Informality and Taxation: Evidence from Seven Latin American Countries

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Abstract

This study examines the impact of the shadow economy on taxation in seven Latin American countries between 1993 and 2018. The technique is built using a MIMIC model and a bootstrap panel Granger causality approach. The results show that the variables are related causally, with the shadow economy having a detrimental impact on tax revenues. Governments are advised to embark on labor market and institutional reforms, reduce barriers to firm entry, provide a reliable and sufficient regulatory environment, and provide employee social protection as ways to reduce the informal economy.

JEL Classifications: O17, H26, H27

Keywords: Informality, Tax revenues, Inflation, Latin America, Causality

*I thank two anonymous referees for their constructive and useful comments. The usual disclaimer applies.
1. Introduction and Overview

In developing economies, estimates of the informal sector's size, often known as the shadow economy, frequently reach 40% (Schneider, 2005; La Porta and Shleifer, 2008; La Porta and Shleifer, 2014; Mazhar and Meon, 2017). A large informal sector that makes up between a third and half of the economy is a common feature of developing nations. The development of the economy is significantly impacted by these high levels of informality. Informality in particular suggests widespread tax evasion (e.g., Auriol and Warlters, 2005; Kanbur and Keen, 2015). These high levels of informality are expected to be a significant barrier to the development of these countries given the significance of increasing fiscal capacity in developing nations (e.g., Besley and Persson, 2010). These sobering numbers suggest that a sizable portion of output simply cannot be taxed since it is still unreported and unregistered. The government's ability to fund itself is severely hampered by this erosion of the revenue base. As a result, governments must find alternative sources of income, specifically inflation, to pay for public spending. Governments with sizable informal sectors have an incentive to switch from taxation to inflation as a source of income (e.g., Koreshkova, 2006; Mazhar and Meon, 2017).

Loayza (2018) shows that in a typical developing country, 30% of production and 70% of labor are classified as informal. Lack of institutional and economic development has informality as a cause and effect. It suggests a culture of noncompliance and productive inefficiency. However, informality exists because it provides benefits like flexibility and employment in countries with poor labor productivity and a lot of regulations. Without informality, unemployment, poverty, and crime would be higher in these circumstances (Loayza, 2018). The measures to lessen informality must cover all pertinent fields because the causes of informality are intricate and connected. Making labor markets flexible, changing social protection, raising productivity, improving the effectiveness of the
regulatory system and the justice system, and simplifying the tax system should all be part of a formalization approach.

The growing cost of taxes is one of the main factors influencing the growth of the shadow economy, according to many empirical studies (e.g., Tanzi, 1999). Depending on the model and the number of components included, this factor can account for up to half of the variation in the sizes of the shadow economies in different countries. Taxes have a distorting effect because they alter the choice between work and leisure and increase the labor supply in the black market. Thus, people are more motivated to engage in the shadow economy to make up the gap between the total cost of labor in the official economy and their after-tax incomes from work. This disparity is mostly a result of the official economy's overall tax burden, which is evaded in the shadow economy.

According to this viewpoint, the emergence of the shadow economy can be interpreted as a response by those who feel oppressed by the government. The growth in the overall tax burden results in an increase in the shadow economy, which has a negative impact on the revenue base and the sustainability of the public finance. This therefore causes the budget deficit to grow even more or taxes to rise, the shadow economy to expand even more, and the social contract's foundations to progressively deteriorate (e.g., Schneider and Enste, 2000). The increase in the number of laws and regulations, such as license requirements, labor market regulations, trade barriers, and labor limitations on immigration, is another significant element influencing the creation of the shadow economy.

Acemoglu (2005) and Acemoglu et al. (2011) discuss the political economy of taxation and the tax burden by demonstrating how a greater shadow economy causes a reduction in taxation. Even after accounting for key macroeconomic factors, they uncover convincing evidence that the shadow economy has considerable and robust effects on taxes. More specifically, they see that taxes drop as the shadow economy grows. Those findings add to our knowledge of the macroeconomic implications of the informal sector. It is a common
assumption and finding of theoretical and empirical studies, such as those by Ihrig and Moe (2004) and Dabla-Norris et al. (2008), that taxes force businesses out of the formal economy.

