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Productivity and technological externalities: Study based on a dynamic panel model for developing countries

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Abstract: The objective of this paper is to examine the effect of trade and financial openness, through the technology transfer channel, on total factor productivity (TFP) in a panel of developing countries between 1988 and 2014. According to a growing body of literature on the subject, there is a strong link between openness and economic growth, but are technological externalities a key element for developing countries? To answer this question, we resorted to dynamic panel data modeling, thus allowing us to detect the eventual impact. The main results of our study show a positive and significant effect of exports and the externalities of technology conveyed by foreign trade on TFP. As for the imports of goods, apart from those with high technological content, they have a negative and significant effect. However, the identification of the effect of human capital and foreign direct investment is far from obvious. The results show that they have a positive but statistically insignificant effect.

Keywords: Openness; technological externalities; total factor productivity; generalized method of moments; developing countries.

1. Introduction

If there is one area where an economy must make a priority, it is that of research into the sources of growth. For several decades, a large debate has taken place on this subject, which has captured the attention of many economists. This debate has been, particularly, fueled by numerous theoretical and empirical studies, which have attempted to reveal the importance of the sources, such as the accumulation of physical capital, human capital, investments in R&D, diffusion of technology, innovation, trade, or financial openness, and many other phenomena in economic growth. In this context, the emergence of certain economies through trade with the rest of the world prompted researchers to list and examine the transmission channels through which openness can impact productivity and, generally, economic growth.

One of the subjects that is attracting great interest in international economics is that of technological externalities spurred by trade and financial openness and their consequences on productivity and economic growth. The free movement of goods and capital is now considered an important factor in the elaboration of development strategies. In theory, openness has its merits, in particular, through its effect on international specialization and competitiveness, which also depend on the level of technology and the ability to innovate.

In light of this, the least developed countries' openness policies could help them gain on the advanced ones. The adoption of international technical progress appears to be vital for developing countries to improve their productivity growth (Romer [1]). The use of technologies developed outside the geographical territory is a possible means and a viable alternative to fill the innovation and technological gaps. A large number of developing countries are accelerating their growth by leveraging technology transfers towards the technological frontier. However, the majority of transfers made during the 1980s failed due to a lack of adequate local conditions for countries to prepare for the successful use of imported technologies, such as human capital and public infrastructure. In general, economic theory, particularly the work of Romer [1, 2] and Lucas [3], has shown that technological transfers can have important feedback on growth, human capital, R&D activities, foreign trade policy, and government action in general.

Neoclassical growth models, such as Solow [4], assume that technological change is exogenous. In such a framework, the trade policies cannot therefore affect growth. Since the early 1990s, new growth theories consider technological change to be endogenous. Ever since, it has become possible to integrate the new trade theory with endogenous growth models. From this perspective, dynamic gains are linked in particular to economies of scale and the diffusion of technological progress through openness. Among others, these authors have argued that countries most open to trade have a greater capacity to absorb techn8ological progress generated by advanced countries, as pointed out by many authors, such as Romer and Rivera-Batiz [5] and Grossman and Helpman [6].

To explain the mechanism by which openness positively affects growth, Barro and Sala-i-Martin [7] construct a model which considers a world with two countries, one advanced and the other developing. Under the hypothesis of the absence of capital mobility, an advanced country innovates, while the developing country is limited to imitating new techniques. The rate of growth of a developing country is determined by the cost of imitation and its initial stock of knowledge. If the cost of imitation is lower than the cost of innovation, the less developed countries will grow faster than the most advanced countries and that will spur the process of convergence. For developing countries, specialization is a factor of acceleration of economic growth. Specializations in developing countries depend on technological changes taking place in competitive industries. In this sense, the product cycle theory describes how a product's life cycle dictates where it is manufactured. Indeed, through specializing in stages of production where developing countries have a comparative advantage, they can accelerate the diversification of their exports. This is known as "the vertical division of labor", it results in an increasing weight of intermediate products in international trade. This is, as we have already mentioned, a source of efficiency, that is, the producer who uses them has a greater variety of inputs, which allows firms to improve their productive combinations (Fontagné et al. [8]).

The work of François, McDonald and Nordström [9] provides an illustrative example of openness gains, in particular through a small number of mechanisms: a good inter-branch specialization that drives growth and improves the level of economic development, which leads to an increase in intra-industry trade. The development of intra-industry trade allows a greater diversity of intermediate and capital goods to be available, which enhances total factor productivity and technological diffusion.

In theory, openness is a driving force of economic growth through expanding into international markets, but also because it increases the number and quality of intermediate goods used in production, and therefore promotes the transfer of technologies and increases the benefits of technological innovation. As a result, the externalities of technology have been of great concern to growth economists. Theoretically, four channels exist that allow the least developed countries to benefit from development in advanced countries: trade in technology intensive capital goods (active diffusion), trade in goods and services incorporating technology (passive diffusion), foreign direct investment and its "spillovers" technological potential towards domestic businesses and the movement of people "labor turnover" with a certain sharing of knowledge among individuals.

