countries became the major recipients of FDI (more than 50 % in 2013).

The increasing presence of the private investment in developing countries explains why private sector has been defined in post-2015 Agenda as an essential pillar to reach the sustainable development goal. The participation of the public sector is pivotal to attract foreign private investment. The public sector is responsible for creating adequate investment climates (World Bank, 2008) and promoting public-private partnerships (UN, 2010; UNCTAD, 2011; UNTT, 2013). The World Bank has launched the initiative of consulting projects for public-private participation in infrastructure (PPIAF-Public-Private Infrastructure Advisory Facility). It gives support to developing countries to create adequate investment environments (policy guidance, development of regulation, consolidation of institutions and governance) that encourage foreign investors to invest in those sectors that the public sector can-

not cover. Public-private investments projects in infrastructure reached 150 billion dollars in 2013 (World Bank, 2013). The projects span investment in transport, telecommunications, energy and water and sanitation.

Previous studies that analyzed the relationship between trade and infrastructure have found a positive and significant impact of infrastructure on trade (Limão and Venables, 2001; Nordäs and Piermartini, 2004; Yeaple and Golub, 2007). Focusing on the increasing public-private partnerships, the aim of this paper is to analyze the relationship between public-private investments in infrastructure on the agricultural exports of developing countries. It seeks to test the hypothesis whether public-private investments in infrastructure in developing countries are positively related to the volume of agricultural exports. We consider a sample of 52 countries in the period from 1995 to 2011. The selected sample (see Appendix I) accounts for 99 % of the public-private investment projects compiled in the Private Participation in Infrastructure Project Database of the World Bank (World Bank, 2014a).

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

## 2. Literature review

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

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

There are several private investment studies that use a sector based approach. Swenson (2004) analyzes the private investment, broken down according to the type

of product, industry and manufacture production. They conclude that the relationship between trade and private investment varies depending on the level of disaggregation. If the analysis focuses on product and industry, investment and trade are substitutes. But, they are complements when the analysis is based on higher disaggregation level. Furtan and Holzman (2004); Rakotoarisoa (2011) study the relationship between private investment in agriculture and food trade in Canada and Sub-Saharan countries, respectively. Both studies conclude that private investment in the agricultural sector and food trade are complements. Aizenman and Noy (2005); Ghosh (2007) propose to carry out new studies based on investments in infrastructures as a part of the production process.

In relation to investments in infrastructure, Nordäs and Piermartini (2004) explore the impact of the quality of infrastructure on the country's trade performance, finding that the quality of infrastructure is an important determinant of trade. Yeaple and Golub (2007) study the effect of the infrastructure investment on ten different industrial sectors, and find that increased provision of infrastructure helps to explain patterns of international specialization and trade. Mbekeani (2010) suggests that inadequate infrastructure and poor transport organization in Africa hinder the timely delivery reliability in the supply of goods. He proposes that Africa could follow the path of other geographic areas (USA, Latin America and Asia) in boosting infrastructure for trade.

The availability of infrastructure has also been considered in the literature as a measure of domestic trade costs. The literature supports the hypothesis that domestic trade costs are significant determinants of the volume of trade between countries (Hoekman and Nicita, 2011). Trade facilitation by investing in physical infrastructure and regulatory reforms, improve the export performance of developing countries (Kyvik and Piermartini, 2004; Portugal-Perez and Wilson, 2012). Indeed, this positive impact is more important than variations in tariffs in explaining North-South trade (Francois, *et al*., 2013). Behar, *et al*. (2011) add that the effect of a better trade logistics reducing trade costs depends on the country size. They find that the trade elasticities are greater for larger countries.