The degree of taxpayer trust in the government, the state of the official economy, labor market participation rates, transfers and subsidies, the standard of public-sector services, and a "culture of tolerance" are additional variables that may have an impact on the size of the shadow economy. The effectiveness of institutions and corruption, according to many empirical research, are the main causes of the rise of the shadow economy in countries (e.g., Schneider, 2007, Schneider, 2009). The quality of institutions explains much of the variance in the size of the shadow economy between developed and undeveloped countries. Improving institutions and respect for the government through increased tax compliance, voice and accountability, rule of law, governance, regulatory quality, and a decrease in corruption are crucial steps towards halting the rise of the shadow economy (Torgler and Schneider, 2009).

Theoretically, Wilson (2011) and Chen (2012) suggest that there are three elements to be considered in the informal economy: 1) the dualist approach, which sees the informal sector as underdeveloped and where work is performed by low-skilled migrants and the lower-skilled workers in the informal sector; 2) the structuralist approach, which seeks out connections between the formal and informal economies as the latter one benefits from the former while seeking greater competitiveness; and 3) the legalist perspective, which views the informal sector as the result of a mercantilist government: a means for new business owners to get around bureaucratic rules and prosper in the market.

Chen (2012) asserts that the "hostile judicial system" is the root of this most recent strategy. Last but not least, Chen (2012) added the so-called voluntarism approach, which contends that the informal sector exists because business owners openly seek to escape taxes and that they must be forced to go formal in order to avoid unfair competition. In sum, the
theoretical literature has pointed to market entry costs (into the formal sector) as a significant barrier to entry for businesses, causing entrants to operate in the shadow (or underground) instead of the official sector. Legal entry hurdles, such as licensing requirements, environmental laws, and bureaucratic delays, have also been noted as major factors in why businesses operate clandestinely (e.g., Schneider and Enste, 2000; Gërxhani, 2004a, b).

Galiani and Weinschelbaum (2011) identify three stylized features about informality: 1) Unqualified employees are more likely to work informally, 2) Small enterprises are more likely to operate this way, and 3) Employees who are not the head of the household are more likely to work informally than the head of the household. They then used these findings to create a model that explained how enterprises behave in terms of formal or informal work, and how the labor force and households behave accordingly. They suggest that as a policy, governments should consider both labor supply and demand when addressing informality.

Goel and Nelson (2016) demonstrate that bureaucratic complexity, rather than monetary harshness, is more important in determining the shadow economy. This finding is supported by three separate cross-national shadow measures and the use of various factors across hundreds of model combinations. Additionally, compared to long-established shadow operators, new shadow entrepreneurs have relatively different incentives. A one standard deviation increases in tax complexity results in a mean increase of almost 10% in the total shadow economy. In contrast, a similar rise in startup costs for businesses nearly doubles the number of new and unregistered entrepreneurs.

Marjit et al. (2017) discuss tax loopholes that let companies take advantage of situations where legitimate tax avoidance and illegal tax evasion coexist. Tax loopholes generally harm a government that seeks to increase its revenue. Tax loopholes might act as a separating mechanism to assist governments optimize revenues and combat corruption,
which could help to explain why emerging countries only progressively abolish tax loopholes.

There is no agreement on a set of enduring dynamics that shape this industry, according to the limited research conducted over the previous few decades. Furthermore, the majority of current empirical studies have some methodological issues. Two-way causality and problems with simultaneity bias or endogeneity, and identification are major issues. The attempts that addressed the reverse causality issue primarily through fixed-effects estimators and instrumental variables later emerged in response to these issues. However, there are a variety of consequences, therefore it is still unclear what the overall effects of shadow economy will be. This study represents a renewed effort to close these scholarly gaps.

To deal with causality and omitted variable bias, most researchers have applied time series techniques or instrumental variables. They have produced contradictory and mixed results. Using data from seven Latin American economies between 1993 and 2018, this study investigates the relationship between shadow economy and tax revenues. In Latin America, the informal economy is projected to account for 34% of GDP on average, whereas it accounts for 19.83% of GDP in the OECD countries, or slightly less than half of the Latin American average. Institutional effectiveness and the level of economic growth in each country account for the differences between those categories of countries (Boitano and Abanto, 2019).

To the best of the author’s knowledge, this is the first study to examine the relationship between the variables by using the bootstrap panel Granger causality approach that accounts for cross-sectional dependence, slope heterogeneity, and structural breaks across countries. This approach has two important advantages: First, testing the unit root and cointegration is not necessary, and second, given the contemporaneous relationships between countries, more panel data can also be acquired.
The paper is organized as follows: Section 2 describes the data and methodology, Section 3 presents the empirical results, and conclusion is offered in Section 4.

