TECHNICAL NOTE Nº IDB-TN-3085

Productivity Spillovers through Trade Integration in Central America

Arnoldo López-Marmolejo
Jeffrey Serrano

Inter-American Development Bank
Country Department Central America, Haiti, Mexico, Panama and the Dominican Republic

February 2025

Productivity Spillovers through Trade Integration in Central America

Arnoldo López-Marmolejo
Jeffrey Serrano

Inter-American Development Bank

Inter-American Development Bank
Country Department Central America, Haiti, Mexico, Panama and the Dominican Republic

February 2025

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
Lopez-Marmolejo, Arnoldo.
Productivity spillovers through trade integration in Central America / Arnoldo López, Jeffrey Serrano.
p. cm. — (IDB Technical Note ; 3085)
Includes bibliographical references.
1. International trade-Central America. 2. International economic integration-Central America. 3. Central America-Economic integration. I. Serrano, Jeffrey. II. Inter-American Development Bank. Country Department Central America, Haiti, Mexico, Panama and the Dominican Republic. III. Title. IV. Series.
IDB-TN-3085

http://www.iadb.org

Productivity Spillovers through Trade Integration in Central America

Jeffrey Serrano[†] Arnoldo López-Marmolejo[†]

Abstract

Central America is a highly trade-integrated region. However, there has been little analysis of the effects such integration has had on macroeconomic aggregates. This study explores how spillovers from country-specific productivity shocks would spread across the countries that comprise the region. To do so, it employs a computable general equilibrium model calibrated to replicate the bilateral trade relationships within the region. As expected, the results show that countries that are more integrated within it would benefit more from idiosyncratic positive productivity shocks. In addition, the analysis enables the identification of spillovers across countries through the trade channel and estimates the beneficial effect of economic integration on economic growth compared to that of autarky.

Keywords: gravity model, general equilibrium, Central America, spillovers, trade.
JEL Codes: F15, F43, C61

[†] Inter-American Development Bank (IDB), 1300 New York Avenue, N.W. Washington, D.C. 20577, USA.

1. Introduction

According to Tamanes (1990) and Petit (2014), economic integration is a process whereby two or more markets join to create a single market that generates greater global competitiveness, facilitates the division of labor, and assigns inputs more efficiently.

The process of economic integration in Central America began in the 1950s with the establishment of the Organization of Central American States, which laid the foundation for the creation of the Central American Integration System (SICA) in the early 90s, an institution aimed at increasing intraregional trade flows and the industrialization of its member states in order to accelerate their economic growth. In the ensuing decades, these countries saw an increase in their production, foreign trade, and foreign direct investment inflows; moreover, this process was accompanied by the development of multiple regional institutions and investments. Examples of this include the creation of the Secretariat for Central American Economic Integration (SIECA), a regional clearing house, the Central American Monetary Board, the Central American Bank for Economic Integration, a regional electricity market, and a regional highway (SIECA, 2021). As can be seen, economic integration in Central America has been a key pillar of economic development policy in SICA member states. Nevertheless, the literature on the contribution of economic integration to regional economic growth is scant.

Some studies have focused on confirming the deepening of the region's economic integration over time, such as Salazar et al. (2023), who construct an index for the purpose of ranking the economic integration of the countries within the region over time. Others have gone further and sought to confirm the existence of regional spillovers. Specifically, Urbina and Marenco (2022) estimate the contribution of individual countries to a common economic growth dynamic with the intention of capturing regional economic integration and determining which countries contribute to this, and who benefits from it. Caceres (2021) focuses on El Salvador's labor productivity (defined as output per worker) and explores the role of investment and employment in neighboring countries Guatemala, Honduras, and Costa Rica, concluding that these variables are relevant and suggesting the presence of spillovers.

While these works are relevant to understanding the dynamic of economic integration in Central America, more work is needed in order to understand the transmission mechanisms of the spillovers and their implications for macroeconomic aggregates across the countries of the region.

In this work, we explore the effect of economic integration on macroeconomic aggregates by analyzing the transmission mechanisms of productivity shocks through trade relationships within the region comprising Central America, Panama, and the Dominican Republic (henceforth CAPDR). Specifically, the channels through which shocks from one country are passed through to the rest are export and import flows. By analyzing these channels, we contribute to the literature on economic integration in CAPDR by: i) evaluating the contribution of the trade channel to passing through idiosyncratic country shocks to the rest of the countries of the region, and ii) estimating the contribution of regional economic integration to economic growth by country compared to counterfactual cases of closed economies.

To do this, we use a Multi-Country Open-Economy Dynamic General Equilibrium (MCOE-DGE) model comprising two stages. In the first stage, we employ an augmented version of the well-known trade gravity model–initially proposed by Tinbergen (1962) and extended by Bergstrand (1985)–to estimate gravity forces in trade across countries in the CAPDR region and the United States. The second stage consists of developing a General Equilibrium Model for a set of open economies that trade with each other in perfect competition conditions.

The economies are differentiated by their levels of technology and capital stock and, therefore, income. They also differ in terms of their population, trade openness, bilateral trade, and balance of trade positions, as a result of calibrating the model parameters to match the data for these variables. In the first stage, we calculate the bilateral elasticities of exports to demand and supply conditions, which can be interpreted as the consumer preferences for foreign goods. In the second stage, the general equilibrium model allows us to generate scenarios for different shocks, as detailed below.

While multiple papers have been written within the literature on open-economy DGE modeling since Smets and Wouters (2002), most of these consider only two economies (i.e., the domestic economy and that of the rest of the world). Others estimate multi-country open-economy Dynamic Stochastic General Equilibrium (DSGE) models to investigate international linkages within an endogenous framework, such as Razafindrabe (2016), who assesses the transmission of shocks in the euro area. In contrast, the Multi-Country Open-Economy DGE model presented here includes a finite number of interdependent small economies (CAPDR members), while incorporating a large independent economy: the United States.[1] Such a structure is not commonly used in the economic literature; nevertheless, it is useful for analyzing small, highly integrated economies such as Central America and certain Asian countries with strong ties to large economies.

Additionally in this model, we incorporate the gravity forces in trade—which dictate the transmission mechanism of any shock—and employ dynamic programming to study the changes in agent decisions. Specifically, the exercise consists of analyzing the spillovers from exogenous productivity shocks by looking at exports and imports in CAPDR. To do this, we perform the following experiment. First, we assume that before any shock occurs, the economies are in their initial steady state, which is characterized by a set of open economies trading among themselves and a consumer preference for foreign goods determined by the gravity equations. Second, we introduce the presence of an exogenous productivity shock. When this shock occurs in at least one economy, production immediately increases and the

[1] In 2019, trade within the region and with the U.S. accounted for 62% of all CAPDR trade, and at the individual country level, it ranged from 31% in Belize to 90% in El Salvador.

spillover effects are transmitted via the trade channel. Lastly, we isolate and quantify the impact on the aggregate variables of each economy in the region.

The expected sign and statistical significance of the coefficients in the gravity trade equations demonstrate their relevance in modeling the trade relationships in the region and support the reliability of the experiments conducted.

The calibration strategy of the baseline model (the model's equilibrium in the initial steady state) ensures that the key economic characteristics and interrelations of the countries in the region are accurately reflected. In particular, the model replicates the output per capita ratio between each CAPDR country and the U.S.—a crucial element in the modeling of trade gravity —, and the consumption-to-GDP ratios, which are commonly used as a proxy for welfare, among other variables.

The results show that the more integrated the economies are within the region, the greater the benefits they derive through trade from a productivity shock, particularly in terms of growth in output, consumption, and investment. Moreover, low-income countries tend to benefit the most due to their higher returns on input factors (capital and labor) when these are at lower levels.

Additionally, the neighboring countries of those experiencing a productivity shock also benefit thanks to an increase in demand as a result of trade, with greater benefits occurring when they are more integrated with the economy where the shock originated. As before, lower-income countries tend to register higher gains. This reflects a positive spillover effect on the rest of the CAPDR region of a country-specific technological shock.

These results are consistent with the findings of studies on other trade-integrated regions worldwide. For instance, Gammadigbe (2021) finds that regional trade integration promotes economic growth in Africa, while for countries of the Association of Southeast Asian Nations (ASEAN), Nwosu et al. (2013) highlight the importance of regional integration in boosting foreign direct investment at the intraregional level. For the European Union (EU), Henrekson et al. (1997) identify a positive effect of European integration on regional economic growth; moreover, they find non-significant differences between the estimated impact on EU countries and European Free Trade Association (EFTA) countries, which suggests that the main driver of the positive effect on economic growth is the common trade integration factor. Similarly, Badinger (2005) estimates that the current level of per capita GDP in the EU would be one-fifth lower if the integration process that has taken place since the fifties had never occurred.

The rest of the document is organized as follows: Section 2 presents the two-stage MCOE-DGE model and describes its calibration. Section 3 shows the estimation of the gravity equations, the analytical solution of the model, and the quantitative results of running experiments consisting of incorporating productivity shocks into the economies of the region. Finally, Section 4 concludes.

2. The model

The model comprises two parts. The first is an augmented version of the well-known gravity model of trade initially proposed by Tinbergen (1962), and subsequently extensively discussed and improved by authors such as Poyhonen (1963), Pullianen (1963), Geraci and Prewo (1977), Anderson (1979), Anderson and van Wincoop (2004), and Santos Silva and Tenreyro (2006), among others.

The second part is a general equilibrium model for a set of open economies that trade with each other in conditions of perfect competition. Hence, the structure of the economies considered in this environment is similar to the neoclassical model initially developed by Ramsey (1928) and later extended by Cass (1965) and Koopmans (1965), with the difference that we expose the economies to international trade flows and, therefore, to access to international capital markets, following Obstfeld (1986). Such an environment comprises multiple small open economies and an independent large open economy that affects these and offsets the disparities that arise from the balance of trade adjustments within the region; in other words, given the bilateral balances of trade of the economies of the region, the big economy works to adjust their regional aggregate deficit or surplus to match with the total surplus or deficit observed in 2019,[2] for every case.

The economies are differentiated by their levels of technological progress and capital stock, and, therefore, their income. At the same time, they differ in population size,[3] degree of trade openness, bilateral trade with the other economies, intertemporal consumption preferences,[4] and balance of trade positions.

Each economy is populated by a continuum unit mass of identical and infinitely lived households that face a utility maximization problem between consumption and savings. There is only one type of good in the global economy that can be either consumed or saved in the form of future capital. Additionally, we assume the agents in each country differentiate this good based on its origin, resulting in preferences for imports extracted from the trade functions in the gravity model.

Firms in each economy maximize profits by choosing between labor and capital, based on prices in domestic competitive factor markets. Competitive prices in domestic markets differ in each economy since they vary in terms of their level of technological progress and capital stock. We incorporate the differences in domestic interest rates by having a global capital

---

[2] i.e., the big economy functions as the rest of the world (excluding the other economies of the region) for every small open economy in the model.

[3] Although we express the model in per capita terms, we consider the population size of the economies when expressing the bilateral trade flows, so the spillovers are properly transmitted through the economies. This has to be done because economies differ in population size and trade flows between economies have to be expressed (or transmitted) in total real units rather than per capita units. For instance, if the population of economy i is ten times greater than that of economy j, then one per capita unit of final good of economy i equals ten per capita units of economy j when expressed in economy j's per capita terms.

