Trade Openness and Innovation

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ABSTRACT

This paper analyzes the relationship between a country's trade openness and innovation. We find evidence that public policies aiming to improve trade openness have a positive impact on the level of innovation in a country. The results are robust to alternative indicators and various forms of measuring innovation. This positive relationship between trade openness and innovation is even stronger in emerging markets. Opening the economy to international trade is a natural route to stimulate innovation in businesses.

***Key words*:** Public policy, trade openness, innovation, Global Innovation Index, instrumental variables. *JEL Code* (economic)**:** F19, H7, H8, O31, O33

Introduction

It is generally acknowledged that innovation is positive for countries.[2] We focus on a broad definition of innovation, understood to be the successful exploitation of novel ideas. In this way, innovation does not only consist of the creation of new ideas but also the adoption of ideas that already exist (Duggan, 1996). Countries that are more innovative also have higher per-capita income (Cheung, 2014). In fact, the correlation coefficient between the Global Innovation Index and per capita income is 0.8.[3] It is unclear, however, what a country can do to facilitate innovation in businesses. The optimal set of public policies to generate a higher level of innovation is still an open query.

In this study, we focus on a public policy at a macro level: trade openness. Trade openness refers to an outward (as opposed to an inward) orientation by a country. An outward-oriented (open) economy takes advantage of the opportunities to trade with other countries. Alternatively, an inward-oriented (closed) direction overlooks or is unable to take advantage of opportunities to trade with other countries. Public policy decisions associated with trade openness are reduced trade barriers, tariffs on imports and exports; investment in infrastructure; and limited regulations affecting market competitiveness. We analyze the relationship between trade openness and the depth of the innovation process at a country level and present evidence that, for many countries, opening up to international trade positively impacts innovation in firms. We also find that the effect is even stronger for emerging than for developed economies.

[1] Erika Chabén provided excellent research assistance.

[2] See Cornell University et al. (2014).

[3] Per-capita income was measured by the per-capita GDP in UD dollars with data from the World Bank (2014). The Global Innovation Index comes from Cornell University et al. (2014). They developed a metric through which innovation can be measured across the globe.

A recent study that included interviews with 100 executives at large international companies from all over the world found that 80 percent of business owners expected to attribute significant portions of their earnings to innovation (Engel, Andrade, Peterson, Zuazua and Ruppert, 2016). According to PricewaterhouseCoopers (2012), businesses in the United States that considered innovation to be one of their main objectives grew at faster rates than their peers that did not consider it a priority. Furthermore, 49 percent of business owners interviewed stated that they had considered adopting new technologies in the next few years that would focus on improving innovation procedures. Moreover, it appears to be essential that the government facilitate the process of adopting new technology alongside more substantial and faster mechanisms for technological transference. This same study found that 55 percent of businesses in the United States that sell to the domestic market considered innovation to be a priority, while businesses that sell abroad have this percentage increase to 87 percent. This data suggests that, not only is broader openness relevant to international trade with regards to facilitating technological transference, but it also shows that businesses in international markets assigned greater importance to innovation procedures, which increased the amount of resources allocated to said process.

Methods to innovate have come to play a fundamental role in businesses, becoming essential to profitability as well as remaining in existence. It is therefore essential to try to understand the determinants of innovation in order to implement public policies and measures that will drive firms to innovate.

The channels through which trade openness policies affect innovation in countries is fundamentally foreign direct investment, imports, exports, and competition.

There is ample evidence that trade openness, allowing opportunities such as free trade agreements, generates an increase in foreign direct investment (MacDermott, 2007; Bühte and Milner, 2008; Medvedev, 2012). As such, countries that are more open to international business tend to attract larger amounts of investment from abroad. These investments encourage technological transference between countries and businesses, since in many cases they involve research and development, new machinery for manufacturing, or novel production methods. Furthermore, foreign direct investment generates positive externalities, since local businesses can observe and replicate the procedures implemented by foreign businesses, as competitors, parent companies, or acquirers (Görg and Greenaway, 2003; Girma et al., 2008).