2. Data and Methodology

The sample spans the years 1993 to 2018 and includes seven Latin American countries: Chile, Costa Rica, Dominican Republic, Peru, Uruguay, Belize, and Jamaica. Based on the availability of the data, the countries and time period were chosen. According to figures 1-7 in Appendix A, these countries exhibit a significant amount of the shadow economy. This study measures the informal economy using a multiple-indicator and multiple-cause model (MIMIC); a structural equations modeling derivative. This model creates a single indicator that encompasses all facets of the informal sector by combining the elements that influence and contribute to this economic phenomenon. Tax revenue as a percentage of GDP is used here. Our control variables are: real GDP per capita growth and inflation (CPI, annual %). Except for Belize's inflation, which comes from Statista, all of the data for these variables are obtained from the World Bank.

The use of inflation as a control variable is justified by Nicolini (1998) who utilized the public finance motive of inflation proposed by Bailey (1956) and Phelps (1973). Cavalcanti and Villamil (2003) and Koreschkova (2006) also suggest that, in the context of a sizeable informal sector, utilizing inflation to support public spending may be the best alternative. These contributions all have the trait of applying the optimal taxation principle to inflation, which states that in order to maximize welfare, the marginal welfare costs of taxes and inflation should be set at parity. Furthermore, it suggests that as the shadow economy grows, taxes decline as inflation rates rise. Government expenses must be paid for, and as taxes are frequently insufficient, a sizable portion of that funding comes from other countries in the form of debt.
Emerging countries today confront ever-increasing borrowing restrictions in international capital markets because of the negative consequences of recent devaluation of local currencies on public-sector balance sheets with dollar obligations. For many emerging nations, borrowing money in their home currencies and changing monetary rules, generally known as quantitative easing (QE), are alternatives. When QE is coupled with money printing and governments have significant fiscal deficits, inflationary effects are greatly increased.

The simple relationship between taxation and economic activity shows that when economic activity increases more quickly, so do tax receipts, which is why economic growth is also used as a control variable. However, it is highly unlikely that this link shows that higher taxes have a favorable impact on output. Instead, each increase in income caused by a positive shock to output increases tax receipts (Romer and Romer, 2007). This suggests that the relative importance of the underground sector declines as countries experience greater prosperity and economic growth, either as a result of strengthened checks and balances linked to economic well-being or by making the transition into the underground sector relatively less appealing (Schneider and Enste, 2000). Figures 1-7 in Appendix A show the variables and Table A1 in Appendix A report the descriptive statistics.

The estimation follows the bootstrap panel Granger causality proposed by Kónya (2006). This approach has two important advantages: First, it does not require testing the unit root and cointegration (i.e., the variables are used in their levels, without any stationarity conditions). Second, additional panel information can also be obtained given the contemporaneous correlations across countries (i.e., the equations denote a Seemingly Unrelated Regressions System- SUR system).

Two steps should be followed before applying the bootstrap panel Granger causality: Testing the panel for cross-sectional dependence and testing for cross-country heterogeneity. The first issue implies the transmission of shocks from one variable to
another. A significant body of the panel-data literature (i.e., cross-sectional and time series data) concludes that panel-data models are likely to show substantial cross-sectional dependence in the errors, which may stem from the presence of common shocks and unobserved components that ultimately become part of the error term, spatial dependence, and idiosyncratic pairwise dependence in the disturbances with no pattern of common components or spatial dependence. One reason for this may be that during the last few decades we have witnessed an ever-increasing economic and financial integration of countries and financial entities, which implies strong interdependencies between cross-sectional units. In other words, all countries in the sample are influenced by globalization and have common economic characteristics. The second issue indicates that a significant economic connection in one country is not necessarily replicated by the others.

A set of three tests is constructed to check the cross-sectional dependence assumption: The Breusch and Pagan (1980) cross-sectional dependence (CDBP) test, the Pesaran (2004) cross-sectional dependence (CDP) test, and the Pesaran et al. (2008) bias-adjusted LM test (LMadj). Regarding the country-specific heterogeneity assumption, the slope homogeneity tests (\(\tilde{\Delta}\) and \(\tilde{\Delta}_{adj}\)) of Pesaran and Yamagata (2008) are used. Kónya's (2006) approach considers both issues, based on SUR systems estimation and identification of Wald tests with country-specific bootstrap critical values.\(^1\) This procedure allows us to consider all variables in their levels and perform causality output for each country: (Appendix B provides more information about these tests)

\[
TXR_{1,t} = \alpha_{1,1} + \sum_{i=1}^{m_{1}} \beta_{1,1,i} TXR_{1,t-i} + \sum_{i=1}^{n_{1}} \gamma_{1,1,i} SE_{1,t-i} + \sum_{i=1}^{k_{1}} \varphi_{1,1,i} INF_{1,t-i} + \\
\sum_{i=1}^{l_{1}} \theta_{1,1,i} YC_{1,t-i} + \varepsilon_{1,1,t},
\]