[4] Intertemporal consumption preferences differ across countries in the impatience parameter β_i. This arises from our assumption of a negative relationship between marginal propensity to consume and income level, which is explained in more detail in the specification of household preferences and the analytical solution of the model.

market in which the uncovered interest rate parity holds; hence, agents are indifferent between domestic and foreign capital markets, and their preferences are purely driven by their external demand according to the gravity equations. There is no aggregate uncertainty in the production outcomes (i.e., there are no stochastic shocks in the spirit of Kydland and Prescott (1982) and Backus, Kehoe, and Kydland (1993)), and the model is solved under perfect foresight.

Economies strictly prefer to trade rather than consume or save all their own output; therefore, each economy will have a nonzero trade balance in the form of debt or credit. Bilateral debt is assumed to accumulate in the form of capital assets in the debtor country's market, being paid at a competitive interest rate. To simplify the analysis, we impose the nonexistence of government.

2.1. The gravity equations for external demand

As mentioned above, we use the augmented gravity model of trade. Specifically, we use the augmented version proposed by Bergstrand (1985), given by equation 1:

$$X_{ij,t} = \frac{\theta_0 \, Y_{i,t}^{\theta_1} \, Y_{j,t}^{\theta_2}}{D_{ij,t}^{\theta_3}} \, F_{ij,t}^{\theta_4} \, \mu_{ij,t} \tag{1}$$

Where $X_{ij,t}$ denotes exports from country i to destination country j, t refers to time, $Y_{i,t}$ is the value of the total output of the exporter country i, $Y_{j,t}$, the value of the total output of destination country j, and $D_{ij,t}$, a measure of the distance between country i and country j. $F_{ij,t}$ is a vector of variables that captures bilateral barriers to trade between countries i and j, and $\mu_{ij,t}$ is the error term.

Equation 1 can be log-linearized as follows:

$$Ln(X_{ij,t}) = \theta_0 + \theta_1 Ln(Y_{i,t}) + \theta_2 Ln(Y_{j,t}) - \theta_3 Ln(D_{ij,t}) + \theta_4 Ln(F_{ij,t}) + \mu_{ij,t}. \tag{2}$$

The gravity equations are estimated using panel data for CAPDR countries and the U.S., with an annual frequency between 1994 and 2019. The sources of the data are included in Table 1. The set of variables intended to proxy the barriers to trade include characteristics that reflect whether or not the partner countries share a common border, whether or not they speak the same language, and the average tariff on trade between each pair of countries, as well as a variable that reflects the institutional factors of each destination country.

When it comes to institutional factors, a set of corresponding variables is summarized into a single Index of Institutional Conditions by reducing their dimensions using the Method of Principal Components (MPC). Specifically, we use the six aggregate governance indicators published by the World Bank, since these reflect a rich and diverse assortment of information on the perception of governance and institutionality across the world. We take the six indicators and reduce their dimensions into a single variable via the MPC; we then rescale the results to produce an index ranging from 0 to 1, where higher values mean better governance and stronger institutions.

The estimation methodology and results are discussed in Section 3.

Table 1: Variables for the gravity model of trade

Variable	Name	Source
$X_{ij,t}$	Bilateral Exports	COMTRADE
$Y_{i,t}$	Real GDP of Origin Country	World Bank Data
$Y_{j,t}$	Real GDP of Destination Country	World Bank Data
$D_{ij,t}$	Bilateral Distance	World Bank Data
	Common Border Dummy	CEPII Data
	Common Language Dummy	CEPII Data
$F_{ij,t}$	Access to Both Oceans Dummy	CEPII Data
	Average Tariff on Bilateral Trade	CEPII Data
	Institutional Quality Index	Own elaboration*
	Components of the Institutional Quality Index	
Factor 1	Voice and Accountability	World Bank Data
Factor 2	Political Stability	World Bank Data
Factor 3	Government Effectiveness	World Bank Data
Factor 4	Regulatory Quality	World Bank Data
Factor 5	Rule of Law	World Bank Data
Factor 6	Control of Corruption	World Bank Data

* Estimation using the principal components method

2.2. Households' maximization problem

Let I be the set of economies such that $\forall i \in I{:}\ i = \{1,2,\dots,9\}$. Every household in economy i chooses between consumption $c_{i,t}$ and saving $s_{i,t}$ to maximize their lifetime expected utility, where t refers to time. The savings of each household can be invested in a set of capital assets such that $s_{i,t} = a_{i,t+1} = a_{ii,t+1} + \sum_{j\neq i} a_{ij,t+1}$, where $a_{ij,t+1}$ denotes the level of economy j's capital assets that the households in economy i hold. The maximization problem is given by

$$\sum_{t=0}^{\infty} \beta_i^t\, U\left(c_{i,t}\right) \tag{3}$$

subject to:

$$c_{i,t} + a_{ii,t+1} + \sum_{j\neq i} \frac{a_{ij,t+1}}{e_{ij,t}} = \left(1 + r_{i,t}\right) a_{ii,t} + \sum_{j\neq i} \frac{1 + r_{j,t}}{e_{ij,t}} a_{ij,t} + \omega_{i,t}\bar{n} \tag{4}$$

$$\forall i,j \in I \qquad\qquad a_{ij,t+1} \geq 0. \tag{5}$$

Where $\beta_i \in (0,1)$ is the country-specific discount factor for the utility function $U(c_{i,t})$, $r_{i,t}$ is the domestic real interest rate, $r_{j,t}$ is the foreign real interest rate corresponding to country j, $e_{ij,t}$ is the exchange rate between economies i and j, $\omega_{i,t}$ is the wage per unit of effective labor, and $\bar{n}$ is the amount of effective labor per period (which is assumed to be perfectly inelastic and equal for all households and economies). Note that equation 5 imposes the restriction of non-borrowing agents for all the economies.[5]

The solution to the household problem is a set of choices for $c_{i,t}$ and $a_{i,t+1}$ such that $\forall t$ maximizes (3) subject to (4) and (5), given the sequences of values for $\{r_{i,t}\}_{t=0}^{\infty}$, $\left[\forall j \neq i,\ \{r_{j,t}\}_{t=0}^{\infty}\right]$, $\left[\forall j \neq i,\ \{e_{ij,t}\}_{t=0}^{\infty}\right]$, and $\{\omega_{i,t}\}_{t=0}^{\infty}$. The solution to this problem is represented through the optimal value function $V(a_{i,t})$ that depends on the choice of level of assets and is the unique solution to the following Bellman equation:

$$V(a_{ii,t}, a_{ij,t}) = \max_{a_{i,t+1}}\{U(c_{i,t}) + \beta_i[V(a_{ii,t+1}, a_{ij,t+1})]\} \qquad (6)$$

subject to:

$$c_{i,t} + a_{ii,t+1} + \sum_{j\neq i}\frac{a_{ij,t+1}}{e_{ij,t}} = (1+r_{i,t})a_{ii,t} + \sum_{j\neq i}\frac{1+r_{j,t}}{e_{ij,t}}a_{ij,t} + \omega_{i,t}\bar{n} \qquad (7)$$

$$\forall i,j \in I \qquad a_{ij,t+1} \geq 0. \qquad (8)$$

In the global competitive equilibrium, uncovered interest rate parity holds[6] and all capital assets bring the same real return. Given the competitive equilibrium for the global capital market, the solution to equation 6 returns the Euler equation (described in greater detail in Section A.1. of the Appendix):

$$\frac{\partial U(c_{i,t})}{\partial c_{i,t}} \geq \beta_i\left[(1+r_{i,t+1})\ \frac{\partial U(c_{i,t+1})}{\partial c_{i,t+1}}\right] \qquad (9)$$

The assumed functional form of $U(\cdot)$ is CRRA, i.e., $U(c_{i,t}) = \frac{c_{i,t}^{1-\gamma}}{1-\gamma}$, with $\gamma > 0$.

[5] This assumption implies that households always decide to hold a positive portfolio of savings so that they can always replace the depreciation of their respective capital and accumulate more stock. Moreover, they can also accumulate capital assets in foreign markets (recall that $a_{i,t+1} = \sum_{j=1}^{I} a_{ij,t+1}$), which is the case for countries with positive positions in their balance of trade.

[6] This condition is formally proved in Section A.1. of the Appendix.

2.3. Firms' maximization problem

Aggregate domestic output is produced by an identical unit mass of firms in a domestic competitive market with a Cobb-Douglas production function. At the aggregate level, a representative firm in each economy i faces the following maximization problem:

$$\forall t = 0, 1, 2, \dots \qquad \max_{K_{i,t}} \Gamma_{i,t} = \max_{K_{i,t}} \left[p_t \mathrm{Y}_{i,t} - \left(r_{i,t} + \delta\right) K_{i,t} - \omega_{i,t} \bar{n} \right] \quad (10)$$

subject to:

$$Y_{i,t} = \mathcal{A}_i K_{i,t}^{\alpha}\, \bar{n}^{1-\alpha}. \quad (11)$$

Where p_t is the price of domestic output at time t and is normalized to one, $K_{i,t}$ is the aggregate stock of capital at time t, $\bar{n}$ is the constant-over-time aggregate supply of labor, $\mathcal{A}_i$ is a measure of technology or productivity, $\alpha \in (0, 1)$ is the share of capital in the production function, and $\delta \in [0, 1]$ is the depreciation rate of the capital. $\bar{n}$, α, and δ are the same for all the economies in set I. Moreover, aggregate output can be used for private consumption $C_{i,t}$ and investment in future capital $I_{i,t}$, as follows:

$$Y_t = C_t + I_t + X_t - M_t = C_{i,t} + I_{i,t} + \sum_{i \neq j} X_{ij,t} - \sum_{j \neq i} X_{ji,t} \quad (12)$$

with $$I_t = \Delta K_{t,t+1} + \delta K_t.$$

Since firms are in perfect competitive domestic markets for both the final good and the production factors, optimal prices in the domestic factor market in country i at time t are given by:

$$r_{i,t} = \alpha\, \mathcal{A}_i \left(\frac{\bar{n}}{K_{i,t}}\right)^{1-\alpha} - \delta \quad (13)$$

$$\omega_{i,t} = (1-\alpha)\, \mathcal{A}_i \left(\frac{K_{i,t}}{\bar{n}}\right)^{\alpha}. \quad (14)$$

2.4. Equilibrium

Given the maximization problem of households and firms for each economy, the price setting in each domestic factor market, and the competitive exchange rates that ensure the uncovered interest parity condition holds, the stationary equilibrium in this global economy characterized by one large economy and multiple small economies is defined as follows:

Definition. *The stationary equilibrium in this global system composed of "I" economies is given by the value function* $V\left(a_{ii,t}, a_{ij,t}\right)$ *with policies* $\left\{c_{i,t}, a_{ii,t}, a_{ij,t}, \bar{n}\right\}_t$ $\forall i \in I$ & $\forall j \neq i$, *the sequence of firm policies* $\left\{K_{i,t}\right\}_t$ $\forall i \in I$, *and the sequence of prices* $\left\{e_{ij,t}, r_{i,t}, \omega_{i,t}\right\}_t$ $\forall i \in I$ & $\forall j \neq i$, *such that:*

i. *Household policies in each economy "i" solve their maximization problem and achieve values* $V\left(a_{ii,t}, a_{ij,t}\right)$ *governed by (9) and driven by (1).*

ii. *Firm policies for every economy "i" maximize their profits according to (13) and (14).*

iii. *Every domestic good market clears according to (12).*

iv. *Every domestic capital asset market clears according to:*

$$a_{i,t} = K_{i,t} + BoT_{i,t}\ ,\ \textit{where}\ BoT_{i,t} = \sum_{i \neq j} X_{ij,t} - \sum_{j \neq i} X_{ji,t}$$

v. *The global capital assets market clears according to:*

$$\sum_i a_{i,t} = \sum_i K_{i,t},\ \textit{which can also be interpreted as}\ \sum_i BoT_{i,t} = 0$$

2.5. Calibration

A period in this model corresponds to one year, while the calibration aims to characterize the economies in the model and their trade interrelations for 2019. Specifically, the calibration seeks to match the per capita output ratios between the economies of CAPDR and the U.S., the consumption levels as a proportion of their respective GDP, and the domestic interest rates.