## 3. Public-private investment projects in infrastructure in developing countries

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

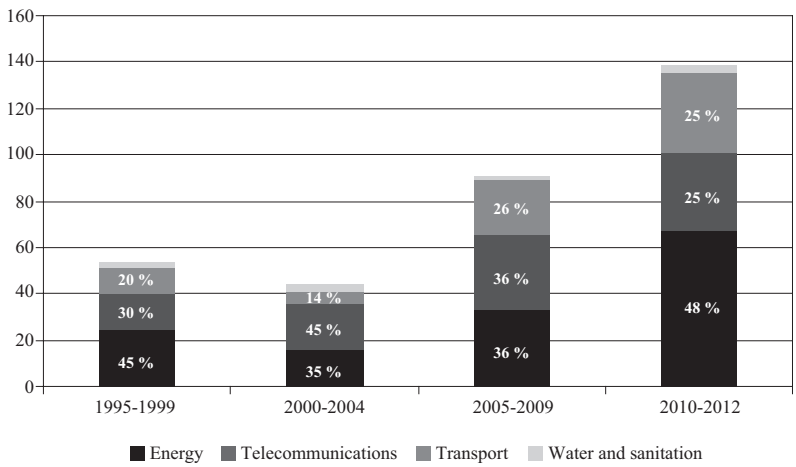
The public-private investment in infrastructure shows a similar trend to FDI trend. As Figure 1 shows, the public-private investment in infrastructure stood at 50 billion

current dollars in period 1990-1994. This figure has increased up to 140 billion current dollars in 2010-2012 (World Bank, 2014a). It is mainly concentrated on upper middle income countries. The major recipients of investment in infrastructure are India, China and Indonesia in Asia and Brazil and Mexico in Latin America; not surprisingly, these are the largest countries in Asia and Latin America.

There is a clear targeting of the public-private investment into the energy sector, reaching more than half of total public-private investment in period 1995-2011 (Figure 1).

FIGURE 1

**Public-private investment in infrastructure by investment sector (billion current dollars). Periods 1995-1999, 2000-2004, 2005-2009 and 2010-2012**




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

Energy sector includes projects of generation, transmission and distribution of electricity and natural gas. Energy is a key element in the development process. It is required for food processing, transportation, fertilizer production and use of industrial equipment, among other multiple uses (Stout, 1990). Telecommunications (investment in fixed access network and mobile communications), in turn, is a priority sector for investment. The International Institute for Communication and Development (IICD) promotes the investment in telecommunications, on the basis that greater access and timely information (prices, clients, suppliers) enhance the bargaining power of small farmers, increase trade and promote agriculture production (IICD, 2006; IICD, 2012). Investment in telecommunications accounted for 45 % of the total public-private investment in infrastructure in 2000-2004. This percentage has decreased over last years on behalf of the investment in transport and energy. Since 2005, investment in transports accounts for 25 % of the public-private investment in

infrastructure. The availability of adequate transportation infrastructure facilitates access of farmers to markets (World Bank, 2005). Investments in transportation include roads, bridges, tunnels, terminals and dredging of channels projects. Public-private investment in water and sanitation includes water transport systems, water treatment and sewerage plants and water and sanitation services. It represents less than 5 % of the public-private investment in infrastructure over the analyzed period[1].

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

## 4. Empirical framework

### *4.1. Description of the study sample*

The sample of the study comprises 52 developing countries. The selected countries differ in income per capita (from least developed countries to upper middle income countries) and belong to four geographical regions, East and South Asia, Europe and Central Asia, North Africa and Near East, Sub-Saharan Africa and Latin America.

To reach the goal of this paper, first we study the performance of agricultural exports of the countries' sample. Due to the heterogeneity of developing countries, we analyze the performance of the agricultural exports considering the relevance of trade on national economies, measured by the trade openness indicator. It is defined as the relation between trade (sum of exports and imports of merchandise and services) and Gross Domestic Product (GDP) in a country. This indicator may be analyzed as an approximation of the dependency level of national economies on international trade. We test the hypothesis that if we compare two countries with the same level of imports-exports, the country with high added-value sectors - that contribute to higher gross domestic product- is less dependent on international trade than the country with low added-value sectors.

We apply Wilcoxon-Mann-Whitney test for independent and non-parametric samples. The sample of the study covers the period 1995-2011. The sample is divided into two sub-samples (sub-sample 1 and sub-sample 2), depending on whether trade openness is higher or lower than a reference value (Table 1). This value is the median of the average trade openness in period 2007-2011 by country, and equals 70.53 % (World Bank, 2014b).

[1] The World Bank database only provides water investment data of 24 out of 52 countries of the sample.