\(^1\)This methodology has also been used, for example, in Irandoust (2022).
In equation systems (1) and (2), TXR is tax revenue, SE denotes shadow economy index, INF is inflation, and YC is real GDP per capita growth, N is the number of panel members, t is the period (t = 1,...,T), and i is the lag length selected in the system. The common coefficient is α, the slopes are β, δ, γ, and θ while ε is the error term.

To test for Granger causality in this system, alternative causal relations for each country are likely to be found: (i) there is one-way Granger causality from X to Y if not all δ_{i,i} are
zero, but all $\beta_{2,i}$ are zero; (ii) there is one-way Granger causality from $Y$ to $X$ if all $\delta_{1,i}$ are zero, but not all $\beta_{2,i}$ are zero; (iii) there is two-way Granger causality between $X$ and $Y$ if neither $\delta_{1,i}$ nor $\beta_{2,i}$ are zero; and (iv) there is no Granger causality between $X$ and $Y$ if all $\delta_{1,i}$ and $\beta_{2,i}$ are zero. It is also allowed for the maximal lags to differ across variables but be the same across equations. In this study, the system is estimated by each possible pair of $l_{m1}, l_{n1}, l_{k1}, l_{p1}, l_{m2}, l_{n2}, l_{k2}, l_{p2}$, and it is assumed that 1 to 4 lags exist. Then the combinations that minimize the Schwarz Bayesian Criterion are chosen.

By inspecting the data, it is found that most break dates correspond to major events such as the financial crisis of 1997-1998 and 2007-2008 and the economic downturn of 2001. Due to the existence of these structural breaks, we choose to incorporate them into our testing model; otherwise, the results will be biased. Since Kónya (2006) cannot allow different break dates into the testing model, we follow the procedure adopted by Tsong and Lee (2011), Enders and Hold (2012), and Irandoust (2022) to adjust the data as follows (Appendix C provides more information):

$$\hat{y}_t = y_t - \alpha - \sum_{i=1}^{m+1} \theta_i DU_{i,j} - \sum_{i=1}^{n+1} \rho_i DT_{i,j} - \epsilon_t,$$

where $\hat{y}_t$ (either $TXR$ or $SE$) is adjusted by the effect of possible structural breaks, $y_t$ is $TXR$ or $SE$, $DU_t$, and $DT_t$ are defined as the following:

$$DU_{k,j} = \begin{cases} 1 & \text{if } TB_{k-1} \prec t \prec TB_k, \\ 0 & \text{otherwise} \end{cases}$$

$$DT_{k,j} = \begin{cases} t - TB_{k-1} & \text{if } TB_{k-1} \prec t \prec TB_k, \\ 0 & \text{otherwise} \end{cases}.$$
3. Empirical Results

Table 1 reports the results of cross-sectional dependence tests ($CD_{BP}$, $CD_p$, and $LM_{adj}$) and slope homogeneity tests ($\tilde{A}_{adj}$ and $\tilde{A}$). The first set of tests, for cross-sectional dependence, clearly reveals that the null hypothesis of no cross-sectional dependence is rejected for all significance levels. More precisely, this implies that there is a cross-sectional dependence in the case of our sample countries. Any shock in one country is transmitted to others, the SUR system estimator being more appropriate than the country-by-country pooled OLS estimator.

The second part of the Table shows that the null hypothesis of slope homogeneity is rejected for both tests and all significance levels. In this case, the economic relationship in one country is not replicated by the others. As there is both cross-sectional dependence and slope heterogeneity, the bootstrap panel Granger causality approach can be applied.