Table 2 summarizes the calibrated parameters used in the model. For the good and the factor markets in each economy, we set the supply of labor $\bar{n}$ equal to 1/3, its standard level in the literature (for instance, Ferriere and Navarro, 2019). The share or elasticity of capital in all the production functions is set at 0.36 and the depreciation rate at 0.06, which are both values found extensively in the literature (see, for example, Domeij and Heathcote, 2004).

The calibrated values of the productivity factor in the domestic production function range from 0.244 to 1.0 and were chosen to match the ratio of steady-state output per capita between each country and the U.S. with those in the 2019 data.

For household preferences, the risk aversion parameter γ is set to 1 for all the economies, implying a logarithmic utility function. The discount factor vector β is set to range from 0.9009 to 0.9791, so that each domestic real interest rate matches the value observed in its economy for 2019.

Table 2: Calibration parameters

Parameter	Name	Value		Target/Source
γ	Risk aversion	1.0		Standard literature
$\bar{n}$	Labor supply	1/3		Ferriere & Navarro (2019)
α	Capital share	0.36		Standard literature*
δ	Depreciation rate	0.06		Domeij & Heathcote (2004)
	Country-Specific Parameters			
		Discount β	Productivity $\mathcal{A}$	
$i = 1$	Belize	0.9009	0.416	$r_i = 11.0\%$ & $y_i/y_{USA} = 0.168$
$i = 2$	Costa Rica	0.9594	0.539	$r_i = 4.23\%$ & $y_i/y_{USA} = 0.335$
$i = 3$	Dominican Republic	0.9518	0.526	$r_i = 5.06\%$ & $y_i/y_{USA} = 0.308$
$i = 4$	El Salvador	0.9624	0.319	$r_i = 3.91\%$ & $y_i/y_{USA} = 0.150$
$i = 5$	Guatemala	0.9732	0.329	$r_i = 2.75\%$ & $y_i/y_{USA} = 0.169$
$i = 6$	Honduras	0.9458	0.244	$r_i = 5.73\%$ & $y_i/y_{USA} = 0.090$
$i = 7$	Nicaragua	0.9346	0.260	$r_i = 7.0\%$ & $y_i/y_{USA} = 0.094$
$i = 8$	Panama	0.9624	0.670	$r_i = 3.91\%$ & $y_i/y_{USA} = 0.479$
$i = 9$	United States	0.9791	*numeraire*	$r_i = 2.13\%$

* See for example Trabandt and Uhlig (2011), Domeij and Heathcote (2004), and Ferriere and Navarro (2022).

Additionally, in order to incorporate the external sector's weight in the economy, we set the net export weights with respect to each economy's aggregate output. Specifically, we use the observed output-weighted net exports in 2019 to determine the steady-state aggregate savings in each economy given the domestic capital assets market clearing condition defined in the equilibrium.

Table 3 compares the results of the calibrated model in steady state to the data observed in 2019. It shows that the model replicates some relevant macro aggregates, namely the output per capita ratio between each CAPDR country and the U.S. (which captures relative income and is crucial in modeling the trade effects between economies), and the consumption-to-GDP ratio (which is used commonly as a proxy for welfare).

Table 3: Properties of the calibrated model in the initial steady state

Economy	Observed data in 2019[1]		Baseline Model	
	Relative Output[2] $\left({}^{y_i}/_{y_{USA}}\right)$	Consumption[3]	Relative Output $\left({}^{y_i}/_{y_{USA}}\right)$	Consumption
Belize	0.168	0.1049	0.168	0.1110
Costa Rica	0.335	0.2091	0.335	0.2034
Dominican Republic	0.308	0.1874	0.308	0.1898
El Salvador	0.150	0.1139	0.150	0.0895
Guatemala	0.169	0.1265	0.169	0.0974
Honduras	0.090	0.0660	0.090	0.0550
Nicaragua	0.094	0.0626	0.094	0.0592
Panama	0.479	0.2277	0.479	0.2879
United States	*numeraire*	0.6244	*numeraire*	0.6244

[1] Own estimation based on data from the World Bank.
[2] The measure of output employed in this analysis is per capita real GDP in PPP.
[3] Converted into General Equilibrium Model (GEM) terms by multiplying the observed ratio of consumption to GDP by the output from the GEM.

3. Results

3.1. The gravity model of trade

The econometric estimation of gravity equation 1 is performed using the Pseudo-Poisson Maximum Likelihood (PPML) method following Santos Silva and Tenreyro (2006), who show that this method makes it possible to obtain unbiased estimators in the presence of heteroscedasticity in log-linearized models. This estimation method is widely used (Yotov et al., 2016) due to its theoretical robustness and the advantages of overcoming inherent problems in gravity estimations. Concretely, in addition to accounting for heteroscedasticity, it takes advantage of the information in zero trade flows and ensures its idiosyncratic terms are identical to those in fixed effects estimation due to its additive properties.

Table 4 shows the estimation results of the gravity equations using the PPML methodology for each country of the region. In general, the elasticities of the GDP of the origin and destination countries are statistically significant and have the expected positive signs. The only exception is Panama, with a negative coefficient in its domestic GDP. This may be capturing a substantial expansion of GDP from the services sector and construction during the expansion of the Panama Canal, together with the stability of or decrease in merchandise exports in the same period. In Nicaragua, Belize, El Salvador, and the Dominican Republic, the elasticities of their GDP (1.99, 1.77, 1.54, and 1.31, respectively) are above those of their trading partner countries, which suggests that their domestic economic activity is a more significant driver of their exports than their foreign economic activity is.

The coefficient of the distance between trade partners presents the expected negative sign except in the case of Belize and the Dominican Republic, where it is not statistically significant.

In general, the coefficients of the variables intended to capture trade barriers present the expected signs, with a few exceptions for each variable. Specifically, the positive sign of the variable *Access to both oceans* suggests that the countries of the region increase their exports to those with access to the Pacific and Atlantic oceans. This variable was not significant in the case of Belize, Honduras, and Panama. Similarly, the Institutional Quality Index generally returns positive values when statistically significant, suggesting the relevance of institutionality to intraregional trade flows, the exception being Nicaragua. The coefficient of the average tariff on bilateral trade is negative in most cases.

In contrast to the previous results, having a common border does not seem relevant for trade flows across the region, as most coefficients are not significant. The coefficients of Costa Rica and Panama are negative, as the results of these countries are affected by each other.

We include dummy control variables to account for the global financial crisis of 2009 and the beginning of the CAFTA-DR trade agreement between the region and the U.S. The dummy for the financial crisis of 2009 includes 1 in that year and 0 in the rest, while the dummy for the CAFTA-DR has 1 from the beginning of its signing in 2006 onwards. The inclusion of this dummy may capture non-tariff policies resulting from this agreement.[7]

We include estimations using pooled OLS and fixed and random effects to perform robustness checks. The results are included in Appendix A.2. and show that the results hold despite the changes in the estimation methodology, with the variables maintaining their statistical significance and signs.

[7] A regression between the average tariff and the CAFTA-DR dummy shows that the dummy coefficient is not significant and, therefore, that these variables are not linearly dependent.

Table 4: Standard gravity model for each economy in CAPDR

	Belize	Costa Rica	Dominican Republic	El Salvador	Guatemala	Honduras	Nicaragua	Panama	CAPDR
GDP of origin country	1.772*** (0.509)	0.583*** (0.165)	1.305*** (0.044)	1.540*** (0.335)	0.380* (0.214)	0.546 (0.607)	1.978*** (0.655)	-1.871*** (0.375)	0.455* (0.245)
GDP of destination country	0.420* (0.226)	0.703*** (0.073)	0.753*** (0.159)	0.452*** (0.127)	0.597*** (0.039)	0.766*** (0.117)	1.113*** (0.101)	1.191*** (0.229)	0.495*** (0.173)
Distance	0.132 (0.807)	-1.320*** (0.300)	0.897 (1.348)	-0.443 (0.515)	-1.315*** (0.193)	-0.897** (0.383)	-2.024*** (0.278)	-4.268*** (1.158)	-2.991** (1.293)
Common border	2.243 (1.420)	-0.329* (0.169)		0.456 (0.803)	-0.210 (0.237)	0.661 (0.472)	-0.166 (0.367)	-2.909*** (0.942)	-1.097 (1.104)
Access to both oceans	1.149 (1.091)	0.120* (0.067)	0.912* (0.529)	1.238** (0.500)	0.532*** (0.149)	-0.220 (0.233)	-1.176*** (0.123)	0.200 (0.261)	-0.101 (0.146)
Institutional Quality Index	-0.346 (0.372)	0.343*** (0.051)	0.124*** (0.042)	-0.413 (0.290)	0.015 (0.148)	0.769*** (0.292)	-0.295* (0.177)	-0.344 (0.246)	0.155 (0.163)
Average tariff on bilateral trade	-2.165 (7.133)	-2.775*** (0.893)	4.465*** (0.241)	3.024 (3.762)	-4.168** (1.757)	0.878 (6.485)	-0.080 (1.528)	-10.790*** (3.905)	-3.354 (2.665)
CAFTA-DR dummy	-0.057 (0.073)	0.120 (0.122)	-0.605*** (0.044)	0.636*** (0.133)	0.787*** (0.154)	0.558*** (0.163)	0.449*** (0.062)	0.325*** (0.098)	0.500*** (0.057)
2009 crisis dummy	0.012 (0.093)	-0.345*** (0.043)	-0.048*** (0.017)	-0.083*** (0.029)	-0.111*** (0.005)	-0.169*** (0.025)	-0.373* (0.192)	0.147*** (0.044)	-0.177*** (0.030)
Constant	-37.862** (19.185)	-7.334 (4.610)	-52.534*** (7.763)	-37.201*** (10.285)	0.975 (6.201)	-16.511 (21.393)	-48.271*** (15.519)	74.736*** (14.660)	14.371* (7.579)
Num. of obs.	192	192	192	192	192	192	192	192	192
R2	0.959	0.985	0.921	0.907	0.965	0.936	0.943	0.955	0.823

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.2. Analytical solution

The steady-state solution is calculated by log-linearizing the equilibrium conditions described in Section 2.4. We use the calibrated risk aversion parameter equal to one ($\gamma = 1$) for all the economies in the model, resulting in a household utility function of the form $U(c_{i,t}) = \ln(c_{i,t})$. Given the equilibrium condition "*i,*" which is governed by equation 7, we obtain:

$$\frac{c_{i,t+1}}{c_{i,t}} \geq \beta_i(1 + r_{i,t+1}), \text{ with equality for } a_{ij,t+1} > 0.$$

In steady state, this results in:

$$\frac{1}{\beta_i} = (1 + r_i). \tag{15}$$

This allows us to derive the following expression for the steady-state capital stock when equation 13 is plugged into equation 11:

$$K_i = \bar{n} * \left(\frac{\alpha\, \mathcal{A}_i\, \beta_i}{1 - \beta_i + \delta}\right)^{\frac{1}{1-\alpha}} \tag{16}$$

Given (16), we can denote the steady-state values of all the endogenous variables and every economy in the model (i.e., the output, wages, consumption, and savings of each economy $i \in I$), as follows:

$$Y_i = \mathcal{A}_i^{\frac{1}{1-\alpha}} \left(\frac{\alpha\, \beta_i}{1 - \beta_i + \delta}\right)^{\frac{\alpha}{1-\alpha}} \bar{n} \tag{17}$$

$$\omega_i = (1 - \alpha)\, \mathcal{A}_i^{\frac{1}{1-\alpha}} \left(\frac{\alpha\, \beta_i}{1 - \beta_i + \delta}\right)^{\frac{\alpha}{1-\alpha}} \tag{18}$$

$$c_i = r_i a_i + \omega_i \bar{n}. \tag{19}$$

The solution for the steady-state consumption level, which depends on the level of domestic household savings, is given by the equilibrium condition *"iv,"* and is given by:

$$a_i = K_i + BoT_i. \tag{20}$$

Since equations (19) and (20) have three unknown variables (c_i, a_i, and BoT_i), in order to obtain a solution, we include the additional restriction in each economy of matching the trade balance (BoT_i) as a proportion of its respective domestic output in 2019. In this sense, the steady-state savings for each economy are given by (20) and the steady-state consumption level by (19).