According to the majority of authors, the link between openness and economic growth is strong. But, do these technological externalities constitute key elements for developing countries? The change in the economic context, at the national and international level, leads us to re-examine the question of the relationship between openness and growth in order to determine the impact of openness via technological externalities on productivity and, subsequently, economic growth in developing countries. To this end, the central question of our study can be expressed as follows: What is the impact of trade and financial openness, particularly through the transfer of technologies, on total factor productivity in developing countries? In this context, several sub questions arise, in particular, can recourse to technology transfers constitute a source of performance, productivity, and improved economic growth in the current economic context of the countries studied? Or, what are the necessary local conditions to allow research and development externalities to accelerate economic growth in these countries?

The objective of this paper is to examine the effect of trade and financial openness through the technology transfer channel on total factor productivity (TFP) for a panel of 35 developing countries between 1988 and 2014. To better estimate the parameters of interest and achieve greater robustness in our results, we will use different estimation methods and a series of tests in order to determine the appropriate estimator to identify, separately and rigorously, the structural component of the variables and the component that refers to unobserved heterogeneity, and to overcome certain problems, such as heteroscedasticity and autocorrelation.

The rest of the paper is organized as follows. Section two presents a review of the literature, section 3 presents the materials and methods, section 4 shows the results, section 6 discusses the results and finally section 7 concludes.

2. Literature review

The econometric analysis of the link between openness and growth was of great interest in the 1990s. The empirical study that had the most influence on this theme is that of Sachs et al [10], which estimated this link for 122 countries between 1970 and 1989. According to these authors, openness policies are the main factor explaining growth in emerging countries. The results of this study showed that open developing countries recorded a high growth rate compared to closed developing countries. Caupin and Saadi-Sedik [11] analyze the effects of the trade openness policy on the volatility of. economic growth of the Middle East and North Africa countries over the period from 1960 to 1999. At the end of the aforementioned study, the authors conclude that there is a beneficial effect of openness policies on the resilience of countries, which outweighs the negative effect caused by increasing exposure to external shocks. Abdeljabbar and Hanchane [12] proposed empirical tests on a panel of 47 developing countries covering a period between 1980 and 1997, and they specified a dynamic model. The results of this study show that the coefficients attached to variables representing openness are always positive and significant. This shows that the opening up of developing countries has an overall positive and significant effect on their economic growth.

Modeling the link between trade and domestic technical change has been the subject of other studies. In particular, Rivera-Batiz & Romer, Grossman & Helpman, Coe & Helpman and Coe et al. [5, 6, 13, 14]. These authors have attempted to explore the benefits of externalities resulting from the diffusion of technological knowledge on TFP. Coe and Helpman [13] are the first to provide evidence of the importance of trade in the international diffusion of technology, and, therefore, as the main driver of technological progress and productivity growth. Furthermore, empirical results have confirmed that the more open a country is to foreign trade, the more likely it is to benefit from foreign R&D. The above study has shown that TFP growth in developing countries is favorably and significantly related to the degree of openness to trade with and R&D in advanced countries. In such a framework, several works, including Coe and Helpman's paper, criticized the constructed variables and the hypotheses developed by these pioneering authors. Critics have focused on building the stock of foreign R&D capital.

Lichtenberger and Pottelesberg [15] proposed extensions by estimating the same equations with an additional explanatory variable expressing foreign externalities. Their results show that the more a country imports from another country which is more advanced in terms of R&D, the more it benefits from technological externalities. They confirm the hypothesis of the existence of a positive correlation between the rate of openness and technology transfers in R&D. Lumenga-Neso et al. [16] thought otherwise on the subject. They built a new variable that explains the technological externalities, namely, the international spillovers of R&D indirectly linked to trade. The results verify the importance of trade in the transmission of knowledge at the international level, but contradict the ideas concerning the strong dependence between a country’s foreign R&D flows and its trading structure. Regarding externalities linked to technology and intra-industry trade, Coe et al. [14] showed that trade plays a significant role in the transfer of technology from industrialized to developing countries. For these authors, the positive externalities of the R&D of the industrialized countries of the North and the developing countries of the South are significant and substantial. A 1% increase in the R&D capital stock in the United States is associated with an increase in TFP of 0.04% on average for the 77 developing countries in the sample. The determining factor of the results found is the quality of the education systems and, therefore, the absorption capacity of developing countries in the South. Hakura and Jaumotte [17] confirmed the previous result while examining the type of trade, intra or inter-branch. These authors have used data from 87 countries over the period 1970-1993, among which 63 are from developing countries and 24 are from OECD countries. According to these authors, intra-industry trade is a channel of more efficient technology transfer than inter-industry trade. Indeed, countries are likely to better absorb foreign technologies when their imports are from the same sectors as the goods they produce and export.

In the work of Okubo [18], it was found that the greater the difference in GDP and factor endowments, as is the case between the countries of the North and those of the South, the more likely technology transfer will take place. In addition, technology transfer is positively correlated with intra-industry trade. On the side of externalities linked to technology and foreign direct investment (FDI), Blomström et al. [19] show that there is technology transfer from developed countries to developing countries through FDI when three conditions are met: i. e., competition; past performance of the country's firms in the South, and above all, the integration of domestic and foreign firms. The work of Bouallegui Imen [20] aims to empirically test, for a panel of 8 developing countries bordering the Mediterranean, the long-term relationship between TFP and technological spillovers generated by both FDI and international trade. This long-term relationship is estimated using recent panel data econometrics techniques, spanning a period of 26 years, from 1981 to 2006. The estimates confirm the presence of a positive and statistically significant impact, through the two technology transfer channels, imports and FDI.