INSERT TABLE 1 HERE

Tables 2-3 display the findings of the bootstrap panel Granger causality test. The results indicate that there is a unidirectional causality from tax revenue to the shadow economy in the Dominican Republic and a unidirectional causality from the shadow economy to tax revenues in Costa Rica. There is also a bidirectional causality between the shadow economy and tax revenues in Uruguay, Peru, Jamaica, and Belize. In Chile, no causality was discovered. The findings also indicate a negative relation between tax revenues and the extent of the shadow economy. This suggests that the size of the informal economy has severely impacted tax collection in all of the Latin American sample countries, with the exception of Chile. The bidirectional causality indicated that informality is both a cause and

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2 The robustness of the results was checked by using the procedure proposed by Toda and Yamamoto (1995) and Yamada and Toda (1998) to ensure that the usual test statistics for Granger causality have standard asymptotic distributions. It has been established that the limiting behavior of the Wald statistic with stochastic trends and cointegration is non-trivial (Toda and Phillips 1993). Without well-behaved asymptotic distribution of the test statistic, bootstrap is likely to be inconsistent if the test statistic’s asymptotic distribution is not continuous with respects to perturbations in the data generating process (Horowitz, 2001). If the asymptotic distribution of the test statistic depends on the parameters of the data generating process, the bootstrap distribution can deviate a great deal from the true asymptotic distribution of the test statistic. Toda and Yamamoto (1995) and Yamada and Toda
a consequence of the lack of economic and institutional development. These findings are more or less in agreement with Schneider and Enste (2000), Oviedo and Karakurum-Zdemir (2009), and Granda-Carvajal and García-Callejas (2022). The findings are also consistent with those of Schneider (2022), who reports that the main factors contributing to informality in EU countries are tax burden (direct and indirect).

**INSERT TABLES 2-3 HERE**

Kelmanson et al. (2019) study the factors that contribute to the shadow economies in Europe, calculate their size with an emphasis on emerging markets, and suggest strategies to increase formality. Although it has shrunk in recent years, Europe's shadow economies are still large, particularly in Eastern Europe. They claim that regulation quality, government efficiency, and human capital are the main factors of the growth of the shadow economy in growing European economies. In order to effectively battle the shadow economy, the study contends that a complete set of reforms that are concentrated on country-specific drivers are required. Reducing administrative and regulatory burdens, fostering transparency, and enhancing government performance, as well as enhancing tax compliance, automating processes, and encouraging electronic payments, are among the measures on the menu that are most pertinent for Europe's growing economies.

Schneider (2022) reports that the average size of the shadow economy in 36 European and OECD countries decreased from 16.48% of GDP in 2020 to 16.07% in 2021 (a decline of 0.41 percentage points) when considering the development of the shadow economy over the period from 2003 to 2022 and the impact of the Coronavirus pandemic from 2020 onward. The average shadow economy of these 36 countries was 15.96% of GDP (average of all 36 countries) in 2022 as a result of a prolonged (forecasted) economic recovery: a very minor

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(1998) utilize a modified Wald test (MWald) for restrictions on the parameters of a VAR \((k)\), where \(k\) is the lag length in the system. This test has an asymptotic chi-square distribution when a VAR \((k+dmax)\) is estimated (where \(dmax\) is the maximal order of integration suspected to occur in the system). The results, however, support our findings regarding the direction of causality.
decrease of 0.11 percentage points.

The one-way causality from tax revenue and the shadow economy shows that taxes are what fuel it, and the opposite is true for the one-way causality from the shadow economy and taxes. The lack of a causal relationship proves that the variables are independent of one another. However, in keeping with our hypothesis, we uncover substantial evidence that the shadow economy affects taxes significantly and robustly, even after adjusting for key macroeconomic factors like inflation and economic growth.

4. Conclusion

Despite the shadow or underground economy's widespread use around the world, scholars and policymakers have been unable to come to a consensus on the persistent and dependable causes of shadow activities. Both theoretical and empirical factors contribute to the lack of clarity. Theoretical models and easily adaptable empirical functional forms appear to be at odds with one another. In this paper, we studied the relation between the size of the shadow economy and tax revenue. The study makes use of a pooled cross-country and time series database for seven developing countries from 1993 to 2018. This research somewhat tries to address empirical shortcomings in the literature.

Because of the two reasons listed below, this article adds to the literature: First, the research takes into account how inflation and economic growth affect the shadow economy and taxation by using them as control variables. Second, the analysis uses the bootstrap panel Granger causality test, which takes cross-sectional dependence, slope heterogeneity, and structural breaks into account. It has been found that tax revenues and the size of the shadow economy have a negative relationship. We identified both bidirectional causality and unidirectional causality, and lack of causality after controlling for inflation and economic growth. It follows that informality is both a cause and a consequence of the lack of economic
and institutional development.