3.2.1. The pass-through of a productivity shock

We can calculate the impact of a productivity shock on the domestic aggregate variables and prices in steady state by using the steady-state solutions in equations (15) to (20). However, to derive the spillover effects on the other economies of a productivity shock in economy i, we need to incorporate the demand-driven pass-through given by the gravity forces of trade expressed in equation (1).

Equation (1) shows that foreign demand for domestic goods will increase whenever foreign and domestic output increase. In consequence, a productivity shock in economy i has a positive impact on its respective output, hence economy i will demand more foreign goods from the other economies and vice versa. In our model, this demand-driven mechanism passes through via changes in intertemporal demand preferences as in Carroll et al. (2014),[8] i.e., via changes in all β_i. The intuition behind this mechanism lies in the behavior of households in the face of a permanent increase in income. Since all the economies face a higher demand for their domestic output given a productivity shock in economy i, households are expected to perceive higher incomes and, therefore, accumulate more wealth. These changes in income and wealth decrease the marginal propensity to consume (see, for example, Mian et al., 2013) and households become less impatient and place greater value on their future consumption.

While nonzero trade exists between the economy with the productivity shock and the other economies in the system, the impatience parameters $\beta_i\ \forall i \in I$ will increase due to the higher demand for foreign goods according to the trade gravity equations. The effect this impatience parameter has on the variables in each economy is derived from equations (15) to (18) and can be written as:

$$\frac{\partial r_i}{\partial \beta_i} = -\left(\frac{1}{\beta_i}\right)^2 < 0 \tag{21}$$

$$\frac{\partial K_i}{\partial \beta_i} = \bar{n}\, \mathcal{A}_i^{\frac{1}{1-\alpha}} * \left(\frac{\alpha\, \beta_i}{1-\beta_i+\delta}\right)^{\frac{2\alpha-1}{1-\alpha}} \left(\frac{\alpha+\alpha\delta}{(1-\beta_i+\delta)^2}\right) > 0 \tag{22}$$

$$\frac{\partial Y_i}{\partial \beta_i} = \mathcal{A}_i^{\frac{1}{1-\alpha}} \left(\frac{\alpha\, \beta_i}{1-\beta_i+\delta}\right)^{\frac{2\alpha-1}{1-\alpha}} \left(\frac{\alpha+\alpha\delta}{(1-\beta_i+\delta)^2}\right) \bar{n} \quad > 0 \tag{23}$$

[8] Our argument for introducing the response of intertemporal demand preferences comes from the Marginal Propensity to Consume (MPC) in the literature on heterogeneous agents. Extensive work has been done to demonstrate how the MPC varies according to the wealth level of the individuals (i.e., the wealthier the individual, the lower their MPC). For instance, Mian et al. (2013) highlight the role of the geographic distribution of wealth shock in explaining the large and unequal decline in consumption during the Great Financial Crisis; Ferriere and Navarro (2019) propose a Heterogeneous-Agents New Keynesian Model, in which they prove that heterogeneous stochastic discount factors allow for a reasonable MPC without overstating wealth concentration (as noted by Kaplan and Violante, 2021). More work on this aspect can be found in Krusell and Smith (1998), Carroll et al. (2014), Misra and Surico (2014), Kaplan et al. (2018), Crawley and Kruchler (2022), among others.

$$\frac{\partial \omega_i}{\partial \beta_i} = (1-\alpha)\, \mathcal{A}_i^{\frac{1}{1-\alpha}} \left(\frac{\alpha\, \beta_i}{1-\beta_i+\delta}\right)^{\frac{2\alpha-1}{1-\alpha}} \left(\frac{\alpha+\alpha\delta}{(1-\beta_i+\delta)^2}\right) > 0 \qquad (24)$$

From equations (21) to (24), we observe that the domestic interest rate decreases while capital stock, output, and wages increase as β_i grows. As for the effect on consumption, the negative effect of the interest rate reduction is less than the positive effect on savings and wages, leading to an increase in consumption in the new steady state for all the economies that become less impatient due to an expected higher permanent income.

3.3. Quantitative solution

This section presents quantitative exercises conducted to analyze the spillovers of a productivity shock across the CAPDR region. The first exercise consists of estimating the growth response of each country when each economy in the region experiences an exogenous positive technological shock.

The analysis consists of solving the steady states of each country while incorporating regional trade relations in two scenarios, before and after a productivity shock, so that their results can be finally compared. Section A.3. of the Appendix describes the simulation process step by step.

Table 5 shows the effects on the output of each economy of a 10% productivity increase in each of the countries of the region. The columns correspond to the countries where the productivity shock originated, while the rows indicate the economies receiving the spillover. As expected, the countries where the shock originates register the highest effect on output, in each case being greater than the 10% of the shock itself, due to the trade benefits and the decreasing returns to scale of the input factors. This is shown by the shaded numbers along the diagonal within the table.

The rest of the countries benefit from spillovers resulting from trade relations, whose effect on output is shown in the unshaded section of Table 5. We can isolate the spillover effects of trade by removing the output growth explained solely by the increase in productivity in the shocked economies when they are closed to trade.[9] The results of doing this are presented in Table 6, which shows the spillover from trade.

[9] We remove this effect by simulating a closed economy experiment in which the economies experience the same productivity shock; we then subtract this effect from the overall growth of the shocked economies. This way, we are able to obtain the change in output explained by the intraregional trade channel alone.

Table 5: Total effect on output of a country-specific productivity shock of 10%

Economy	Country of origin of productivity shock[1] ISO Code							
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN
Belize	18.65%	0.10%	0.00%	0.83%	0.72%	0.21%	0.05%	0.61%
Costa Rica	0.00%	18.07%	0.06%	0.61%	0.15%	0.09%	0.40%	0.55%
Dominican Republic	0.00%	0.07%	16.51%	0.11%	0.03%	0.01%	0.02%	0.20%
El Salvador	0.00%	0.36%	0.04%	19.9%	0.91%	0.38%	1.28%	0.49%
Guatemala	0.03%	0.31%	0.03%	1.63%	17.86%	0.10%	0.24%	0.31%
Honduras	0.05%	0.42%	0.10%	3.39%	0.60%	20.1%	0.96%	0.51%
Nicaragua	0.00%	0.66%	0.16%	1.89%	0.45%	0.32%	18.95%	0.64%
Panama	0.00%	0.32%	0.04%	0.21%	0.05%	0.00%	0.06%	16.74%
CAPDR	0.11%	2.70%	4.51%	2.41%	4.22%	1.51%	1.23%	3.05%

[1] For this experiment, we assumed a productivity shock of 10% in each simulation

Table 6 shows that the effects vary substantially across countries. The biggest increases in output through the trade channel as a result of a productivity shock in their own economies occur in Honduras, El Salvador, Nicaragua, and Belize, at 4.0%, 3.84%, 2.89%, and 2.59%, respectively, with 2% or lower in the rest.

As for the spillovers from the shocked economies to the other countries of the region, El Salvador, Guatemala, and Costa Rica contribute most to the region's growth, as the average in the last row of Table 6 (corresponding to CAPDR) shows.

Table 6: Spillover effects from trade on output of a country-specific productivity shock

Economy	Economy with the productivity shock[1] ISO Code							
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN
Belize	2.59%	0.10%	0.00%	0.83%	0.72%	0.21%	0.05%	0.61%
Costa Rica	0.00%	2.01%	0.06%	0.61%	0.15%	0.09%	0.40%	0.55%
Dominican Republic	0.00%	0.07%	0.45%	0.11%	0.03%	0.01%	0.02%	0.20%
El Salvador	0.00%	0.36%	0.04%	3.84%	0.91%	0.38%	1.28%	0.49%
Guatemala	0.03%	0.31%	0.03%	1.63%	1.80%	0.10%	0.24%	0.31%
Honduras	0.05%	0.42%	0.10%	3.39%	0.60%	4.00%	0.96%	0.51%
Nicaragua	0.00%	0.66%	0.16%	1.89%	0.45%	0.32%	2.89%	0.64%
Panama	0.00%	0.32%	0.04%	0.21%	0.05%	0.00%	0.06%	0.68%
CAPDR	0.03%	0.54%	0.17%	1.19%	0.63%	0.41%	0.45%	0.42%

[1] For this experiment, we assumed a productivity shock of 10% for every simulation

From the previous analysis, we are able to identify two patterns that help explain the magnitude of the effect of the productivity shock on output: (i) More-integrated economies obtain greater benefits from a productivity shock and this applies to both the countries where the shock is originated and to the rest, and (ii) relatively lower-income economies, measured by GDP per capita, benefit more than economies with a higher income. These patterns are shown in Figures 1 and 2.

Figure 1 shows the positive relationship between the spillover effects on a country's output of its own 10% productivity shock and its degree of integration (measured as the weight of intraregional trade in each economy's total trade). In addition, the size of the circles indicates the size of the countries' GDP per capita. By comparing their relative incomes, we can see that despite their having similar levels of trade integration, economies with relatively higher income (such as Panama, Costa Rica, and Guatemala) experience lower effects compared to smaller economies (such as Belize, Honduras, and Nicaragua). The intuition behind these differences is that less-developed economies present higher returns from accumulating the productive factors resulting from the productivity shock and the relatively larger external demand from richer economies, as they expect their income to grow.

Figure 2 shows the positive relationship between the spillover effects on output transmitted by the shocked economies to each other country of the region and the share those other countries represent of the total trade of the shocked economies. The results suggest that economies benefit more from increments in the productivity of a trade partner whenever these economies are more integrated with their partners. Moreover, as in Figure 1, we can see that the magnitude of the spillover also depends on the economy's level of income, with low-income economies, on average, presenting higher effects.