More recently, Moskalyk [21] uses panel data methods in combination with instrumental variable analysis to determine the effects of technological trade openness and technology transfers on growth in developing countries. The results indicate that imports with high technological content and R&D spillovers from advanced countries remain the main channels of international technology diffusion, affecting productivity growth in developing countries. Similarly, the level of education, domestic R&D activity, use of foreign intellectual property rights, and institutional improvement can positively and substantially increase TFP in a developing country.

Time series studies are no different from panel data models. Sanusia et al. [22] explored the dynamic relationships between technological innovation, trade openness, and GDP in Saudi Arabia between 1989 and 2019. Using an error correction model, the results show that technological innovation and trade openness have short-term impacts on economic growth. Also, pairwise Granger causality indicates a causality running from technological innovation and trade openness to GDP growth without feedback. This supports an economy driven by innovation and trade liberalization. This result suggests a more strategic opening of the economy to foreign trade and a massive investment in R&D and technological innovation for the achievement of strong and sustainable economic growth. In researching the indirect effects of technological transfers on growth through improving the innovation capacity of manufacturing entities in Nigeria, Enemuo et al. [23] found a significant positive effect of technology transfers.

Theoretical and empirical analysis tends to show that international trade is a mechanism by which technological and knowledge are transferred. It can be a vector for the diffusion of high technology products. As a result, developing countries should use imports as a source of knowledge accumulation in order to enhance their level of growth and position themselves in sectors where international demand is strong and the potential productivity gains are greater. However, it should be noted that in the case of developing countries, the effect of imported technologies on growth is determined by the countries' ability to absorb and disseminate them.

3. Materials and Methods (Data and Methods)

3.1. Empirical methodology

3.1.1. Definition of the variables

Total factor productivity (TFP) is the endogenous variable that measures the fraction of growth output (generally GDP) not attributable to growth in the volume of factors of production (physical capital and labor). A theoretical framework proposed by Solow [4] is intended for measuring TFP. Thus, the production possibilities are assumed to be represented by a global production function with Hicks-neutral technical change. This technical progress is assumed to be exogenous and cost-free:

$$Y = A.\ F\ (K, L). \qquad (1)$$

Where Y is an aggregate output, A is technical progress or TFP and F is a function using two factors of production, capital (K) and labor (L).

To fully capture the effects of openness on TFP in developing countries, we used in our model variables, such as imports of goods excluding those with high technological content such as equipment goods, exports of goods, and an index of R&D externalities.

However, openness is no longer confined to international trade; it additionally comes from the capital flows of multinational firms. This can improve the overall efficiency of an economy through the transfer of technological and organizational knowledge to the rest of the economy. We therefore find it necessary to add FDI to our growth equation to account for all channels through which openness affects economic growth, a variable represented by net FDI inflows.

We express technological externalities in terms of a composite variable consisting of imports of capital goods from high-income countries and the share of R&D expenditure of industrial countries in their GDP. This variable that we built represents a "proxy" for the transfer of technology and knowledge to developing countries. The definitions and sources of the variables used are presented in Table 1.

We add to our specification the human capital variable, as in the work by Coe and al [14] and Levin and Raut [24]. These works suggest that in order to benefit from openness, developing countries must be endowed with skilled labor, i.e., human capital able to assimilate foreign technology. Based on a common approach in the literature, which is that of Caselli [25], we use an index of human capital based on average years of schooling and an assumed rate of return to education and multiply it by the number of workers.

Table 1 summarizes all the variables chosen, their definitions, as well as their sources, respectively.

Table 1. List of variables.

Variables	Definitions	Sources
Total factor productivity (TFP)	Total (Global) Factor Productivity measures the fraction of output growth not attributable to the growth in the volume of production (physical, capital, and labor).	Penn world table
Imports of goods other than equipment (M)	Imports of goods represent the value in CAF price of goods other than equipment received from the rest of the world valued in the current US dollar.	Author's calculations
Exports of goods (X)	Exports of goods represent the value in FOB price of the goods supplied to the rest of the world valued in the current US dollar.	World Bank data
Foreign direct investment (FDI)	FDI refers to the flow of direct investment. It is the sum of equity, reinvestment of profits, and other capital coming from foreign multinational firms.	World Bank data
The externalities of R&D (EXT)	The "Proxy" for technology transfers and knowledge transfers to developing countries built from imports of capital goods from countries in our panel and the share of R&D expenditure of industrial countries (OECD countries) in their GDP.	Own calculations
Human capital (HC)	Human capital index, based on years of schooling and returns to education.	Penn world table
Research and development spending (R&D)	R&D expenditures are current and capital expenditures (public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, society, and the use of knowledge for new applications. R&D covers fundamental research, applied research, and experimental development.	OECD
Number of people engaged	The number of people hired out of all people aged 15 and up who have worked, even if only one hour per week, or who were not at work but had a job or business from which they were temporarily absent.	Penn World Table
Imports of capital goods	Imports of capital goods are imports of tangible goods such as machines, vehicles, and tools that an organization uses to produce goods or services (equipment).	World Integrated Trade Solution

3.1.2. Presentation of dynamic panel data models

Dynamic panel data models are characterized by the presence of one or more lagged endogenous variables among the explanatory variables. We take, for instance, the case where there is only one lagged endogenous variable.

$$Y_{it} = \alpha Y_{it-1} + \beta X_{it} + u_i + \varepsilon_{it} \; (i = 1, \dots, N \; t = 1, \dots, T) \quad (2)$$

With:

- ✧ Y is the endogenous variable.
- ✧ X is the set of exogenous variables;
- ✧ (α, β) are the parameters to estimate;
- ✧ u_i represent the set of individual heterogeneity (u_i are independent and identically distributed, "iid", with zero mean and constant variance);
- ✧ Ɛ is the error term, which is "iid", with zero mean and constant variance.