TABLE 1

**Sample of developing countries classified according to their trade openness**

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

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

We select three target variables: GDP per capita, public-private investment in infrastructure and agricultural trade (see Appendix II and Appendix III)[2]. Wilcoxon-Mann-Whitney methodology tests the null hypothesis ($H_0$) that sub-sample 1 is similar to sub-sample 2 considering each target variable. First, it ranks all observations of the selected sample regardless of whether they belong to sub-sample 1 or sub-sample 2. The observations are sorted from lowest to highest value of the target variable, assigning one to the smallest value. Second, the rank sum is performed according to the following expressions:

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

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

where,

$T_1$ = Rank sum of sub-sample 1,
$R_{1i}$ = Ranks of i countries of sub-sample 1,
$n_1$ = Sample size of sub-sample 1,
$T_2$ = Rank sum of sub-sample 2,
$R_{2i}$ = Ranks of i countries of sub-sample 2,
$n_2$ = Sample size of sub-sample 2.

Third, based on rank sum, the expression of the calculation of the Mann-Whitney statistical ($U_1$ and $U_2$) is as follows. Between $U_1$ and $U_2$, we consider the lowest value to study its significance.

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

where,

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

The results are shown in Table 2. The target variables are shown in the columns. For each target variable we summarize the number of observations (columns 1, 4, 7), the rank sum (columns 2, 5, 8) and the statistic Z (columns 3, 6, 9)[3]. The rows present the different sub-samples analyzed: Row 1 (sub-sample 1: Trade opennes lower than the median), row 2 (sub-sample 2: Trade opennes higher than the median) and row 3 (the whole sample). We analyze the data of 52 countries over the period 1995-2011 (17 years). The whole sample size includes 883 observations and the rank sum stands at 391.170 (N x (N + 1) /2)). Depending on the variable analyzed, there are missing values that explain why the rank sum in row 3 is lower than 391.170 in all the cases.

First, we test the null hypothesis ($H_0$) that GDP per capita in developing countries of sub-sample 1 is similar to GDP per capita in developing countries of sub-sample 2. It can be seen that the rank sum of sub-sample 1 is higher than the rank sum of sub-sample 2. This difference is statistically significant. It means that GDP per capita

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

is higher in countries with lower trade openness than in those with higher trade openness. This result supports the hypothesis on the trade openness indicator, mentioned at the beginning of this section: those countries with high added value sectors (higher GDP per capita) show lower trade openness (dependency on international trade) that those countries with lower GPD per capita.

TABLE 2

**Wilcoxon-Mann-Whitney test results**

| | GDP per capita | | | Public-private investment in infrastructure | | | Agricultural exports | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nº obs. | Rank sum | Z | Nº obs. | Rank sum | Z | Nº obs. | Rank sum | Z |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Sub-sample 1: Trade openness lower than median (70.53 %) | 442 | 205,935 | | 380 | 171,295 | | 419 | 215,444 | |
| Sub-sample 2: Trade openness higher than median (70.53 %) | 441 | 184,351 | | 368 | 108,830 | | 415 | 132,751 | |
| Whole sample | 883 | 390,286 | | 748 | 280,125 | | 834 | 348,195 | |
| | | | 2.79** | | | 9.81*** | | | 11.65*** |

Note: *, **, *** denote statistical significance level at 5 %, 1 % and 0.1 %.

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

Similarly, considering the other target variables, there are significant differences in public-private investment and agricultural exports between sub-sample 1 and sub-sample 2. The rank sum of sub-sample 1 is higher than the rank sum of sub-sample 2 in all the cases and the differences are statistically significant. This suggests that the public-private investment in infrastructure and agricultural exports are higher in countries with lower trade openness. We conclude that on average developing countries with lower trade openness have higher GDP per capita, attract more private investment in infrastructure and have a greater agricultural export capacity.

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

### *4.2. Methodology*

Several studies analyze the direction and sign of the causality relationship between investment and trade. Using country specific data, authors apply Granger causality test in order to find out if the current and past performance of FDI explains exports or the causal relationship follows the opposite direction (Alguacil *et al.,* 2002; Pramadhani *et al.,* 2007). Other studies use gravity models. These models try to explain bilateral trade analyzing the variables that measure the weight of the countries involved in trade (population, GDP, FDI, and so on) and variables that measure the distance between them (trade barriers, language and so on) (Magalhaes and Africano, 2007; Bezuidenhout and Naudé, 2008). Finally, some authors broaden the sample size and analyze the relationship between investment and trade for a set of countries using panel data analysis (Gyfalson, 1999; Furtan and Holzman, 2004; Ghosh, 2007).