Figure 1: Effect on a country's output of its own 10% productivity shock

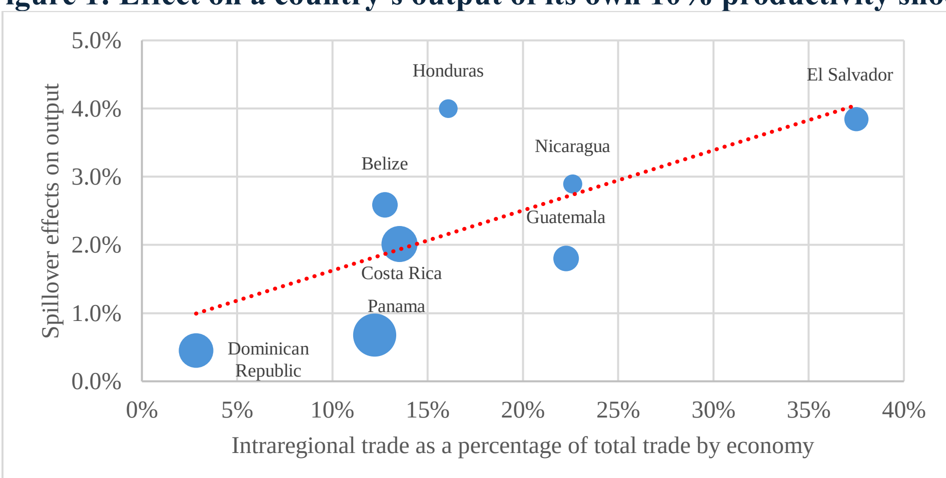
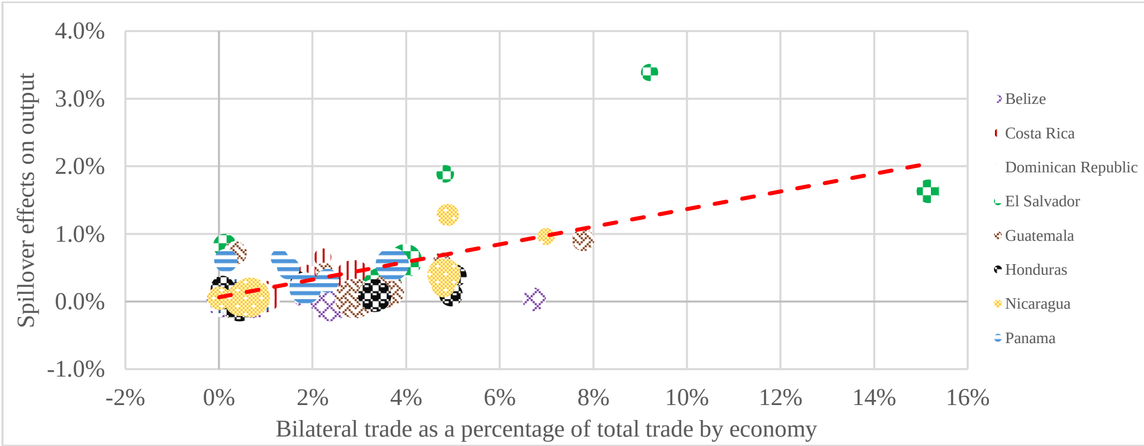


Figure 2: Spillover effects of a 10% country-specific productivity shock on the output of the rest of the countries



The spillover effects of the productivity shock on consumption, capital, and interest rates that are transmitted through the trade channel are presented in Section A.4. of the Appendix. The effects on consumption are very similar to those of output in terms of their variability and dependency on the level of economic integration and income of the economies, the only difference being the magnitude of the variation, which is lower for consumption. This is a consequence of household consumption and saving decisions, i.e., households begin to value savings more as the marginal propensity to consume decreases due to their higher income, which causes consumption to grow less compared to output.

Regarding competitive wages, these grow at the same rate as output in each economy due to the assumption of an inelastic labor supply. Capital stock grows at a faster rate than output due to the constant-return-to-scale specification of the production function, while its rate differs across countries depending on the steady-state level before the shock takes place. Finally, domestic interest rates decrease as the consumers' preference for saving is higher (i.e., they now are willing to supply the same amount of capital assets to firms at a lower price).

As we have highlighted, in the face of a productivity shock, the more integrated an economy is within the region, the higher the spillover effects. This argument applies to all economies, shocked or otherwise, but the effects are considerably greater when the economies experience increased productivity. Considering this result, we estimate the benefits of economic integration when the region as a whole becomes more productive. To do this, we perform an additional simulation in which all the countries of the region increase their productivity by 1% due to an external shock. This also allows us to estimate the enhanced benefit of economic integration in terms of increased productivity by comparing the results with those of autarky.

Table 7 summarizes the spillover effects results of the simulation mentioned above. CAPDR increases its output by 0.19% due to spillovers through the trade channel. El Salvador and Honduras are the economies that benefit most from regional spillovers, with 0.46% and

0.43% increases in output, respectively. Nicaragua registers a 0.38% increase in output, and Belize 0.36%. Higher-income economies such as Costa Rica, and those that are less economically integrated, such as the Dominican Republic, present lower growth rates. The Dominican Republic's share of exports to the region is 1.6% of the total and 3.4% of total imports. Appendix A.5. presents intraregional trade by country.

A comparison of the relative differences among economies shows the effects on consumption and capital to be similar to those for output. The changes in domestic interest rates also depend on their respective initial steady state, where the higher the interest rate in the initial steady state, the higher the changes due to spillover effects.

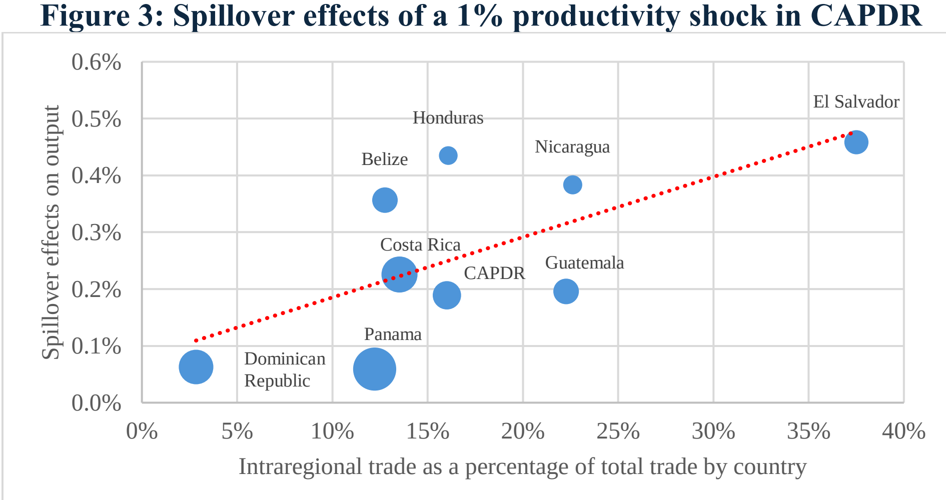
Table 7: Spillover effects of a 1% productivity shock across the region

Economy	Output	Consumption	Capital Stock	Interest Rate[1]
Belize	0.36%	0.23%	0.99%	-10.7
Costa Rica	0.23%	0.12%	0.63%	-4.1
Dominican Republic	0.06%	0.04%	0.17%	-1.2
El Salvador	0.46%	0.24%	1.28%	-8.0
Guatemala	0.20%	0.09%	0.54%	-3.0
Honduras	0.43%	0.27%	1.21%	-9.0
Nicaragua	0.38%	0.28%	1.07%	-8.8
Panama	0.06%	0.04%	0.16%	-1.0
CAPDR	0.19%	0.11%	0.52%	-

[1] The change is measured in basis points

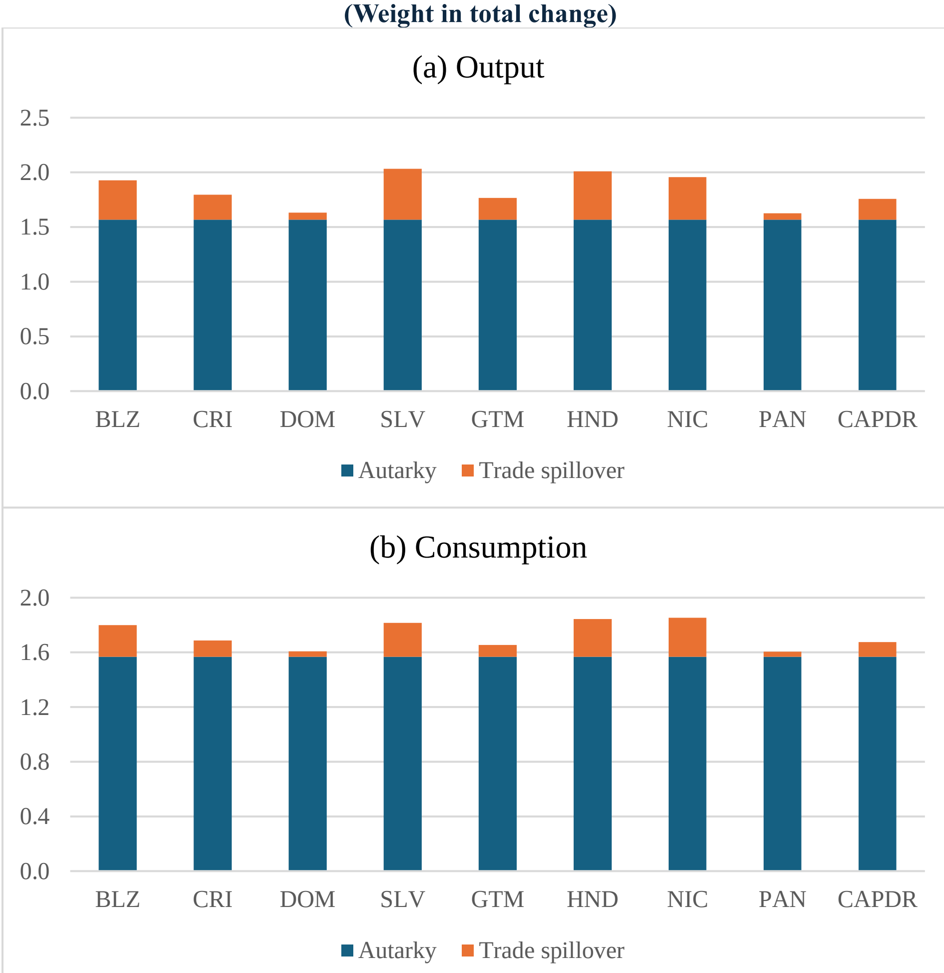
As in Figure 1, Figure 3 shows a positive relationship between regional trade integration and spillover effects. The more trade-integrated the country is within the region, the greater the effects of a productivity shock on the macroeconomic aggregates, while the lower the income level, the greater their magnitude.

Figure 3: Spillover effects of a 1% productivity shock in CAPDR



To estimate the role of economic integration in transmitting productivity improvements compared to that of autarky, we calculate a counterfactual consisting of a 1% productivity shock when the economies are in autarky and compare the results with our previous estimates. Figure 4 shows the effect on output and consumption of a 1% regional productivity shock in the scenario of autarky and when there is regional transmission through the trade channel. These effects are calculated as the change due to the productivity shock from the initial steady state to a new steady state. A significant share of the total growth can be explained by the spillovers through the trade channel. The magnitude of this growth differs across countries depending on the degree of economic integration and level of income, ranging from 3.9% of total growth in the Dominican Republic to 22.9% in El Salvador, representing 10.9% in CAPDR.

Figure 4: Spillover effects of a 1% productivity regional shock
(Weight in total change)



4. Conclusion

This work estimates the spillover effects through the trade channel of a productivity shock in Central America, Panama, and the Dominican Republic. To do so, it performs simulations using a calibrated model that matches the main macroeconomic aggregates and trade relations of the region.

The analysis finds positive spillover effects on the macroeconomic variables of all the economies in the CAPDR region. More-integrated economies experience greater spillover effects on output and consumption of a productivity shock originating in a country within the region. Furthermore, economies with relatively lower income experience greater output growth through these spillovers.

In addition, countries experiencing increased productivity reap the greatest benefits from economic integration, while those economies that do not experience such an improvement benefit more from the spillover effects when they trade intensively with a partner that does.