Public policies that enhance international trade of tangible goods facilitate the exchange of intangible ideas (Grossman and Helpman, 1995). In other words, the importation of capital goods with high technological content that are used in manufacturing contribute to technology transference.[4] Evidence suggests that imports with high technological content generate a positive and significant impact on innovation (Schneider, 2005). A country that imports goods with higher technological composition than those available in the local market will be able to improve efficiency and quality of manufactured goods, and to produce goods with higher added value. Furthermore, the contribution to productivity from technology coming from countries with more

[4] In addition, according to Wacziarg (2001) the accelerated accumulation of physical capital is one of the most important channels through which openness positively affects economic growth.

innovation is even larger than that coming from domestic research and development (Acharya and Keller, 2009).

The beneficial impact of trade on innovation does not relate only to the import of capital goods with high technological content, however. Benefits can also be seen in exports. According to Kiriyama (2012), innovation can also be acquired in the export process. When businesses enter the international market, they have better access to sophisticated practices and advanced methods of production. Furthermore, commercializing with high quality standards encourages innovation. De Loecker (2007) found evidence that when businesses start to export they increase their productivity as soon as they enter the international market, and that the productivity gap between exporters and non-exporters increases with time. He also found that the gains in productivity are superior in companies that export to countries with higher income. At the same time, opening up the market exposes local businesses to international competition, creating incentives for them to adopt new technology and innovative activities in order to become more competitive. Entering the international marketplace allows manufacturers to expand their consumer base, allowing them to exploit economies of scale and to have the ability to defray the costs of investment in research and development. This process of trade openness does not only generate an increase in innovation, but also leads the market to be dominated by more efficient producers and to improve the allocation of resources. Bugamelli and Schivardi (2010) found evidence that surviving businesses in a globalized and competitive market offer products with more differentiation and can escape cost-based competition.

The paper continues as follows. In the next section, we present our empirical strategy. Then, we describe the data used and report the results obtained. Finally, we conclude and discuss the results.

Empirical Methods

In order to estimate the relationship between the level of innovation and public policies that enhance trade openness, we suppose that for each country *i* there exists a direct linear relationship between the level of innovation (I_i) and trade openness (T_i):

$$I_i = \alpha + \beta T_i + \varepsilon_i \qquad (1)$$

If we estimate the value of parameter β using ordinary least squares, we obtain the first approximation of the effect of international trade on innovation. However, we could not identify this as a causal effect because not only is innovation determined by trade openness but also the level of trade openness is determined by greater levels of innovation. It could happen that a more open country would be more likely to have a higher level of innovation, but it is also possible that elevated levels of innovation cause trade openness, because not only would local producers want to place their competitive products on the market, but also the demand for these products would be high throughout the world.

To unravel the reverse causality induced by the fact that innovation could itself generate trade openness, we follow the method developed by Frankel and Romer (1999) who studied the

relationship between trade openness and economic growth. Previous literature (Linnenman, 1966; Frankel, Stein and Wei, 1995; Frankel, 1997) considered the fact that bilateral trade between countries depends on the geographic proximity (P_i). At the same time, they considered that the level of innovation should not affect the geographic proximity of the country to the rest of the world.

We assume a linear relationship between trade openness and geographic proximity:

$$T_i = \gamma + \delta P_i + \omega_i \quad (2)$$

Substituting (2) for (1), we rewrite the original relationship as:

$$I_i = \alpha + \beta\gamma + \beta\delta P_i + \beta\omega_i + \varepsilon_i$$

And if we define the following variables:

$$\tilde{\alpha} = \alpha + \beta\gamma,\ \tilde{\beta} = \beta\delta,\ \tilde{\varepsilon}_i = \beta\omega_i + \varepsilon_i \quad (3)$$