We compile a panel database of a sample of 52 developing countries, over the period 1995-2011. Considering the country-year as the unit of analysis, the total number of observations varies from 608 to 707, depending on the missing values. We build on previous causality studies that suggest that the private investment precedes trade (Liu *et al.,* 2001; Alguacil *et al.,* 2002; Pacheco-López, 2005; Pramadhani *et al.,* 2007). In our model, agricultural export is the dependent variable and public-private investment in infrastructure is one of the explanatory variables. We test the hypothesis that there is a positive relationship between public-private investment in infrastructure and agricultural exports (see Appendix II and Appendix III). Public-private investment in infrastructure is broken down according to the investment sector: Telecommunications, energy and transport sectors[4]. We analyze whether there is a significant effect resulting from the different types of investment on agricultural exports.

We analyze economic variables that have been tested previously by other authors (Model 1). The economic variables selected are: a) Nominal annual exchange rate (Furtan and Holzman, 2004; Hacker and Hatemi, 2004; Ali, *et al.*, 2014)[5]; b) GDP per capita of the exporter country (Ghosh, 2007); and c) Average world GDP per capita (Samad *et al*., 2009). All the variables are expressed in logarithms. The estimation of the baseline Model 1 is as follows:

$$L_Agri_X_{it} = \alpha_0 + \alpha_1 \mathrm{L_PPI_infra}_{it} + \alpha_2 \mathrm{L_XRT}_{it} + \alpha_3 \mathrm{L_GDP_cap}_{it} + \alpha_4 \mathrm{WGDP_cap}_t + \varepsilon_{it} \quad [3]$$

[4] We do not analyze public- private investment in water sector because there is data only for 24 out of 52 countries of the sample. See footnote 1.

[5] Aizenman and Noy (2005) and Ghosh (2007) propose to use the real exchange rate. We have estimated the model with the real exchange rate variable. This variable is not statistically significant. The results of this regression are available from the author upon request.

where,

i = 1…52 developing countries;

t = 1…17 years (period 1995-2011);

$L_Agri_X_{it}$ = Logarithm of agricultural exports, country i, year t;

$L_PPI_Infra_{it}$ = Logarithm public-private investment in infrastructure, country i, year t;

$L_XRT_{it}$ = Logarithm nominal annual exchange rate, country i, year t;

$L_GDP_cap_{it}$ = Logarithm GDP per capita, country i, year t;

$L_WGDP_cap_{t}$ = Logarithm average world GDP per capita, year t;

$\varepsilon_{it}$ is the error term;

We apply four techniques for testing the robustness of the results of the baseline Model 1:

- We introduce fixed effects in the estimation model. We use dichotomous variables that identify some of the strategic characteristics of developing countries. We define dummy variables for oil exporting countries; and another for countries with sea access. As result we present the Models 2 and 3.
- We introduce additional control variables, tested in the literature, in the baseline Model 1. We consider macroeconomic stability variables as inflation and income growth volatility (Ghosh, 2007) in the Model 4[6]. In Model 5, we add to Model 1 variables that measure the institutional quality such as general government final consumption expenditure (Gyfalson, 1999) and political regime[7] (Aizenman and Noy, 2005; Ghosh, 2007). Finally, Model 6 includes variables that describe the agricultural sector: The agriculture value added (Gyfalson, 1999) and the agricultural gross production value per capita (see Appendix II and Appendix III).
- As has been shown in previous section, there are statistically significant differences between developing countries according to their trade openness. Taking into account this result, we define a new Model 7, introducing in the baseline Model 1 a new dummy variable that controls if the country belongs to the sub-sample of countries with lower trade openness (sub-sample 1) or with higher trade openness (sub-sample 2), being 1 if the country belongs to sub-sample 1.
- We run the baseline Model 1 on the sub-sample 1 and on the sub-sample 2, separately.