The estimation of the model, by the classical methods (OLS and within), yields biased estimators and is not convergent because of the correlation between the lagged endogenous variable and individual heterogeneity. We propose here the method of Arellano and Bond [26], which consists of obtaining convergent estimators. The previous dynamic model can be rewritten for each individual as:

$$Y_i = \delta \, W_i + i \, u_i + v_{it} \quad (3)$$

Where δ is a vector of parameters α and β. W_i is a matrix that contains the lagged dependent variable and the explanatory variables, i is a row vector, and its terms are equal to one.

The method proposed by these authors makes it possible to obtain a "GMM" estimator in two stages. Written in the following form:

$$\hat{\delta} = [(\textstyle\sum_i W_i' * Z_i) A_N (\sum_i Z_i' W_i *)]^{-1} (\sum_i W_i' * Z_i) A_N (\sum_i Z_i' \, y_i *) \quad (4)$$

Where $W_i *$ and $y_i *$ represent the transformations of W_i and y_i in the first difference, the matrix represents the instruments used after the transformation, However, to have the previous "GMM" estimator, it is necessary to go through a first step that consists of making the desired transformation (first difference), finding and using the matrix of suitable instruments Z_i (those that are correlated with the explanatory variables and that are not with the error term), and carrying out a first estimate called "estimate of the first stage". This step, which corresponds to a " 2 SLS " estimate, makes it possible to provide the estimated residuals after transformation. These residuals will be used in the second step to calculate a matrix $H_i = \hat{v}_i^* \hat{v}_i^{*\prime}$ which allows, in turn, after combination with the instruments, to calculate the weight matrix A_N such as:

$$A_N = [1/N(\textstyle\sum_i Z_i' \, H_i \, Z_i)]^{-1} \quad (5)$$

The goal of the transformation is to remove individual heterogeneity from the model. The number of instruments increases over time for each individual. However, the assumption of no autocorrelation of errors is essential for the "GMM" estimator to be consistent.

Arellano and Bond [26], proposed a test to verify the absence of first and second-order autocorrelation. This test is based on the auto-covariance of the standardized mean residuals and follows a reduced centered normal distribution under the null hypothesis. In addition, the authors proposed Sargan's instrument validity test. Thus, if A_N is optimally chosen for a given instrument matrix Z_i, the S statistic of the test asymptotically follows a chi-square law with (p-k-1) of the degree of freedom under the null hypothesis of validity of the instruments.

It has been recognized that the standard deviations of the two-step GMM estimator are biased in small samples. To overcome this issue, we use the Windmeijer method, which corrects this type of bias. Note that the weighting matrix used in the calculation of the efficient two-step GMM estimator is based on initial parameter estimates. In the article by Windmeijer [27], it is shown that the extra-variation due to the presence of these estimated parameters in the weight matrix represents a large part of the difference between the usual asymptotic variance of the two-step GMM estimator and that of the finite sample, when the moment conditions are linear in the parameter. This difference can be estimated with a finite sample, which gives a corrected estimate of the standard deviations, leading to a more precise inference.

4. Results

4.1. Descriptive statistics

To overcome the bias due to omitted variables, we have attempted to determine the effects of several measures of openness in order to better assess their impact on TFP. These are mainly imports of goods, excluding those of equipment; exports of goods;

foreign direct investment; and a synthetic variable representing the externality of foreign technology that cannot be beneficial without a qualified workforce. This is why we included a human capital index in our analysis.

The choice of the number of countries and the time horizon is dictated by the availability of data and the date of the onset of the openness process for all the selected countries. Indeed, we identified in our study 35 developing countries (Table 3) from 1988 to 2014. The following graphs show the evolution of these variables for this period (Figure 1, Figure 2, Figure 3).

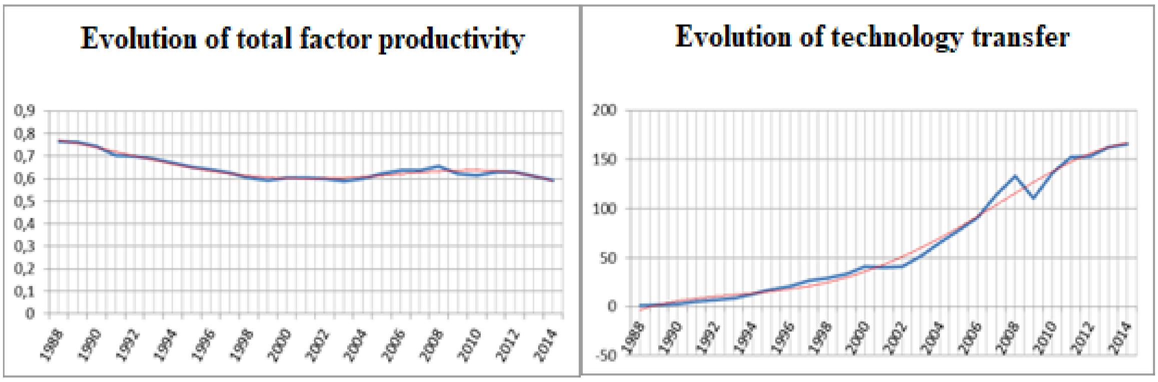

Figure 1. Evolution of total factor productivity and technology transfer.