We come to the following equation for each country i:

$$I_i = \tilde{\alpha} + \tilde{\beta} P_i + \tilde{\varepsilon}_i \quad (4)$$

To compute the effect of trade openness on innovation (β) we first made estimates of δ using ordinary least squares in equation (2). Next, we made estimates of $\tilde{\beta}$ using Ordinary Least Squares (OLS) in equation (4).[5] With the estimated values of δ and $\tilde{\beta}$ we finally obtained β of equation (3), the causal impact of trade openness on innovation. This is no more than an estimate of equation (1) using the Instrumental Variable (IV) method, our instrument being geographical proximity.[6]

Data

We define trade openness as the sum of exports and imports as a percentage of GDP, using data from the World Bank. The geographic proximity variable is taken from Frankel and Romer (1999), which includes information on the distance between countries, the size of countries, whether they have direct access to the ocean, and if they have land borders. The population data (millions of people) and geographic area (square miles) are those published by the World Bank. We consider all the data for 2014. We classify countries as developed or

[5] OLS chooses the parameters of a linear function of a set of explanatory variables by the principle of least squares, which minimizes the sum of the squares of the differences between the observed dependent variable in the data and those predicted by the linear function.

[6] IV is an estimation method that allows for consistent estimation when the explanatory variables are correlated with the error terms in a regression model. In linear models, the instrument must be correlated with the endogenous explanatory variables, conditionally on the other covariates and cannot be correlated with the error term in the explanatory equation, conditionally on the other covariates.

emerging using the criteria of the Organization for Economic Co-operation and Development (OECD) (according to per capita gross national income).[7]

To quantify the level of innovation in countries, we use the Global Innovation Index in 2014, developed by Cornell University. The Global Innovation Index is a ranking of countries on their capacity for, and success in, innovation based on both subjective and objective data extracted from several sources, including the International Telecommunication Union, the World Bank and the World Economic Forum. It includes a total of 81 indicators for 143 countries representing 98 percent of the global GDP. This indicator is the simple average of two sub-indexes, the Innovation Input Sub-Index and the Innovation Output Sub-Index. The first reflects elements necessary to implement the innovation process: institutions, human resources and research, infrastructure, market sophistication, and business sophistication. The second reflects the results of innovative activity in the economy: technological, knowledge, and creative production.

In accordance with the Global Innovation Index of 2016, the countries that lead innovation are Switzerland, Sweden, the United Kingdom, the United States, Finland, Singapore, Ireland, Denmark, the Netherlands, and Germany. There is a clear majority of countries from North America and Europe in the first positions of the ranking. Nevertheless, in the last few years, countries from the Asia-Pacific region such as Australia, Japan, Korea, Singapore, Israel and Australia, began to ascend to the top spots in the global rankings. On the other hand, China is the first emerging economy country to enter the first quartile of the most innovative countries, after climbing through positions in each edition of the global ranking.

In Table 1 we present a summary of the statistics for the data used in our estimates.

Table 1: Summary Statistics

	Median	Standard Deviation	Minimum	Maximum
Trade Openness	90	64	25	439
Global Innovation Index	38	12	18	65
Input Sub-Index	44	13	25	74
Output Sub-Index	32	12	7	63
Geographical Proximity (index)	24	30	2	281
Population (millions of inhabitants)	62	189	0.1	1364
Area (square miles)	343	756	0.2	3852

Results

Firstly, we analyze the quality of the instrument (the first step in two-stage OLS estimates) using a regression of the variable openness against geographical proximity.

[7] See OECD Country Classification for aid and repayment terms.

Given that the components of geographical proximity are correlated to the size of the countries, we use geographic area and population as control variables in order to identify the pure effect of trade, and to set aside the fact that larger countries have less openness because of the diversion of commerce towards their domestic market (Frankel and Romer, 1999).