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

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

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

## 5. Results and discussion

The results of the baseline Model 1 are summarized in the first column of Table 3. As shown in the table, the coefficient of the public-private investment in infrastructure is positive and statistically significant. This result suggests that public-private investment in infrastructure enhances agricultural exports in developing countries. Our result is consistent with previous results that find a positive relationship between FDI and trade (Fontagné, 1999; Alguacil *et al.,* 2002). The coefficient shows the elasticity of the agricultural trade because the variables were transformed in logarithms. Hence, it indicates that 1 % increase in public-private investment in infrastructure would generate an increment of 0.08 % of the agricultural exports. If we compare the coefficients of the explanatory variables we can see that the coefficient of the public-private investments is the smallest. This can be explained by the fact that investment in infrastructure is not a direct investment in agriculture but it is a cross-sectoral investment[8].

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

The second column of the Table 3 summarizes the results of the Model 1 considering the public-private investment by sector. Results show that the impact of the investments in the three different sectors on agricultural exports is positive and statistically significant. The elasticity of the telecommunications investments is higher than the elasticity of the energy and transport investments. The relevance of the access to the information for economic development has been supported by other authors (Dholakia and Harlam, 1994; Hudson, 2013). The impact of the energy investments is similar to that of transport investment. The number of observations is much lower

[8] In order to control the influence of public-private investment on trade with a time lag, we have estimated the model with the public-private investment lagged one period. The sign and significance of the coefficients prevail. These results are available from the author upon request.

when we study the public-private investment by sector (136 observations) than when we study total public-private investment (707 observations). The number of observations increases up 213 if we only take into consideration the energy and telecommunication investments in the model. In this case, the elasticity of the telecommunication investment remains higher than that of energy investment.

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

TABLE 3

**Results of the baseline Model 1, Model 2 and Model 3**
**Sample of 52 countries in period 1995-2011**

| | **Model 1 Total investment** | **Model 1 Investment by sector** | **Model 2** | **Model 3** |
|---|---|---|---|---|
| PPI_infra | $0.08^{***}$ (0.01) | | $0.06^{***}$ (0.01) | $0.06^{***}$ (0.01) |
| PPI_Telecommunications | | $0.26^{***}$ (0.06) | | |
| PPI_Energy | | $0.09^{**}$ (0.04) | | |
| PPI_Transport | | $0.09^{*}$ (0.04) | | |
| XRT | $0.10^{***}$ (0.01) | $0.24^{***}$ (0.05) | $0.05^{***}$ (0.01) | $0.11^{***}$ (0.01) |
| GDP_cap | $0.44^{***}$ (0.04) | $0.50^{***}$ (0.10) | $0.36^{***}$ (0.04) | $0.42^{***}$ (0.04) |
| WGDP_cap | $0.61^{***}$ (0.15) | 0.08 (0.47) | $0.79^{***}$ (0.14) | $0.62^{***}$ (0.14) |
| Petrol_export | | | $0.50^{***}$ (0.13) | |
| Access to the sea | | | | $0.94^{***}$ (0.12) |
| Intercept | $2.70^{*}$ (1.30) | $6.04^{***}$ (1.25) | 1.80 (1.15) | 1.90 (1.22) |
| N | 707 | 136 | 707 | 707 |
| $R^2$ | 0.94 | 0.98 | 0.94 | 0.94 |

Note: *, **, *** indicate significant statistical levels at 5 %, 1 % and 0.1 %. Figures in parentheses are the coefficients standard errors.

Source: Own elaboration.

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

TABLE 4

**Results of the Model 4, Model 5 and Model 6**
**Sample 52 countries in period 1995-2001**

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

Note: *, **, *** denote statistical significant level at 5 %, 1 % and 0.1 %. Figures in parentheses are the coefficients standard errors.

Source: Own elaboration.

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

Concerning the macroeconomic stability control variables (Model 4), it can be seen that the coefficient of inflation is positive and statistically significant, contrary to our expectation. The analysis of the correlations (Appendix III) shows a negative correlation between agricultural exports and inflation rate. The negative impact of inflation on trade variables has been found by several authors. Thus, inflation has a negative impact on trade openness (Ghosh, 2007) and on the exports as a share of GDP (Gyfalson, 1999). The coefficient of the income growth volatility is negative but not statistically significant. This result is consistent with that obtained by Ghosh (2007), who claims that the relationship between income volatility and trade is indirect and negative, but not direct.