The evolution of total factor productivity generally shows stability over time (Figure 1). Nevertheless, it went from 0.8 in 1988 to 0.6 in 2004. This can be explained by the debt crisis of developing countries (repayment of loans) following the oil shocks of the years 1973 and 1978. Then it fluctuates around 0.65 for the rest of the period. We have seen a peak in 2008, which was due to the subprime crisis, where the world experienced a decrease in the stock market, which occurred in October 2008. As a result, the non-financial sector began, for its part, to be affected by the crisis. The evolution of technology transfer generally has an upward trend. It has been influenced by the same facts mentioned above. The debt crisis of the developing countries prevented its expansion until the year 2002, and the 2007 crisis forced countries to reduce their imports of capital goods from high-income countries. As a result, technological externalities decreased, and then started to increase again after 2009.

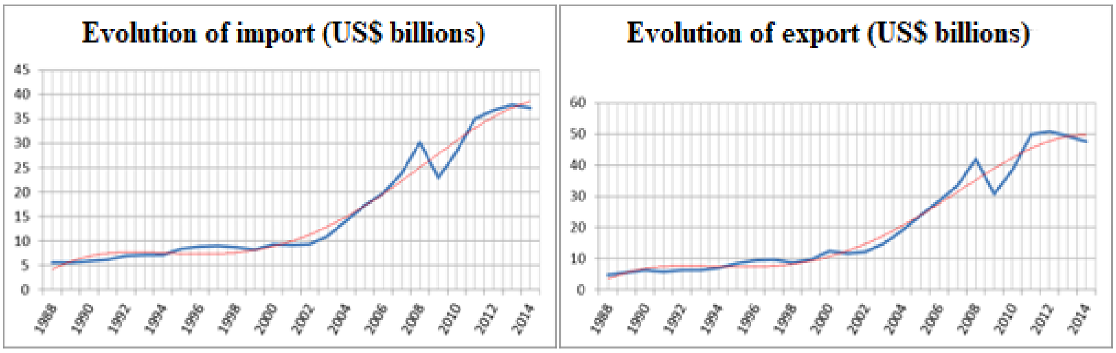

Figure 2. Evolution of the import and export.

The trends in exports of goods and those in imports of goods, excluding equipment, do not differ. They experienced an upward trend, and only after the global financial crisis in 2008. They dropped by 10 billion dollars, followed by an increase of 20 billion dollars for exports and 12 billion dollars for imports for intermediate and final consumption (Figure 2).

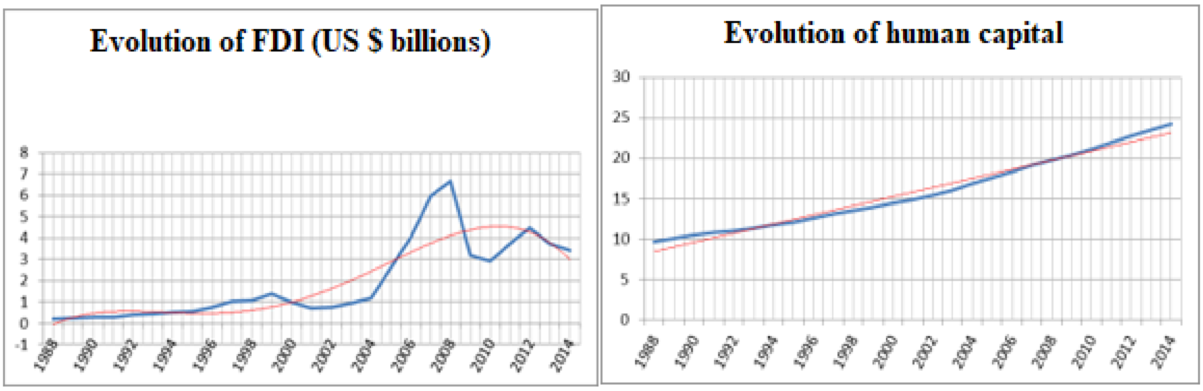

Figure 3. Evolution of FDI and human capital.

The evolution of FDI shows some volatility relative to other variables, which explains more or less its sensitivity to the international condition. Between 2008 and 2009, it went from 7 to 3 billion dollars (Figure 3). The evolution of this variable is influenced by the same facts mentioned above. FDI, in general, is sensitive and closely correlated with the political stability of receptive countries. As for the human capital index, its evolution showed an upward trend, which seems beneficial for these countries in order to have a skilled labor force capable of assimilating and imitating imported technology.

Table 2 contains descriptive statistics for the variables used for the entire panel:

Table 2. Descriptive statistics of the variables in level.