Table 2: Quality of the Instrument

Dependent Variable: Trade Openness

	(1)	(2)	(3)	(4)
Constant	174.27***	120.55***	112.37***	63.37***
	(12.16)	(16.60)	(8.90)	(19.61)
Geographical Proximity		0.86***		0.99***
		(0.20)		(0.36)
Ln Population	-1.02	2.44	-11.41***	-8.84***
	(4.33)	(4.05)	(2.98)	(2.99)
Ln Area	-18.81***	-13.33***	-0.51	4.30
	(3.56)	(3.50)	(2.78)	(3.18)
Sample	100	100	72	72
R^2	0.38	0.48	0.35	0.42

Estimates calculated using Ordinary Least Squares. Standard deviations are between parentheses.[8] (*) significant at 10%, (**) significant at 5% and (***) significant at 1%. The sample of 72 countries only included emerging countries. Ln is the Naperian logarithm.

The results indicate that geographical proximity is a variable that explains the amount of trade between countries, even after controlling for the effect of size (see columns (1) and (2) in Table 2).[9] Similar results hold when we consider exclusively emerging economies (see columns (3) and (4) in Table 2).

In Table 3 we present the main empirical results. The columns with OLS in the heading considered equation (1) and suffered from the problem of reverse causality. However, the columns with IV in the heading considered equations (2), (3), and (4) in the two stages of the OLS estimation. In all specifications of the model, openness has a positive, statistically significant impact on innovation.

The effect is stronger when we use specifications (2) and (4), which capture the pure effect of openness on innovation. As such, as countries increase trade with the rest of the world, their level of innovation will increase. The largest effect is observed in column (4), where we only consider emerging countries, which suggests that developing countries, which are the ones that are the most dependent on foreign technology, can benefit the most from technology transference through international commerce. According to Soubbotina (2006), countries with

[8] The results are robust if standard error is calculated as per White (1980).

[9] The simple correlation between openness and geographical proximity is 0.62.

the least ability to develop new technology are those that benefit the most from importing items with high technological content.

Table 3: Main Results

Dependent variable	Global Innovation Index			
	OLS	IV	OLS	IV
Constant	28.80***	24.38**	25.92***	14.56
	(4.75)	(10.04)	(3.66)	(10.75)
Trade Openness	0.08***	0.10*	0.06**	0.17*
	(0.02)	(0.06)	(0.03)	(0.09)
Ln Population	0.50	0.52	-0.31	0.85
	(0.96)	(0.97)	(0.74)	(1.30)
Ln Area	0.32	0.79	0.45	0.51
	(0.89)	(1.31)	(0.63)	(0.69)
Sample	100	100	72	72
R^2	0.13	0.12	0.11	-0.07

OLS refers to Ordinary Least Squares and IV to Instrumental Variables. Standard deviations are between parentheses. (*) significant at 10%, (**) significant at 5% and (***) significant at 1%. The sample of 72 countries only included emerging countries. Ln is the Naperian logarithm.

With the exception of specification (3), country size, whether measured using geographical area or population, has a positive impact on the level of innovation, although it is not significant. This result appears to be quite intuitive, and it is consistent with the literature. According to Boserup et al. (1981), there are demographic factors that can explain failures in technology transmission, a fundamental factor in innovation. For example, there are certain technologies, products, and procedures that are not appropriate for areas with small populations.

The Global Innovation Index, which is used to quantify the level of innovation, is composed of two sub-indexes, the Output Sub-Index, which reflects the results of innovation, and the Input Sub-Index, which takes into account the inputs that make this possible.

Given that inputs such as human capital, quality of institutions and political stability, among others, are factors that require deep reforms, with results in the long run, it is crucial to study the effect of trade openness exclusively on the results of innovative procedures. For this, we use the dependent variable of the Output Sub-Index, which measures technological, knowledge, and creative production in countries. As with the rest of the models, we controlled for the size of the countries.

The impact of trade openness is stronger than in the previous models, maintaining their positive sign and significance (see Table 4). The effect is larger in specifications which use the IV estimation. The largest impact of trade on innovation is seen when only emerging countries are examined.