Referring to institutional quality (Model 5), our model does not identify a direct relationship between institutional quality and trade. The coefficients of the government expenditure and democracy are no statistically significant. These results are consistent with the other results that do not find the direct impact of institutional quality on trade (Aizenman and Noy, 2005; Ghosh, 2007). Rodrik (1998) identifies this relationship and claims that the institutional quality enhances exports. Model 6 shows several results. First, the coefficient of agriculture value added is negative and statistically significant. It is the highest coefficient in the Model 6. The direction of the effect implies that higher agricultural value is followed by lower agricultural exports. In making sense of this result, we return to the negative correlation found between GDP per capita and agriculture value added (Appendix III). An increment of GDP per capita is accompanied by a reduction of the agriculture value added. As income grows, the investments in high added value productive sectors increase and the contribution of agriculture to GDP decreases. Dependence theory poses that this result does not always hold (Prebisch, 1959). Agricultural export revenues fund imports of manufactured goods from developed countries, instead of being invested in high value productive sectors (Import-Substitution industrialization, ISI). Gyfalson (1999) concludes that an intensification of agriculture in an economy may ultimately harm exports. Agriculture does not make use of qualified manpower and high technology that confer benefits to other manufactured industries where there is higher trade liberalization. Bertola and Ocampo (2012) highlight that Latin American economies are not taking advantage of the boom in agricultural exports to invest in productive sectors unrelated to natural resources. Achieving a sustainable economic growth requires bridging the technology gap with industrialized countries. Second, as expected, the coefficient of agricultural production is positive and statistically significant. As agricultural production rises, the agricultural exports increase.

In section 4.1 we classified the countries of the sample according to the trade openness and defined two sub-samples (Table 1). Table 5 summarizes the results of Model 1 considering the sub-sample 1 (26 countries less open to trade) and sub-sample 2 (26 countries more open to trade). The second column of the Table 5 presents the Model 7 that includes the dummy variable (trade openness) that equals to 1 if the country belongs to sub-sample 2. The column 3 and 4 show the results of the Model 1 that runs on the sub-sample 1 and sub-sample 2 respectively.

TABLE 5

**Results of the Model 7, sample 52 countries in period 1995-2001. Results of the baseline Model 1, sub-sample 1 and sub-sample 2 in the period 1995-2001**

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

Note: *, **, *** denote statistical significant level at 5 %, 1 % and 0.1 %. Figures in parentheses are the coefficients standard errors.

Source: Own elaboration.

As shown in Table 5 the results of Model 7 are similar to those in those of Model 1. The coefficient of public-private investment remains positive and statistically significant. The sign of the dummy variable "Trade openness", that indicates the countries that belong to sub-sample 2, is negative and statistically significant. The negative sign shows that the agricultural exports of the countries that belongs to sub-sample 2 (those with higher trade openness) are lower than the exports of the countries of sub-sample 1. This result confirms the results of the Wilcoxon-Mann-Whitney test presented in section 4.1.

There are no modifications in the results when we consider the sub-sample 1 and sub-sample 2 separately (column 3 and 4). All the coefficients remain positive and statistically significant, even if the number of observations drops to 350. Comparing the results of the model run between sub-sample 1 and sub-sample 2, the following results stand out: (1) The coefficient of the public-private investment in infrastructure in sub-sample 1 is higher than sub-sample 2. This means that the same investment in countries with higher income generates a higher improvement in exports than in those with lower incomes. This result is consistent with the findings of Portugal-Perez and Wilson (2012). They argue that the impact of investments in infrastructure on exports appears increasingly important as the country´s GDP grows. This result may explain why private investment is focused mainly on higher income countries; (2) The coefficient of GDP per capita is higher in sub-sample 2 than in sub-sample 1, suggesting that income generates higher improvements in agricultural exports in low

income countries than in middle-upper income countries; (3) the coefficient of the world GDP per capita is positive and statistically significant in sub-sample 1, but it is not in sub-sample 2. This result may reflect that global agricultural demand does not influence agricultural exports of lower income developing countries because they do not have as much export capacity to participate in international trade.