Spillovers through the trade channel play a significant role in boosting the economic growth that stems from a positive productivity shock, and increase in magnitude when there is a higher degree of regional integration and lower levels of income.

References

Anderson, J.E. (1979), "A Theoretical Foundation for the Gravity Equation," *American Economic Review* 69(1), 106-116.

Anderson, J.E., and van Wincoop, E. (2004), "Trade Costs," *Journal of Economic Literature* 42(3), 691-751.

Backus, D., Kehoe, P., and Kydland, F. (1993). "International Business Cycles: Theory and Evidence," National Bureau of Economic Research, Working Paper 4493.

Badinger, H. (2005), "Growth Effects of Economic Integration: Evidence from the EU Member States," *Review of World Economics* 141(1), 50-77.

Bergstrand, J.H. (1985), "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence," *Review of Economics and Statistics* 67(3), 474-481.

Cass, D. (1965). "Optimum Growth in an Aggregative Model of Capital Accumulation," *The Review of Economic Studies*, Volume 32, Issue 3, July 1965, pp. 233-240.

Caceres, L. (2021), "Labor Productivity the Economic Integration in Central America: a case for El Salvador," *ECLAC Journal*: Santiago, Chile (Translated from Spanish).

Carroll, C., Slacalek, J., Tokuoka, K., and White, M. (2017), "The distribution of wealth and the marginal propensity to consume," *Quantitative Economics* 8(3), 977-1020.

Carroll, C. (2006), "The Method of endogenous grid points for solving dynamic stochastic optimization problems," *Economics Letters* 91(3), 312-320.

Crawley, E., and Kruchler, A. (2022), "Consumption heterogeneity: Micro drivers and macro implications," *American Economic Journal: Macroeconomics.*

Domeij, D. and Heathcote, J., (2004), "On The Distributional Effects of Reducing Capital Taxes," *International Economic Review* 45(2), 523-554, Department of Economics, University of Pennsylvania and Osaka University Institute of Social and Economic Research Association.

Ferriere, A., and Navarro, G. (2022), "The Heterogeneous Effects of Government Spending: It's All About Taxes," *Federal Reserve Board Working paper,* European University Institute.

Gammadigbe, V. (2021), "Is Regional Trade Integration a Growth and Convergence Engine in Africa," *IMF Working Paper* 21(19).

Geraci, V. and Prewo, W. (1977), "Bilateral Trade Flows and Transport Costs," *The Review of Economics and Statistics* 59(1), 67.

Henrekson, M., Torstensson, J. and Torstensson, R. (1997), “Growth Effects of European Integration,” *European Economic Review* 41(8), 1537-1557

Kaplan, G., Moll, B., and Violante, G. (2018), “Monetary Policy According to HANK,” *American Economic Review* 108(3), 697-743.

Kaplan, G., and Violante, G. (2021), “The Marginal Propensity to Consume in Heterogeneous Agents Models,” *Working Paper,* Princeton University.

Koopmans, T.C. (1965), On the Concept of Optimal Economic Growth, In *The Econometric Approach to Development Planning*, Johansen, J. (Ed.), Amsterdam: North Holland.

Krusell, P., and Smith, A. (1998), “Income and Wealth Heterogeneity in the Macroeconomy,” *Journal of Political Economy* 106(5), 867-896.

Kydland, F.E., and Prescott, E.C. (1982), “Time to Build and Aggregate Fluctuations,” *Econometrica* 50(6), 1345-1370.

Mian, A., Rao, K., and Sufi, A. (2013), “Household Balance Sheets, Consumption, and the Economic Slump,” *The Quarterly Journal of Economics* 128(4), 1687-1726.

Misra. K., and Surico, P. (2014), “Consumption, income changes, and heterogeneity: Evidence from two fiscal stimulus programs,” *American Economic Journal: Macroeconomics* 6(4), 84-106.

Nwosu, O.E., Orji, A., Urama, N. and Amuka, J.I. (2013), “Regional integration and foreign investment: The case of ASEAN countries,” *Asian Economic and Financial Review* 3(12), 1670-1680.

Obstfeld, M. (1986), “Capital mobility in the world economy: Theory and measurement,” *Carnegie-Rochester Conference Series on Public Policy* Volume 24, 55-103.

Petit, J. (2014), “Economic Integration Theory and its Fundamental Principles,” *Venezuelan Journal of Situation Analysis*, 137-162. (Translated from Spanish).

Poyhonen, P. (1963), “A Tentative Model for the Volume of Trade between Countries,” *Weltwirtschaftliches Archiv* 90, 93-100.

Pullianen, K.A. (1963), “World Trade Study: An Econometric Model of the Patterns of the Commodity Flows in International Trade 1948–1960,” *Economiska Samfundets Tidskrift* 2, 78-91.

Ramsey, F.P., (1928), “A Mathematical Theory of Savings,” *The Economic Journal* 38(152), 543-559, Oxford University Press.

Razafindrabe, T. (2016), “A multi-country DSGE model with incomplete exchange rate pass-through: An application for the Euro-area,” *Economic Modelling* 52(A), 78-100.

Salazar, N., Caldentey, P. and Delgado, M. (2023), “Measuring Economic Integration in Developing Countries: The Case of Central America,” *Bulletin of Latin American Research* 42(5), 692-706, https://doi.org/10.1111/blar.13506

Santos Silva, J.M.C. and Tenreyro, S. (2006), “The Log of Gravity.” *The Review of Economics and Statistics* 88(4), 641-658.

SIECA (2021). *Estudio conmemorativo de los 60 años de la Secretaría de Integración Económica Centroamericana* (SIECA), Guatemala City.

Smets, F., and Wouters, R. (2003). “An estimated dynamic stochastic general equilibrium model of the Euro area,” *European Central Bank*, Working Paper No. 128.

Tamanes, R. (1990), *Estructura Economica Internacional*, Alianza Editorial: Madrid.

Tinbergen, J. (1962), *Shaping the World Economy: Suggestions for an International Economic Policy*, New York: The Twentieth Century Fund.

Trabandt, M. and Uhlig, H., (2011), “The Laffer Curve revisited,” *Journal of Monetary Economics* 58(4), 305-327.

Urbina, J. and Marenco, M. (2022), “Midiendo el grado de integración económica centroamericana vía dinámica de interconectividad y spillovers,” Call for Papers, 4th edition 15-28. SG-SICA, BCIE, and SIECA, Central America.

Yotov, Y., Piermartini, R., Monteiro, J., and Larch, M. (2016), *An Advanced Guide to Trade Policy Analysis the Structural Gravity Model*, Martin, A. (Ed.), Geneva: WTO Publications.

Appendix

A.1. Solution to the households' maximization problem for open economies

Consider the optimal value function $V\left(a_{i,t}, z_{i,t}\right)$, which is the unique solution to the following Bellman equation:

$$V\left(a_{i,t}, z_{i,t}\right) = \max_{a_{i,t+1}}\left\{U\left(z_{i,t} - a_{i,t+1}\right) + \beta_i\left[V\left(a_{i,t+1}, z_{i,t+1}\right)\right]\right\} \qquad (a1)$$

Subject to:

$$c_{i,t} + a_{ii,t+1} + \sum_{j\neq i}\frac{a_{ij,t+1}}{e_{ij,t}} = \left(1 + r_{i,t}\right)a_{ii,t} + \sum_{j\neq i}\frac{1 + r_{j,t}}{e_{ij,t}}a_{ij,t} + \omega_{i,t}\bar{n} \qquad (a2)$$

$$\forall i, j \in I \qquad a_{ij,t+1} \geq 0 \qquad (a3)$$

With:

$$a_{i,t} = a_{ii,t} + \sum_{j\neq i}\frac{a_{ij,t}}{e_{ij,t}} \qquad (a4)$$

$$z_{i,t} = \left(1 + r_{i,t}\right)a_{ii,t} + \sum_{j\neq i}\frac{1 + r_{j,t}}{e_{ij,t}}a_{ij,t} + \omega_{i,t}\bar{n} \qquad (a5)$$

The first-order conditions (FOCs) for $a_{i,t+1}$ and $\forall\ (i,t)\ \ and\ \forall j \neq i$ are such that:

$$a_{ii,t+1}: \quad \frac{\partial V\left(a_{i,t}, z_{i,t}\right)}{\partial a_{ii,t+1}} = -\frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ii,t+1}} + \beta_i\left[\frac{\partial V\left(a_{i,t+1}, z_{i,t+1}\right)}{\partial a_{ii,t+1}}\right] = 0 \quad (a6)$$

$$a_{ij,t+1}: \quad \frac{\partial V\left(a_{i,t}, z_{i,t}\right)}{\partial a_{ij,t+1}} = -\frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ij,t+1}}\frac{1}{e_{ij,t}} + \beta_i\left[\frac{\partial V\left(a_{i,t+1}, z_{i,t+1}\right)}{\partial a_{ij,t+1}}\right] = 0 \quad (a7)$$

Therefore:

$$a_{ii,t+1}: \qquad \frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ii,t+1}} = \beta\left[\frac{\partial V\left(a_{i,t+1}, z_{i,t+1}\right)}{\partial a_{ii,t+1}}\right] \qquad (a8)$$

$$a_{ij,t+1}: \qquad \frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ij,t+1}}\frac{1}{e_{ij,t}} = \beta\left[\frac{\partial V\left(a_{i,t+1}, z_{i,t+1}\right)}{\partial a_{ij,t+1}}\right] \qquad (a9)$$

By the envelope theorem and given the equivalent expression for $z_{i,t}$ in equation a5, from equation a1 we can obtain the following equalities $\forall\ (i,t)\ \ and\ \forall j \neq i$:

$$a_{ii,t+1}: \qquad \frac{\partial V\left(a_{i,t}, z_{i,t}\right)}{\partial a_{ii,t}} = \frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ii,t}} * \left(1 + r_{i,t}\right) \qquad (a10)$$

$$a_{ij,t+1}: \qquad \frac{\partial V\left(a_{i,t}, z_{i,t}\right)}{\partial a_{ij,t}} = \frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ij,t}} * \left(\frac{1 + r_{j,t}}{e_{ij,t}}\right) \qquad (a11)$$

Now, from (a8), (a9), (a10) and (a11), the following Euler equations for all t, i, and all $j \neq i$ can be defined as:

$$a_{ii,t+1}: \qquad \frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ii,t+1}} = \beta\left[\left(1 + r_{i,t+1}\right) * \frac{\partial U\left(z_{t+1} - a_{t+2}\right)}{\partial a_{ii,t+1}}\right] \qquad (a12)$$

$$a_{ij,t+1}: \qquad \frac{\partial U\left(z_{i,t} - a_{i,t+1}\right)}{\partial a_{ij,t+1}} = \beta\left[\left(\frac{e_{ij,t}}{e_{ij,t+1}}\right)\left(1 + r_{j,t+1}\right) * \frac{\partial U\left(z_{t+1} - a_{t+2}\right)}{\partial a_{ij,t+1}}\right] \quad (a13)$$

Given equation a2, we can show the MRS between $c_{i,t}$ and $a_{i,t+1}$ to be equal to one, as follows:

From a2, we have $\frac{\partial c_{ii,t+1}}{\partial a_{ii,t+1}} = -1$ and $\frac{\partial c_{ij,t+1}}{\partial a_{ij,t+1}} = -\frac{\frac{1}{e_{ij,t+1}}}{\frac{1}{e_{ij,t+1}}} = -1$