Table 4: Alternative Results: Output Sub-Index

Dependent variable	Innovation - Output Sub-Index			
	OLS	IV	OLS	IV
Constant	22.26***	11.06	19.11***	4.72
	-4.81	-10.53	-4.21	-12.58
Trade Openness	0.07***	0.13**	0.06*	0.19*
	-0.02	-0.06	-0.03	-0.11
Ln Population	0.9	0.97	0.31	1.78
	-0.97	-1.01	-0.85	-1.52
Ln Area	0.31	1.52	0.44	0.5
	-0.91	-1.37	-0.72	-0.81
Sample	100	100	72	72
R^2	0.1	0.03	0.06	-0.18

OLS refers to Ordinary Least Squares and IV to Instrumental Variables. The standard deviation is between parentheses. (*) significant at 10%, (**) significant at 5% and (***) significant at 1%. The sample of 72 countries includes those with emerging economies. Ln is the Naperian logarithm.

To measure how robust these results are, we regressed the Input Sub-Index upon trade openness (Table 5). Using OLS estimation, the coefficient for trade openness is significant, but when IV estimation is used this significance is lost. The coefficients that emerge when using the Input Sub-Index as a dependent variable, in addition to not being significant, are considerably less than those obtained with the Output Sub-Index.

Table 5: Alternative Results: Input Sub-Index

Dependent variable	Innovation - Input Sub-Index			
	OLS	IV	OLS	IV
Constant	35.28***	37.8***	32.68***	24.33**
	-4.95	-10.41	-3.64	-10.28
Trade Openness	0.08***	0.07	0.07***	0.15
	-0.02	-0.06	-0.03	-0.09
Ln Population	0.09	0.08	-0.93	-0.08
	-1	-1	-0.74	-1.24
Ln Area	0.33	0.06	0.48	0.52
	-0.93	-1.36	-0.63	-0.66
Sample	100	100	72	72
R^2	0.15	0.15	0.2	0.12

OLS refers to Ordinary Least Squares and IV to Instrumental Variables. The standard deviation is between parentheses. (*) significant at 10%, (**) significant at 5% and (***) significant at 1%. The sample of 72 countries includes those with emerging economies. Ln is the Naperian logarithm.

We also checked robustness by excluding from the sample three countries with extreme values: Hong Kong, Luxembourg, and Singapore. The results remained constant.[10]

Conclusions and Discussion

This paper analyzed the relationship between trade openness and innovation. Using geographical proximity as an instrumental variable to avoid the possible reverse causality generated by the fact that innovation can generate more openness, there is evidence that public policies that reinforce trade openness have a positive impact on the degree of innovation in countries. This effect is even stronger in countries that are emerging economies. As such, opening the economy to international commerce appears to be the natural choice for stimulating the process of innovation in businesses.

Having presented evidence that suggests opening up to international trade has a positive impact on innovation, it is relevant to ask what factors are behind this process. According to the World Bank (2008), technological progress in most developing countries is determined by the speed with which they adopt, adapt, and successfully use existing technology. The different speeds can be explained by a country's ability to adopt, through qualified labour, the appropriate business environment to incentivize investment. This can be affected by access to capital, quality of institutions, and a public sector responsible for promoting the dissemination of technology when private demand or market forces fail to do so. Many of these characteristics can be stimulated by public policy.

Di Stefano et al. (2012) also suggested that the level of innovation does not only depend on having adequate conditions for production but also on demand, which affects the rapidity of adoption of innovation. According to a poll carried out by the European Commission in 2011, two thirds of European business owners confirmed that uncertainty about demand for their more innovative products tended to limit and slow the innovation process. While technological gaps between countries allow for accelerated growth and convergence towards levels of development shown in more advanced countries, they can also act to the contrary if businesses, consumers, and government in those countries do not have the necessary conditions for transference and adoption of technology. This reveals the importance of implementing appropriate public policy to create an environment that stimulates innovation.

The next line of possible research would be to analyze, in depth, the channels for transmission between openness and innovation by considering firm-level data.

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[10] Details on the estimates are available upon request.

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