## 6. Conclusions

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

First, public-private investment in infrastructure contributes positively to increasing agricultural exports in developing countries. After a few robustness tests, we confirm the positive and significant relationship between public-private investment in infrastructure and agricultural trade. According to this conclusion, the private sector contributes to development goals through the growth of agricultural exports in developing countries. We also conclude that the public-private investments in different sectors do not show the same impact on agricultural exports. The greater impact of telecommunications public-private investment on agricultural exports may support the action to prioritize this kind of public-private investments in developing countries.

Second, the investment in infrastructure and its impact does not show the same performance across the countries analyzed. This finding leads to conclude that the intensity of the positive impact of the public-private investment on agricultural exports depends on the GDP per capita of the exporting country. The impact of the public-private investment in infrastructure is stronger in higher income countries than in lower income countries. The fact that the same public-private investment in infrastructure generates higher agricultural exports in higher income countries explains why private investors appear to be more attracted to higher income countries. Further, this result is even more relevant if we consider the developed and emerging countries concern to access to natural resources in order to cover their food demand. The least developed countries do not raise the interest of private foreign investors. Private investment in these countries is declining and public-private infrastructure investment does not exceed 20 % of the amount invested in the most advanced developing countries. Development goals have to define measures that enhance public-private investment in infrastructure, with special emphasis in less developed countries. This conclusion suggest that the poorest countries require the intervention of public sector without which foreign private investment cannot help national economies to became active participants in international trade. Public-private investment situated

in the framework of a policy of export-led growth should be accompanied by measures that enable farmers to participate in markets by enhancing education, promoting the access to assets and social capital and strengthening institutional structures and financial security (Lapar *et al.,* 2003).

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

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## Appendix I: Sample of countries

| Country | OECD_ Income Classification |
|---|---|
| Bangladesh | Least Developed Country |
| Benin | Least Developed Country |
| Burkina Faso | Least Developed Country |
| Tanzania | Least Developed Country |
| Mozambique | Least Developed Country |
| Senegal | Least Developed Country |
| Uganda | Least Developed Country |
| Yemen | Least Developed Country |
| Kenya | Least Developed Country |
| Cameroon | Lower Middle Income country |
| Egypt | Lower Middle Income country |
| Guatemala | Lower Middle Income country |
| India | Lower Middle Income country |
| Indonesia | Lower Middle Income country |
| Pakistan | Lower Middle Income country |
| Sri Lanka | Lower Middle Income country |
| Bolivia | Lower Middle Income country |
| Côte d´Ivoire | Lower Middle Income country |
| El Salvador | Lower Middle Income country |
| Honduras | Lower Middle Income country |
| Moldova | Lower Middle Income country |
| Morocco | Lower Middle Income country |
| Nicaragua | Lower Middle Income country |
| Paraguay | Lower Middle Income country |
| Philippines | Lower Middle Income country |
| Swaziland | Lower Middle Income country |
| Syrian Arab Republic | Lower Middle Income country |
| Ukraine | Lower Middle Income country |
| Vietnam | Lower Middle Income country |
| Albania | Upper Middle Income Country |
| Argentina | Upper Middle Income Country |
| Brazil | Upper Middle Income Country |
| Chile | Upper Middle Income Country |
| China (People´s Republic of) | Upper Middle Income Country |

## Appendix I (cont.): Sample of countries

| Country | OECD_ Income Classification |
|---|---|
| Colombia | Upper Middle Income Country |
| Ecuador | Upper Middle Income Country |
| Iran | Upper Middle Income Country |
| Mexico | Upper Middle Income Country |
| Peru | Upper Middle Income Country |
| South Africa | Upper Middle Income Country |
| Turkey | Upper Middle Income Country |
| Uruguay | Upper Middle Income Country |
| Venezuela | Upper Middle Income Country |
| Azerbaijan | Upper Middle Income Country |
| Belarus | Upper Middle Income Country |
| Costa Rica | Upper Middle Income Country |
| Gabon | Upper Middle Income Country |
| Kazakhstan | Upper Middle Income Country |
| Malaysia | Upper Middle Income Country |
| Macedonia (Former Yugoslav Republic of) | Upper Middle Income Country |
| Thailand | Upper Middle Income Country |
| Tunisia | Upper Middle Income Country |

Note: Least Developed Countries and Low Income countries: GNI per capita ≤ $1,045 in 2013; Lower Middle Income Countries: GNI per capita $1,046-$4,125 in 2013; Upper Middle Income Countries: GNI per capita $4,126-$12,745 in 2013.