From equation a4, and since $c_{i,t} = c_{ii,t} + \sum_{j \neq i} \frac{c_{ij,t}}{e_{ij,t}}$, we can conclude that:

$$MRS_{c_{i,t}, a_{i,t+1}} = \frac{\partial c_{i,t+1}}{\partial a_{i,t+1}} = -1 \qquad (a14\,)$$

Now, given (a14), equations (a12) and (a13) are equivalent to:

$$\frac{\partial U\left(c_{i,t}\right)}{\partial c_{i,t}} = \beta\left[\left(1 + r_{i,t+1}\right) \ \frac{\partial U\left(c_{t+1}\right)}{\partial c_{t+1}}\right] \qquad (a15)$$

$$\frac{\partial U\left(c_{i,t}\right)}{\partial c_{i,t}} = \beta\left[\left(\frac{e_{ij,t}}{e_{ij,t+1}}\right)\left(1 + r_{j,t+1}\right) \ \frac{\partial U\left(c_{t+1}\right)}{\partial c_{t+1}}\right] \qquad (a16)$$

Uncovered Parity of Interest Rates

The Euler equations given by (a15) and (a16) are consistently the same for the households in economy "i" if and only if the condition of uncovered parity of interest rates holds. This is proved as follows:

From the maximization problem for the consumer according to equations 3 to 5, the following Lagrangian equation can be derived:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta_i^t \left[U\left(c_{i,t}\right) + \lambda_t\left(\left(1 + r_{i,t}\right)a_{ii,t+1} + \sum_{j \neq i} \frac{1 + r_{j,t}}{e_{ij,t}} a_{ij,t+1} + \omega_{i,t}\bar{n} - c_{i,t} - a_{ii,t+1} - \sum_{j \neq i} \frac{a_{ij,t+1}}{e_{ij,t}}\right)\right]$$

The FOCs for the saving decisions in period t are as follows:

$$\mathcal{L}_{a_{ii,t+1}}: \qquad \lambda_t = \beta_i\left[\lambda_{t+1}\left(1 + r_{i,t+1}\right)\right] \qquad (a17)$$

$$\mathcal{L}_{a_{ij,t+1}}: \qquad \frac{\lambda_t}{e_{ij,t}} = \beta_i\left[\lambda_{t+1}\left(\frac{1 + r_{j,t+1}}{e_{ij,t+1}}\right)\right] \qquad (a18)$$

From the FOCs in equations (a17) and (a18), we can equalize "$\beta_i\left({}^{\lambda_{t+1}}/_{\lambda_t}\right)$" for both expressions, which gives us:

$$\left(\frac{e_{ij,t+1}}{e_{ij,t}}\right)\frac{1}{1 + r_{j,t+1}} = \frac{1}{1 + r_{i,t+1}} \qquad (a19)$$

By log-linearizing expression (a19), we can derive the uncovered interest rate parity such that:

$$r_{j,t+1} = r_{i,t+1} + \Delta\%\left(e_{ij,t}\right) \qquad (a20)$$

Equation (a20) is the uncovered parity of interest rate that holds for all the economies in this global system. Hence, given that (a20) holds $\forall i \in I$, and $\forall j \neq i$, we can conclude that (a15) and (a16) are equivalent, so the solution to the maximization problem for the consumers in economy *"i"* is governed by equation (7) or (a15), such that:

$$\forall i \in I, \qquad \frac{\partial U\left(c_{i,t}\right)}{\partial c_{i,t}} = \beta\left[\left(1 + r_{i,t+1}\right)\ \frac{\partial U(c_{t+1})}{\partial c_{t+1}}\right]$$

A.2. Gravity equation results by country

Table 8: Gravity model estimation for Belize
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	-8.948 (5.131)	-8.948* (5.131)	-7.225 (5.393)	1.772*** (0.509)
GDP of destination country	1.178*** (0.298)	1.178*** (0.298)	0.138 (0.813)	0.420* (0.226)
Distance	-1.863* (0.876)	-1.863** (0.876)	-17.768 (17.425)	0.132 (0.807)
Common border	1.425 (1.377)	1.425 (1.377)	0.000 (.)	2.243 (1.420)
Access to both oceans	1.168 (1.195)	1.168 (1.195)	0.000 (.)	1.149 (1.091)
Institutional Quality Index	-1.266 (0.955)	-1.266 (0.955)	-0.303 (0.280)	-0.346 (0.372)
Average tariff on bilateral trade	34.044 (39.395)	34.044 (39.395)	-28.654*** (7.057)	-2.165 (7.133)
Constant	137.139 (143.776)	137.139 (143.776)	305.822 (182.056)	-37.862** (19.185)
Num. of obs.	190.000	190.000	190.000	192.000
R2	0.690		0.640	0.959

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 9: Gravity model estimation for Costa Rica
Comparative between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	-1.356 (1.714)	-1.704 (1.423)	-1.548 (1.216)	0.583*** (0.165)
GDP of destination country	0.999*** (0.172)	1.176*** (0.168)	0.965** (0.380)	0.703*** (0.073)
Distance	-2.247*** (0.588)	-2.758*** (0.602)	29.421** (10.841)	-1.320*** (0.300)
Common border	-0.648* (0.340)	-0.821*** (0.270)	0.000 (.)	-0.329* (0.169)
Access to both oceans	-0.128 (0.234)	-0.425 (0.720)	0.000 (.)	0.120* (0.067)
Institutional Quality Index	0.191** (0.080)	0.095 (0.124)	0.056 (0.121)	0.343*** (0.051)
Average tariff on bilateral trade	1.197 (6.795)	7.544 (5.705)	8.356 (5.320)	-2.775*** (0.893)
Constant	33.669 (35.393)	34.422 (27.743)	-184.210** (53.825)	-7.334 (4.610)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.949		0.806	0.985

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 10: Gravity model estimation for the Dominican Republic
Comparative between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	-4.225 (5.645)	-4.049 (5.811)	-3.474 (5.311)	1.305*** (0.044)
GDP of destination country	0.878*** (0.134)	0.774*** (0.179)	-0.538 (1.331)	0.753*** (0.159)
Distance	-0.731 (1.265)	1.177 (1.642)	-583.387 (581.427)	0.897 (1.348)
Access to both oceans	1.166* (0.504)	1.723** (0.767)	0.000 (.)	0.912* (0.529)
Institutional Quality Index	-0.506 (0.378)	-0.392 (0.316)	-0.416 (0.305)	0.124*** (0.042)
Average tariff on bilateral trade	-11.570* (5.097)	5.271 (5.441)	5.120 (4.152)	4.465*** (0.241)
Constant	106.268 (141.521)	71.040 (132.596)	4542.628 (4463.575)	-52.534*** (7.763)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.929		0.693	0.921

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 11: Gravity model estimation for El Salvador
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	0.713 (1.324)	0.115 (0.134)	0.133 (1.249)	1.540*** (0.335)
GDP of destination country	0.409** (0.123)	0.033 (0.334)	0.356 (0.583)	0.452*** (0.127)
Distance	-0.388 (0.448)	0.611 (1.129)	-70.322*** (13.647)	-0.443 (0.515)
Common border	0.781 (0.581)	1.758 (1.121)	0.000 (.)	0.456 (0.803)
Access to both oceans	1.279** (0.478)	2.306** (1.111)	0.000 (.)	1.238** (0.500)
Institutional Quality Index	0.428* (0.218)	0.144 (0.184)	0.185 (0.153)	-0.413 (0.290)
Average tariff on bilateral trade	-2.921 (5.142)	0.856 (2.111)	-0.966 (2.135)	3.024 (3.762)
Constant	-11.603 (28.696)	0.000 (.)	455.106*** (92.120)	-37.201*** (10.285)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.931		0.892	0.907

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 12: Gravity model estimation for Guatemala
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	0.251 (0.600)	0.255 (0.588)	0.374 (0.600)	0.380^{*} (0.214)
GDP of destination country	0.544^{***} (0.036)	0.552^{***} (0.068)	0.367 (0.265)	0.597^{***} (0.039)
Distance	-1.272^{***} (0.178)	-1.273^{***} (0.257)	-11.981 (7.719)	-1.315^{***} (0.193)
Common border	-0.404 (0.361)	-0.416 (0.415)	0.000 (.)	-0.210 (0.237)
Access to both oceans	0.389^{*} (0.176)	0.505^{**} (0.231)	0.000 (.)	0.532^{***} (0.149)
Institutional Quality Index	-0.025 (0.127)	-0.034 (0.086)	-0.001 (0.097)	0.015 (0.148)
Average tariff on bilateral trade	-14.038^{***} (3.461)	-6.884^{**} (3.005)	-8.060^{*} (3.442)	-4.168^{**} (1.757)
Constant	15.975 (11.765)	7.716 (12.055)	81.441 (58.839)	0.975 (6.201)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.969		0.942	0.965

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 13: Gravity model estimation for Honduras
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	-15.550*** (2.953)	0.636*** (0.231)	-16.432*** (3.396)	0.546 (0.607)
GDP of destination country	0.737*** (0.053)	0.759*** (0.051)	1.608** (0.665)	0.766*** (0.117)
Distance	-1.080*** (0.096)	-1.097*** (0.109)	-5.981 (11.802)	-0.897** (0.383)
Common border	0.632** (0.211)	0.663*** (0.230)	0.000 (.)	0.661 (0.472)
Access to both oceans	-0.196 (0.112)	-0.182 (0.119)	0.000 (.)	-0.220 (0.233)
Institutional Quality Index	0.427** (0.170)	0.369** (0.177)	0.254 (0.142)	0.769*** (0.292)
Average tariff on bilateral trade	-17.884** (5.451)	-14.873*** (4.333)	-8.829** (3.502)	0.878 (6.485)
Constant	376.708*** (71.393)	0.000 (.)	398.100*** (90.457)	-16.511 (21.393)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.944		0.787	0.936

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 14: Gravity model estimation for Nicaragua
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	0.814 (0.926)	0.515 (0.757)	0.202 (0.851)	1.978*** (0.655)
GDP of destination country	1.262*** (0.251)	1.251*** (0.418)	1.032 (0.633)	1.113*** (0.101)
Distance	-2.513*** (0.645)	-2.375** (1.034)	-34.099* (16.362)	-2.024*** (0.278)
Common border	0.021 (0.644)	0.117 (0.680)	0.000 (.)	-0.166 (0.367)
Access to both oceans	-1.018* (0.518)	-0.645 (0.692)	0.000 (.)	-1.176*** (0.123)
Institutional Quality Index	-0.202 (0.210)	-0.092 (0.130)	-0.026 (0.074)	-0.295* (0.177)
Average tariff on bilateral trade	-19.651** (6.431)	1.237 (3.373)	1.416 (3.818)	-0.080 (1.528)
Constant	-0.784 (22.741)	-18.070 (19.547)	201.882* (103.872)	-48.271*** (15.519)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.877		0.692	0.943

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 15: Gravity model estimation for Panama
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	-9.322* (4.624)	-9.103* (4.724)	-7.745 (4.813)	-1.871*** (0.375)
GDP of destination country	1.205*** (0.065)	1.221*** (0.111)	-0.411 (0.760)	1.191*** (0.229)
Distance	-4.255*** (0.238)	-4.260*** (0.431)	58.179* (30.167)	-4.268*** (1.158)
Common border	-2.839*** (0.245)	-2.849*** (0.387)	0.000 (.)	-2.909*** (0.942)
Access to both oceans	0.262 (0.160)	0.311 (0.221)	0.000 (.)	0.200 (0.261)
Institutional Quality Index	-0.119 (0.344)	0.039 (0.372)	0.113 (0.306)	-0.344 (0.246)
Average tariff on bilateral trade	-5.436 (5.647)	-0.500 (8.098)	4.848 (4.095)	-10.790*** (3.905)
Constant	243.534* (105.975)	232.350** (107.766)	-211.076 (274.991)	74.736*** (14.660)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.950		0.394	0.955