Variables	Obs	Mean	Standard deviation	Min	Max
Total productivity factors	945	.6442435	.3115238	.114149	2.49254
Foreign direct investment ($ billions)	941	1.957389	5.099637	-20.93351	75.013
Import ($ billions)	939	16.07385	26.8573	.0731358	222.6783
Export ($ billions)	945	20.49318	42.1119	.006	388.4008
Import of goods other than equipment ($ billions)	945	2.828693	10.47759	6.61e-06	104.703
Employed workers (In millions) *1	945	7.806785	9.471223	.185059	56.82107
Human Capital index (Performance) *2	945	2.014525	.5472511	1.11379	3.687228
Synthetic index of human capital (1*2)	945	15.77287	19.46269	.3778992	105.2077
R&D / GDP	945	2.147608	.1194428	1.957717	2.362092
Technological Externalities (transfers)	945	.0632196	.2388704	1.40e-07	2.473181

Countries that show a large TFP are Turkey, Egypt, and those exporting oil, like Kuwait and Saudi Arabia. The countries that have a low TFP are Peru and Thailand (Table 3).

The countries that show positive growth in TFPs are the oil-exporting countries. The countries which are experiencing great growth in their imports of goods other than equipment are Iraq, Argentina, and Sierra Leone. Zimbabwe is in the last row. Iraq, Kuwait, and Sierra Leone are countries experiencing high growth in their exports. In the last row, we find Zimbabwe, Central Africa, and Bulgaria. As for FDI, the most significant growth is that of Rwanda, Kuwait, and Morocco. Iraq and Saudi Arabia are in last place. For technological externalities, the highest growth rates are those of the Dominican, Sierra Leone, and Gabon. Jordan, Tunisia, and Israel are in the last rank. The highest growth in the human capital index is in Jordan, as well as Kuwait. Bulgaria, Hungary, and Uruguay are in the last row.

Table 3. Average growth of variables by country.

Countries	Tfp	Ext	M	X	Fdi	Hc
Argentina	-.01828	.303914	.16042	.089081	.254074	.025673
Bahrain	.006626	.347203	.076413	.101215	.122161	.056702
Benin	-.02018	1.01832	.119735	.108082	-.70457	.048577
Bulgaria	-.01992	.40475	.058026	.056076	.886838	-.00477
Cameron	-.03305	.616209	.07998	.085301	-.66817	.04467
Central Africa	-.00510	.452265	.058064	.004034	.1433	.032537
Columbia	-.00896	.4385	.115046	.103854	.356026	.041499
Costa Rica	-.00621	.555773	.109071	.094493	.154161	.041403
Cote d'Ivoire	-.00707	.852783	.081499	.068061	-.51332	.039409
Dominican	-.00482	5.16365	.079159	.068309	.285689	.041576
Egypt	.003484	.303138	.059177	.079048	.061544	.052544
Gabon	-.00750	2.27684	.07227	.108317	2.73577	.038793
Guatemala	-.02231	.569553	.105793	.104486	.634667	.038861
Honduras	.004059	.299343	.106417	.097484	.208756	.047255
Hungary	-.01311	.277852	.081902	.104917	.323881	-.00138
Iran	.026039	.263205	.087048	.113388	2.27365	.047197
Iraq	.037601	.673171	.247857	.373032	-113.30	.054658
Israel	-.00695	.234438	.063518	.082541	.327507	.039759
Jordan	-.00747	.193331	.094173	.090486	-.21554	.064536
Kenya	-.01561	.280097	.09745	.074254	8.04168	.046874
Kuwait	.047921	.545449	.07726	.307548	21.1772	.040564
Mauritania	.005713	1.66235	.12469	.097909	3.48702	.034245
Morocco	-.02733	.378623	.09849	.085961	4.365	.042698
Mozambique	.00195	1.11208	.115578	.173736	.479469	.032625
Nigeria	-.00426	.493839	.134609	.139193	.268378	.042783
Peru	-.00972	.348122	.125275	.120452	.18505	.039397
Rwanda	-.02650	1.65477	.095782	.114731	85.463	.035156
Saudi Arabia	.01073	.514663	.092058	.13519	-4.0381	.052484
Senegal	-.03357	.361308	.081693	.065641	-2.5724	.040359
Sierra Leone	-.0164	4.94094	.146752	.252975	3.00922	.031914
Thailand	.002668	.338825	.099202	.11317	.281463	.02486
Tunisia	-.02288	.213219	.07786	.084563	.406419	.041534
Turkey	-.00495	.308001	.131804	.111464	.311065	.029712
Uruguay	-.04599	1.00347	.10934	.082163	.627101	.012462
Zimbabwe	-.04599	.461254	.054867	.041951	1.03938	.03973
Mean	-.00821	.853178	.10052	.11237	.454210	.038197

4.2. Model

Before estimating our model, we first carry out the unit root tests specific to the analysis of panel data, in order to avoid the risk of a spurious regression. We present below the most recognized tests for our variables in growth rates (Table 4), since they are not all integrated in levels, so we cannot consider an error correction model (VECM).All variables are stationary in growth rates, as indicated by the tests of common and individual unit roots.

Table 4. Unit root tests.

Variables	Levin, Lin & Chu	Im, Pesaran & Shin	ADF-Fisher	PP-Fisher	Stationarity
Growth of TPF	0.0000	0.0000	0.0000	0.0000	Yes
Growth of EXT	0.0000	0.0000	0.0000	0.0000	Yes
Growth of FDI	0.0000	0.0000	0.0000	0.0000	Yes
Growth of X	0.0000	0.0000	0.0000	0.0000	Yes
Growth of M	0.0000	0.0000	0.0000	0.0000	Yes
Growth of HC	0.0000	0.0000	0.0000	0.0000	Yes

After the unit root test of the variables, we will start our regression with the random effects estimator to proceed with the Breusch-Pagan test, which, with a zero chi-square and a probability equal to one, validates the presence of heterogeneity between countries and leads us to analyze our sample within the framework of fixed effects.