Source: OCDE (2014).

## Appendix II: Descriptive statistics of the variables included in the models

| Variable | Measure | Source | Nº obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Agri_X | Current million US$ | World Development Indicators | 834 | 784 | 1,598 | 6 | 15,807 |
| PPI_Infra | Current million US$ | PPI World Bank | 748 | 1,605 | 4,975 | 1 | 68,190 |
| XRT | Local currency per US$ | World Development Indicators | 879 | 1,102 | 3,405 | 0 | 25,000 |
| GDP_cap | Current US$ per habitant | World Development Indicators | 883 | 2,583 | 2,522 | 141 | 14,501 |
| WGDP_cap | Current US$ per habitant | World Development Indicators | 884 | 6,808 | 1,704 | 5,161 | 10,201 |
| Inflation | Difference of logharitms | World Development Indicators | 883 | 12 | 34 | -9 | 99.87 |
| Volatility | Moving standard deviation | World Development Indicators | 884 | 2 | 2 | 0 | 9 |
| Gov_expend | Percent of GDP | World Development Indicators | 870 | 13 | 4 | 4 | 27 |
| Democracy | Index | POLITY IV Project database | 867 | 3 | 6 | -9 | 10 |
| Agri_sector | Percent of GDP | World Development Indicators | 862 | 16 | 9 | 2 | 56 |
| Agri_prod_ cap | Current US$ per habitant | FAO Database | 761 | 327 | 228 | 18 | 1,725 |

Note: Nº obs (Number of observations); Std. Dev (Standard Deviation); Min (Minimum); Max (Maximum).

Source: Own elaboration based on World Bank (2014a), World Bank (2014b) and FAO (2014).

## Appendix III: Partial correlations. Sample of 52 countries in period 1995-2011

| | Agri_X | PPI_Infra | XRT | GDP_cap | WGDP_cap | Inflation | Volatility | Gov_expend | Democracy | Agri_sector | Agri_Prod_cap |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agri_x | 1.00 (834) | | | | | | | | | | |
| PPI_Infra | 0.55* (711) | 1.00 (748) | | | | | | | | | |
| XRT | 0.12* (829) | -0.16* (744) | 1.00 (879) | | | | | | | | |
| GDP_cap | 0.33* (834) | 0.29* (747) | -0.28* (878) | 1.00 (883) | | | | | | | |
| WGDP_cap | 0.18* (834) | 0.15* (748) | 0.04 (879) | 0.37* (883) | 1.00 (884) | | | | | | |
| Inflation | -0.07* (804) | 0.01 (724) | -0.03 (848) | -0.03 (852) | -0.06* (853) | 1.00 (853) | | | | | |
| Volatility | -0.03 (834) | 0.06 (748) | -0.19* (879) | 0.10* (883) | -0.29* (884) | 0.27* (853) | 1.00 (884) | | | | |
| Gov_expend | 0.02 (826) | 0.03 (734) | -0.18* (865) | 0.14* (870) | 0.05 (870) | 0.03 (839) | 0.02 (870) | 1.00 (870) | | | |
| Democracy | 0.03 (817) | 0.13* (734) | -0.09* (862) | 0.20* (866) | 0.04 (867) | 0.03 (836) | -0.04 (867) | -0.04 (856) | 1.00 (867) | | |
| Agri_sector | -0.29* (816) | -0.29* (727) | 0.32* (857) | -0.84* (862) | -0.20* (862) | 0.02 (831) | -0.08* (862) | -0.16* (858) | -0.18* (848) | 1.00 (862) | |
| Agri_prod_cap | 0.24* (727) | 0.16* (649) | -0.13* (756) | 0.79* (761) | 0.48* (761) | 0.01 (738) | 0.06* (761) | 0.24* (752) | 0.12* (744) | -0.48* (747) | 1.00 (761) |

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

Source: Own elaboration based on World Bank (2014a), World Bank (2014b) and FAO (2014).