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

Table 16: Gravity model estimation for CAPDR
Comparison between models

	Pooled OLS	GLS Random Effects	GLS Fixed Effects	PPML
GDP of origin country	-0.747 (0.625)	-0.697 (0.532)	-0.646 (0.544)	0.455* (0.245)
GDP of destination country	0.669*** (0.173)	0.665*** (0.210)	0.599** (0.230)	0.495*** (0.173)
Distance	-2.712** (1.108)	-3.142*** (1.197)	59.164 (77.522)	-2.991** (1.293)
Common border	-0.891 (0.922)	-1.293 (0.885)	0.000 (.)	-1.097 (1.104)
Access to both oceans	0.023 (0.300)	0.210 (0.533)	0.000 (.)	-0.101 (0.146)
Institutional Quality Index	0.134 (0.140)	0.001 (0.086)	-0.003 (0.083)	0.155 (0.163)
Average tariff on bilateral trade	-15.629* (7.171)	-0.929 (1.288)	-1.420 (1.416)	-3.354 (2.665)
Constant	52.279** (15.525)	37.879*** (12.252)	-386.383 (525.139)	14.371* (7.579)
Num. of obs.	192.000	192.000	192.000	192.000
R2	0.897		0.946	0.823

Notes: Explanatory variables in natural logarithms
Standard errors in parenthesis ()
Significance such that: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$
A dummy for CAFTA-DR and the 2009 global financial crisis was added to the model

A.3. Solution algorithm

This subsection explains the algorithm employed to find the steady states of the proposed model and to simulate the productivity shock and its spread throughout the system.

Steady-state solution

i. For each economy i:

    a. Assign a positive random value for the domestic aggregate capital stock[10] $K_{i,t}$ and, using the equilibrium conditions, calculate the values of domestic aggregate output $Y_{i,t}$, the domestic salary rate $\omega_{i,t}$, and the domestic interest rate $r_{i,t}$.
    b. Solve the households' maximization problem to obtain the consumption and saving policies. To do this, we employed the Endogenous Grid-Points Method (EGM) algorithm proposed by Carroll (2006).
    c. Using these consumption and saving policies, simulate the economy to generate a stationary level of asset holdings (i.e., either 0 or K_{max}).
    d. Check that the assets market clearing condition is met for the case of a closed economy $(\text{i.e.}, A_t = K_t)$.
    e. Adjust K_t such that the new value $K_{new,t}$ decreases if $A_t < K_{old,t}$, and increases otherwise. Iterate this procedure until $K_{new,t} = K_{old,t}$.

ii. Use the observed net exports as a proportion of total output by country and multiply by their respective stationary-state output levels for the GEM. This involves converting the initial steady-state net exports into GEM terms.

iii. Given the domestic assets market clearing condition defined in the equilibrium (i.e., $a_{i,t} = K_{i,t} + BoP_{i,t}$), find the steady-state domestic levels of savings assets.

iv. Since the system is composed of just nine economies (rather than the whole world or an infinite number of economies), we impose a restriction on one large economy that fulfills the foreign capital needs of the small economies. For this case, we assume that the U.S. economy holds a level of savings assets commensurate with its observed level of consumption.[11]

v. Given the domestic levels of savings assets of the small economies, we estimate the corresponding level of consumption according to equation 4.

Solution to the experiment

a. Update the productivity vector so that the target economy (or economies) experience(s) a proportional increase in its/their current productivity.

[10] Initially, as a "rule of thumb" we set a positive random value smaller than ten, considering that the highest steady-state aggregate capital level–which corresponds to the U.S.–is no greater than four. Nevertheless, one can assign any positive value for the initial level of aggregate capital $K_{i,t}$ and the algorithm will find the $K_{i,t}$ that converges towards its unique steady-state level.

[11] This restriction, of course, returns a level of savings assets for the U.S. way higher than the level needed for clearing the global assets market. The assumption we impose consists of these excess savings being placed in an exogenous market that pays a competitive price.

b. Update the steady-state level for the shocked economy (or economies).
c. Update the bilateral trade flows between the shocked economy and the rest of the economies according to the estimations for the gravity model of trade.
d. Incorporate the changes in the bilateral trade flows so that the weights in all domestic total exports are updated.
e. Change the bilateral trade flows from "exports to country i" to "imports from country j." For this procedure, it is important to take into account the population of each partner relative to that of the other, so that the flows are properly converted.
f. Given the export and import flows of all the economies, update the current account balances for every economy according to the changes in bilateral trade flows.
g. Use the import flows to update the new level of consumption in every economy. These new levels of consumption are the steady-state goal to reach, which is achieved as follows:
    i. Assign the value of β_i for every economy. As the initial value, we use the initial steady-state levels.
    ii. With the new values of $\beta_{new,i}$ for every economy, find the updated steady state according to the *steady-state solution* described at the beginning of this section.
    iii. Once the new optimal levels of consumption $c_{new,i}$ have been obtained, compare these with their respective new steady-state goals $c_{goal,i}$.
    iv. If the updated levels of consumption are below the goal levels $\left(c_{new,i} < c_{goal,i}\right)$, increase the corresponding β_i where applicable, so that their respective interest rates decrease and households are willing to consume more in the next iteration.
    v. Repeat this process until the relative differences between the updated consumption levels and their respective goals are less than a small parameter value ε_i.

A.4. Other results from experiments for a 10% productivity shock in a single economy

Table 17: Spillover effects from trade on consumption of a country-specific productivity shock

Economy	Economy with the productivity shock[1] ISO Code							
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN
Belize	1.99%	0.07%	0.00%	0.54%	0.48%	0.14%	0.03%	0.40%
Costa Rica	0.00%	1.02%	0.03%	0.30%	0.09%	0.05%	0.20%	0.28%
Dominican Republic	0.00%	0.04%	0.34%	0.06%	0.02%	0.01%	0.01%	0.11%
El Salvador	0.00%	0.20%	0.02%	2.11%	0.49%	0.22%	0.67%	0.26%
Guatemala	0.01%	0.13%	0.01%	0.69%	0.75%	0.05%	0.10%	0.13%
Honduras	0.03%	0.27%	0.07%	2.05%	0.38%	2.35%	0.60%	0.32%
Nicaragua	0.00%	0.42%	0.10%	1.19%	0.29%	0.23%	2.42%	0.40%
Panama	0.00%	0.18%	0.04%	0.12%	0.04%	0.01%	0.04%	0.33%
CAPDR	0.02%	0.28%	0.13%	0.62%	0.28%	0.25%	0.30%	0.22%

[1] For this experiment, we assumed a productivity shock of 10% for every simulation

Table 18: Spillover effects from trade on capital stock of a country-specific productivity shock

Economy	Economy with the productivity shock[1] ISO Code							
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN
Belize	7.36%	0.28%	0.00%	2.31%	2.01%	0.58%	0.14%	1.69%
Costa Rica	0.00%	5.69%	0.17%	1.69%	0.43%	0.25%	1.10%	1.54%
Dominican Republic	0.00%	0.20%	1.26%	0.29%	0.08%	0.04%	0.06%	0.54%
El Salvador	0.00%	1.01%	0.11%	11.05%	2.55%	1.06%	3.60%	1.37%
Guatemala	0.09%	0.86%	0.09%	4.59%	5.09%	0.28%	0.66%	0.86%
Honduras	0.13%	1.17%	0.29%	9.70%	1.68%	11.51%	2.69%	1.42%
Nicaragua	0.00%	1.83%	0.46%	5.33%	1.24%	0.90%	8.25%	1.79%
Panama	0.00%	0.89%	0.11%	0.60%	0.13%	0.00%	0.17%	1.89%

[1] For this experiment, we assumed a productivity shock of 10% for every simulation

Table 19: Spillover effects from trade on interest rates of a country-specific productivity shock
(Change in basis points)

Economy	Economy with the productivity shock[1] ISO Code							
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN
Belize	-75.50	-3.05	-0.48	-24.69	-21.50	-6.26	-1.49	-18.15
Costa Rica	0.00	-35.63	-2.14	-10.92	-2.80	-1.62	-7.16	-9.95
Dominican Republic	0.00	-1.43	-3.79	-2.08	-0.58	-0.26	-0.39	-3.83
El Salvador	0.00	-6.34	-0.69	-64.27	-15.83	-6.69	-22.15	-8.57
Guatemala	-0.48	-4.76	0.00	-24.81	-27.35	-1.59	-3.66	-4.76
Honduras	-0.96	-8.68	0.00	-67.46	-12.41	-78.99	-19.78	-10.57
Nicaragua	0.00	-15.01	0.00	-42.51	-10.23	-7.44	-64.28	-14.69
Panama	0.00	-5.60	0.00	-3.76	-0.79	0.00	-1.09	-11.83

[1] For this experiment, we assumed a productivity shock of 10% for every simulation

A.5. Intraregional trade in CAPDR

Table 20: Intraregional bilateral exports in CAPDR
(Percentage of total exports by country)

Origin economy	Destination economy by ISO code								
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN	Total
Belize	0.00%	0.05%	0.19%	0.08%	3.00%	2.08%	0.00%	0.34%	5.7%
Costa Rica	0.07%	0.00%	2.04%	2.70%	5.20%	3.45%	3.96%	5.17%	22.6%
Dominican Republic	0.00%	0.29%	0.00%	0.11%	0.18%	0.29%	0.33%	0.37%	1.6%
El Salvador	0.42%	5.51%	2.16%	0.00%	19.68%	19.65%	8.23%	2.51%	58.2%
Guatemala	0.92%	3.82%	1.51%	12.37%	0.00%	8.94%	4.92%	2.09%	34.6%
Honduras	0.31%	2.60%	0.78%	6.25%	3.87%	0.00%	4.42%	0.87%	19.1%
Nicaragua	0.02%	3.01%	0.33%	5.59%	2.43%	4.72%	0.00%	0.76%	16.9%
Panama	0.38%	6.27%	4.92%	3.24%	4.70%	3.71%	3.40%	0.00%	26.6%

Source: Own estimations based on World Bank Data for 2019

Table 21: Intraregional bilateral imports in CAPDR
(Percentage of total imports by country)

Destination economy	Origin economy by ISO code								
	BLZ	CRI	DOM	SLV	GTM	HND	NIC	PAN	Total
Belize	0.00%	0.96%	0.05%	1.18%	7.66%	1.72%	0.05%	2.89%	14.5%
Costa Rica	0.00%	0.00%	0.22%	1.44%	2.47%	0.73%	0.97%	1.24%	7.1%
Dominican Republic	0.00%	1.09%	0.00%	0.56%	0.80%	0.44%	0.10%	0.42%	3.4%
El Salvador	0.00%	3.34%	0.10%	0.00%	13.26%	4.80%	3.41%	3.90%	28.8%
Guatemala	0.03%	3.48%	0.12%	5.20%	0.00%	2.41%	0.74%	3.37%	15.3%
Honduras	0.00%	3.57%	0.16%	4.65%	5.33%	0.30%	0.76%	0.29%	15.1%
Nicaragua	0.00%	6.17%	0.55%	4.36%	6.58%	8.70%	0.00%	0.59%	27.0%
Panama	0.02%	2.33%	0.20%	0.55%	1.04%	0.20%	0.17%	0.00%	4.5%

Source: Own estimations based on World Bank Data for 2019