Policies like lowering taxes or lowering barriers to formalization are not solutions on their own. The institutional setting, which includes the government, plays a significant role in whether the informal economy grows or shrinks. It is less likely that the informal sector can be eliminated if institutions do not want to become more effective, transparent, and committed to people's wellbeing. In order to completely eradicate corruption at all levels of the economy, the institutional problem must be resolved. In a similar vein, laws and regulations must be followed regardless of the issue. Additionally, there is a clear link between self-employment and unemployment and informal work, which fills the gaps left by formal employment in terms of hiring. Because a country with greater inequality would likely have a larger informal economy, the Gini coefficient is a significant indication.

It is also known that strict rules can encourage the shadow economy (Pickhardt & Shinnick, 2008). Restrictive laws that raise labor costs and encourage employment in the informal economy include licensing, minimum wages, and early retirement requirements. Empirical studies conducted by Loayza (1996), Johnson et al. (1997), and Buehn and Schneider (2008) conclude that countries with more stringent laws likely to have a larger shadow economy.

The discussion above suggests that additional research is required in order to address the following issues: (i) it is necessary to identify potential control variables besides economic growth and inflation, which were used in this study; (ii) it is necessary to strengthen the theoretical framework in order to understand the behavior of agents in the informal economy; (iii) a single solution (a recipe) is not practical; instead, we must tailor the potential solutions to the specific causes of the informal economy in each country, (IV) facts like political and public confidence, openness and effectiveness of government spending, the eradication of corruption, increasing perceived social welfare, and education are likely more significant and effective factors to consider when attempting to reduce informality than tax reduction schemes, (V) it is helpful to utilize alternative techniques to estimate the size of the shadow
economy because the MIMIC model is not theoretically sound enough to incorporate indicators as causes or robust enough to manage data transformations or modify the units of measurement, and (VI) it is emphasized that taxes and regulations, in the vein of Schneider et al., are ultimately led to the underground economy. The issue with this strategy is that it would be counterproductive to reduce the shadow economy in order to raise taxes because doing so would necessitate lowering taxes in the first place. Tax collection would only grow if the elasticity of the shadow economy to taxes was very high, and most definitely greater than unity. Therefore, elasticity estimates might be a helpful indicator for addressing these problems.
Bibliographical references


Table 1: Cross-sectional dependence and slope homogeneity tests

<table>
<thead>
<tr>
<th>Method</th>
<th>Test statistics</th>
<th>p-value</th>
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<tbody>
<tr>
<td>Cross-sectional dependence test</td>
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<tr>
<td>CD_{BP}</td>
<td>272.533**</td>
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<tr>
<td>CD_{P}</td>
<td>16.782***</td>
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<td>LM_{adj}</td>
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<td>Slope homogeneity test</td>
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<td>Δ test</td>
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<tr>
<td>Δ test_{adj}</td>
<td>9.737***</td>
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</table>

Notes: a. *** indicate significance for 0.01 levels. CD_{BP} test, CD_{P} test, and LM_{adj} test show the cross-sectional dependence tests of Breusch and Pagan (1980), Pesaran (2004), and Pesaran et al. (2008), respectively. b. The slope homogeneity tests proposed by Pesaran and Yamagata (2008).

Source: Own estimations
**Table 2: The bootstrap panel Granger causality results**

H0: TXR does not Granger cause SE

<table>
<thead>
<tr>
<th>Country</th>
<th>Coef. value</th>
<th>Wald test</th>
<th>Bootstrap critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belize</td>
<td>-1.137</td>
<td>23.157**</td>
<td>33.754</td>
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<tr>
<td>Chile</td>
<td>-0.294</td>
<td>5.128</td>
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<td>Costa Rica</td>
<td>-0.172</td>
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<td>36.346</td>
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<tr>
<td>Dominican Rep.</td>
<td>-0.335</td>
<td>16.285*</td>
<td>42.367</td>
</tr>
<tr>
<td>Jamaica</td>
<td>-0.421</td>
<td>12.036*</td>
<td>24.835</td>
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<tr>
<td>Peru</td>
<td>-1.336</td>
<td>43.637***</td>
<td>21.636</td>
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<td>Uruguay</td>
<td>-1.568</td>
<td>30.945***</td>
<td>12.312</td>
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</table>

Notes: a. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively. b. Bootstrap critical values are obtained from 10,000 replications.