First, we regressed the TFP on the control variables. Only two coefficients are significant, and the generated residuals are strongly correlated with the exogenous variables, which indicates the presence of endogeneity.

However, the fit quality is very poor, which leads us to use the Generalized Method of Moments (GMM) for a dynamic panel data model, both to overcome the problem of endogeneity of the variables and to improve the quality of estimation by taking into account the issue of autocorrelation of errors and that of heteroscedasticity indicated by the Woodridge and modified Wald tests, respectively. However, the Woodridge test of autocorrelation failed to reject the null hypothesis of the absence of first-order autocorrelation in our panel data with a Fisher of 0.532 and a probability of 0.4708. Thus, the modified Wald test for heteroscedasticity rejected the null hypothesis of homoscedasticity with a very high chi-square and a probability equal to 0. The idea of introducing the lagged endogenous variable is not to analyze the restoring forces or the speed of adjustment of the TFP, but to overcome the problem of omitted variables, so we can improve the fit quality.

4.3. Estimation and interpretation

The specification we have opted for is as follows:

$$ptf_{it} = \alpha\ tfp_{it-1} + \beta\ ext_{it} + \lambda\ fdi_{it} + \gamma\ M_{it} + \delta\ X_{it} + \theta\ hc_{it} + u_i + \varepsilon_{it} \quad (6)$$

The results that we present in Table 5 below correspond to the GMM estimation of Arellano and Bond (1991) in two steps, corrected by Windmeijer's method. We only consider the results of the second estimate because it allows us to simultaneously eliminate in a rigorous way any bias linked to unobserved individual heterogeneity, gives a corrected estimate of the standard deviations, and therefore offers better efficiency and robustness in the estimation results. The results are presented in Table 5 below.

Empirical estimates confirm the positive and significant effect of technological externalities and exports on TFP, with a magnitude of 0.025 and 0.17, respectively. Which means that an increase in the growth rate of technology transfers (exports) by 10%, either due to an increase in imports of capital goods from developing countries, or to an increase in the share of R&D spending by industrial countries exporting technology, increases the TFP by more than 0.0025 (0,017). As for imports of goods, excluding those with high technological content, they have a negative and significant effect of around -0.25, which is greater than the two previous effects in absolute value. A growth of 10% in imports of goods excluding capital goods would reduce TFP by 0.025. However, identifying the effect of human capital and FDI is far from obvious. The results show that they have an insignificant effect.

Table 5. Results of dynamic panel estimation, two-step GMM.

Variables	Regression in 2 steps	Sign	Regression in 2 steps (Robust)	Sign
Lag of TFP Growth	-0.2146186 (0.0048134)	0.000	-0.2146186 (0.0717442)	0.003
Growth of EXT	0.0258179 (0.0012724)	0.000	0.0258179 (0.0113888)	0.023
Growth of FDI	0.0005635 (0.0000477)	0.000	0.0005635 (0.0005054)	0.265

Table 5. Continued.

Variables	Regression in 2 steps	Sign	Regression in 2 steps (Robust)	Sign
Growth of M	-0.250106 (0.0184821)	0.000	-0.250106 (0.1101398)	0.023
Growth of X	0.17181 (0.0101014)	0.000	0.17181 (0.0860298)	0.046
Growth of HC	0.0966302 (0.061343)	0.115	0.0966302 (1.006669)	0.924

The following table (6) provides Arellano-Bond and those of Sargan and Hansen indicate tests, which indicate, respectively, the absence of the first and second autocorrelation order and the absence of over-identification, which means that our instruments are valid. The Hansen test validated all the instruments we used, even if this test is not of great interest, since we have excluded variables such as the index of import and export prices, population growth, and that we have as an instrument only the second lag of the independent variable.

Table 6. Results of dynamic panel tests.

Test	Regression in 2 steps		Regression in 2 steps (Robust)	
	Statistic	Sign	Statistic	Sign
Autocorrelation test:				
Arellano-Bond AR (1) z	-2.25	0.024	-1.90	0.058
Arellano-Bond AR (2) z	-0.45	0.653	-0.42	0.674
Identification test:				
Sargan chi² (42)	37.93	0.650	37.93	0.650
Hansen chi² (42)	33.80	0.812	33.80	0.812
Global significance Khi²	0.000			

5. Discussion

The findings are consistent with the endogenous growth theory and most empirical studies on developing countries using panel data, such as Coe & Helpman and Coe & al., Lichtenberger and Pottelesberg, Lumenga-Neso et al., Hakura and Jaumotte [13, 14, 15, 16, 17], or more recently, Moskalyk [21]. The openness of the countries under study has, in our study, a positive and significant effect on their economic growth. Such an effect stems from the fact that developing countries have a negligible level of R&D. Therefore, openness allows them to access foreign knowledge through the import of goods with high technological content, particularly capital goods, which are necessary in the process of production. This result is consistent with theoretical models on the subject [5-7].