Source: Own estimations.

**Table 3: The bootstrap panel Granger causality results**

H0: SE does not Granger cause TXR

<table>
<thead>
<tr>
<th>Country</th>
<th>Coef. value</th>
<th>Wald test</th>
<th>Bootstrap critical value</th>
</tr>
</thead>
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<td>Uruguay</td>
<td>-1.390</td>
<td>25.432***</td>
<td>19.735</td>
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</tbody>
</table>

Notes: a. **, and *** indicate significance at the 0.05, and 0.01 levels, respectively. b. Bootstrap critical values are obtained from 10,000 replications.

Source: Own estimations.
Appendix A: Figures 1-7: Tax revenue (TXR), the shadow economy (SE), inflation (INF), and real GDP per capita growth (YC), 1993-2018.
Fig. 3: Costa Rica

Fig. 4: Dominican Republic
Fig. 5: Jamaica

Fig. 6: Peru
Fig. 7: Uruguay

Source: Own elaborations based on World Bank Data.
Table A1: Descriptive statistics for the variables, n = 26 for each country

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean</th>
<th>S.D.</th>
<th>Skewness</th>
<th>Kurtosis</th>
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<td></td>
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Source: Own calculations based on World Bank Data.
Appendix B:

**Cross-sectional dependence tests**

Breusch and Pagan's (1980) LM test has been used in many empirical studies to test cross-sectional dependency. LM statistics can be calculated using the following panel model:

\[ y_{it} = \alpha_i + \beta_i x_{it} + \mu_{it}, \quad i = 1, 2, ..., N, \quad t = 1, 2, ..., T, \]

where \( i \) is the cross-section dimension, \( t \) is the time dimension, \( x_{it} \) is a \( k \times 1 \) vector of explanatory variables while \( \alpha_i \) and \( \beta_i \) are the individual intercepts and slope coefficients that are allowed to differ across states. In the LM test, the null hypothesis of no cross-sectional dependence \( H_0 : \text{Cov}(\mu_i, \mu_j) = 0 \) for all \( t \) and \( i \neq j \) is tested against the alternative hypothesis of cross-sectional dependence \( H_1 : \text{Cov}(\mu_i, \mu_j) \neq 0 \) for at least one pair of \( i \neq j \). For testing the null hypothesis, Breusch and Pagan (1980) developed the following test:

\[ CD_{BP} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}^2, \]

where \( \rho_{ij} \) is the estimated correlation coefficient among the residuals obtained from individual OLS estimation of Eq. (1A). Under the null hypothesis, the LM statistic has an asymptotic chi-square distribution with \( N(N-1)/2 \) degrees of freedom. Pesaran (2004) proposes that the LM test is only valid when \( N \) is relatively small and \( T \) is sufficiently large. To overcome this problem, Pesaran (2004) introduces the following LM statistic for the cross-section dependency test:
However, Pesaran et al. (2008) state that while the population average pair-wise correlations are zero, the CD test will have less power. Therefore, they proposed a bias-adjusted test that is a modified version of the LM test by using the exact mean and variance of the LM statistic. The bias-adjusted LM statistic is calculated as follows:

\[
CD_p = \sqrt{\frac{1}{N(N-1)} \sum_{m=1}^{N-1} \sum_{j=n+1}^{N} \left( T \rho_{ij} - 1 \right)^2}.
\]

\[
LM_{adj} = \sqrt{\frac{2T}{N(N-1)} \sum_{m=1}^{N-1} \sum_{j=n+1}^{N} \frac{(T-k)\rho_{ij} - u_{Tij}}{v_{Tij}^2}},
\]

where \( u_{Tij} \) and \( v_{Tij}^2 \) are the exact mean and variance of \( (T-k)\rho_{ij} \), which are provided in Pesaran et al. (2008). Under the null hypothesis of no cross-sectional dependence with \( T \to \infty \) first followed by \( N \to \infty \), the results of this test follow an asymptotic standard normal distribution.