As for exports of goods, they contribute positively to the growth of the TFP because they allow developing countries to obtain foreign assets to finance their foreign currency debt and their imports. On the other hand, openness offers a greater exposure of domestic firms to international competition, which favors the absorption of innovations and increases the competitiveness of these exporting firms, through the adoption of better technology and by specializing in the sector in which they have a comparative advantage. Subsequently, the adopted technology can then be diffused to non-exporting firms, improving their productivity and economic growth.

Imports of goods, excluding capital goods, have a negative impact on developing countries because a large portion of imports are directed toward final consumption rather than production. In addition, the consumption of foreign goods exposes national companies to fierce competition that causes reductions in market share or the closure of national firms, and consequently reducing TFP and growth. Moreover, these imports deplete foreign assets that can be used to finance imports of equipment that is important for growth and for improving technology and productivity.

Nonetheless, our sample data failed to identify the positive effects of human capital and FDI on growth. In contrast to emerging countries, human capital in developing countries does not allow taking full advantage of their openness. They should improve this factor both quantitatively and qualitatively. Moreover, it could be done with the help of policies that focus on education and training, creating a work environment that encourages creativity, dividing labor based on specialization, in order to assimilate and imitate foreign technology to transfer it, in the end, to the whole economy.

As for FDI, in contrast with Bouallegui, I. [20] results, it has an insignificant effect either because of crowding-out effects, which give monopoly power in the market acquired by multinationals or because of profit repatriation by multinationals, which leads to huge outflows of capital that harmfully affects the balance of payments and foreign currency reserves. Thus, host countries should adopt policies that encourage multinationals to reinvest their profits instead of being repatriated. To attract more FDI, the business and investment climate doesn't have to allow exemptions and relaxation of regulatory requirements. However, host countries need to increase their regulations and take more into consideration the international environmental standards.

Our results show a negative effect of imports that outweighs the two positive effects of technological externalities and exports. In this case, based on the principle of comparative advantages, the developing countries should adopt measures to encourage cost-effective production, in particular, through reliance on labor, which is abundant. Implementing these so-called export promotion policies for these countries consists of measures such as professional training of the workforce, use of advanced technologies, and export subsidies. In addition, tax incentives for foreign investment will generate more exports, especially in labor-intensive manufacturing.

However, our work presents some limits that may be the subject of subsequent improvements, in particular through the distinction between the import of final consumption goods and intermediate goods, considering the weight of imports of goods with high technological content of each partner to better measure technological externalities. In addition, this type of dynamic modeling in GMM focuses on estimating the short-term impact. However, there are methods for estimating the short and long-term dynamics, such as error correction models, which allow estimating the long-term effects of technological externalities on TFP as well as the speed of convergence of developed countries. Moreover, instead of working with variables in growth rate or in the first difference, which loses information, this method does not require stationary variables, which means that we can carry out the estimation with the variables in the levels. In regards to the construction of the panel, estimations can be improved by separating the oil-exporting countries (which have higher TFPs compared to other countries) from the rest of the countries. It is important to stress that there are other conditions, such as the quality of institutions and the tax system, which can improve model results. Taking all these factors into account in our model can play an important role in better understanding the impact of technological externalities on economic growth.

6. Conclusions

In this paper, we empirically tested the effects of openness, notably through the channel of technology transfers, on TFP for a panel of 35 developing countries for a period from 1988 to 2014. We sought to overcome the main limitations of the empirical studies that we mentioned in our review of the literature. Indeed, our contribution to the empirical literature lies in the integration of several indicators into the growth equation that can represent more or less exhaustively the various dimensions of openness, such as exports of goods, imports of goods other than equipment, foreign direct investment, and externalities of foreign technology. It also lies in the use of the most appropriate econometric approach for our problem to estimate a dynamic model, ensuring that any bias related to unobserved individual heterogeneity is rigorously eliminated and that the estimation results are more efficient. The coefficients attached to the variables representative of openness are significant, with the exception of that of FDI, which is positive but not significant. These results confirm the hypothesis that openness allows developing countries to improve their TFP by providing access to foreign knowledge contained in the imports of capital goods essential for production. We also highlighted the insignificant impact of human capital on growth by briefly recalling the problems specific to education and vocational training in these countries. Qualified human capital is a necessary condition to properly assimilate and imitate imported technology.

After all, the present research could be the subject of further refinement. In terms of the choice of the variables, we can distinguish the import of final consumption goods from intermediate goods and consider the weight of imports of goods with high technological content of each partner to better measure technological externalities. We add that there are other variables that can improve model results, such as the quality of institutions, the tax system, and inflation. At the methodological level, the GMM dynamic model focuses on the short-term impact. However, there are methods for estimating both the short and long-term dynamics, such as error correction models, which allow estimating the long-term effect of technological externalities on TFP as well as the speed of convergence. Moreover, with regards to the construction of the panel, estimations can be improved by separating the oil-exporting countries from the rest of the countries. Taking all these factors into account in our model can play an important role in better understanding the impact of technological externalities on economic growth in developing countries.

Data Availability Statement: Data is public and available for download at:

https://wits.worldbank.org/CountryProfile/en/Country/BY-COUNTRY/StartYear/1988/EndYear/2019/TradeFlow/Import/Indicator/MPRT-TRD-VL/Partner/WLD/Product/UNCTAD-SoP4

https://databank.worldbank.org/source/world-development-indicators

https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt8.1?lang=en

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