**Slope homogeneity tests**

To relax the assumption of homoscedasticity in the F-test, Swamy (1970) developed the slope homogeneity test that examines the dispersion of individual slope estimates from a suitable pooled estimator. Pesaran and Yamagata (2008) state that both the F-test and Swamy's test require panel data models where \( N \) is relatively small compared to \( T \). To overcome this problem, they proposed a standardized version of Swamy's test (the so-called \( \Delta^- \) test) for testing slope homogeneity in large panels. The \( \Delta^- \) test is valid when \( (N, T) \to \infty \) without any restrictions on the relative expansion rates of \( N \) and \( T \) when the
error terms are normally distributed. Pesaran and Yamagata (2008) then develop the following standardized dispersion statistic:

$$\tilde{\Delta} = \sqrt{N} \left( \frac{N^{-1} S^* - k}{\sqrt{2k}} \right),$$  \hspace{1cm} 5B

where $S^*$ is Swamy's statistic. Under the null hypothesis with the condition of $(N, T) \to \infty$ and when the error terms are normally distributed, the $\Delta^*$ test has an asymptotic standard normal distribution. The small sample properties of the $\Delta^*$ test can be improved when there are normally distributed errors by using the following mean and variance bias-adjusted version:

$$\tilde{\Delta}_{adj} = \sqrt{N} \left( \frac{N^{-1} S^* - E(z^*_n)}{\sqrt{\text{var}(z^*_n)}} \right),$$  \hspace{1cm} 6B

where $E(z^*_n) = k$, $\text{var}(z^*_n) = 2k(T - k - 1)/(T + 1)$.

The bootstrap procedure

The procedure to generate bootstrap samples and country specific critical values (in the test of no causality from $X$ to $Y$) consists of the following five steps (Konya, 2006)

1st step: Implement an estimation of (2) under the null hypothesis of no causality from $X$ to $Y$ by (i.e. imposing $\gamma_{1,i,s} = 0$ for all $i$ and $s$) and get the corresponding residuals:

$$e_{H_0,i,t} = y_{i,t} - \hat{\alpha}_{i,1} + \sum_{s=1}^{l_y_1} \hat{\beta}_{1,i,s} y_{i,t-s}$$  \hspace{1cm} 7B

From these residuals, build the $N \times T [e_{H0,i,t}]$ matrix.
2nd step: In order to preserve the contemporaneous dependence between error terms in (2), randomly select a full column from \([e_{H_0,i,t}]\) matrix at a time (i.e., do not draw the residuals for each country one-by-one); and denote the selected bootstrap residuals as \([e^*_{H_0,i,t}]\) where \(t = 1, \ldots, T^*\) and \(T^*\) can be greater than \(T\).

3rd step: Build the bootstrap sample of \(Y\) under the hypothesis of no causality from \(X\) to \(Y\), i.e., using the following formula:

\[
y_{i,t}^* = \hat{\alpha}_{i,1} + \sum_{s=1}^{l_y} \hat{\beta}_{1,i,s} y_{i,t-s}^* + e^*_{H_0,i,t}
\]

4th step: Replace \(y_{i,t}\) by \(y_{i,t}^*\), estimate (2) without any parameter restrictions and then implement the Wald test for each country to test for the no-causality null hypothesis.

5th step: Develop the empirical distributions of the Wald test statistics by repeating (10,000 replications) the steps 2-4 many times and build the bootstrap critical values.
Appendix C:

Modelling of structural breaks

Following Tsong and Lee (2011), Enders and Hold (2012), and Irandoust (2022), we include both sharp shifts and smooth breaks in the estimation of a level and trend equation and adopt the following data generation process:

\[ y_t = \alpha_0 + \beta t \sum_{l=1}^{m+1} \theta_l DU_{Lt} + \sum_{l=1}^{m+1} \rho_l DT_{Lt} + \sum_{k=1}^{n} \gamma_{1,k} \sin \left( \frac{2\pi kt}{T} \right) + \sum_{k=1}^{n} \gamma_{2,k} \cos \left( \frac{2\pi kt}{T} \right) + \epsilon_t, \]

where \( t, T, \) and \( m \) are time trend, sample size, and the optimum number of breaks, respectively. The other regressors are defined as:

\[ DU_{k,t} = \begin{cases} 1 & \text{if } TB_{k-1} \prec t \prec TB_k, \\ 0 & \text{otherwise} \end{cases} \]

\[ DT_{k,t} = \begin{cases} 1 - TB_{k-1} & \text{if } TB_{k-1} \prec t \prec TB_k, \\ 0 & \text{otherwise} \end{cases} \]

The terms \( DU \) and \( DT \) are entered in the model to capture the sharp and smooth shifts, respectively. In order to obtain a global approximation from the smooth transition, we use the Fourier approximation where \( n \) and \( k \) represent the number of frequencies contained in the approximation and particular frequency, respectively. (Gallant, 1981).