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Internet, Participation in International Trade, and Tax Revenue Instability

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Abstract This study investigates the effect of the Internet on tax revenue instability (TRI), notably through the international trade channel. It used a sample of 142 countries over the period 1995-2017 and relied primarily on the two-step system generalized method of moments estimator. The findings indicate that greater access to the Internet negatively affects TRI, and this effect works through the trade openness avenue. Especially, countries enjoy a higher negative effect of the Internet on TRI as they experience a greater trade openness. Moreover, Internet access reduces TRI in countries that have experienced a greater extent of tax reform and a greater export product concentration. Therefore, these findings add to the potential benefits of Internet adoption by showing that it could also help stabilize tax revenue, particularly through countries' participation in international trade.

Keywords: internet use; participation in international trade; tax revenue instability

JEL Classifications: L86; F13; F14; H20

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I. Introduction

Digital technologies, underpinned by the widespread use of information communication and technology (ITC) tools — notably the Internet — are profoundly changing people's lives, affecting all activities in society and exerting strong impacts on countries' economic, financial, social, and environmentally sustainable paths (ECLAC, 2016; OECD, 2016). Meanwhile, Kenny (2003) noted that past "information revolutions" have had a limited impact on less-developed countries, probably because these countries were ill-prepared to take advantage of the digital economy (due to the absence of the appropriate physical and human capital, and institutions). The digitalization of the economy through, *inter alia*, greater access to the Internet can reduce the costs associated

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with the collection of tax revenue by tax and customs administrations and fraud by taxpayers (e.g., Agrawal and Wildasin, 2020; Capasso et al., 2021; Uyar et al., 2021). As a result, it can help ensure a stable tax revenue stream and thus reduce tax revenue fluctuations. This is essential for governments that rely first on tax revenue to meet their development objectives.

Several empirical studies on the macroeconomic effects of Internet penetration have been conducted in recent years, including studies on international trade (e.g., Freund and Weinhold, 2002, 2004; Clarke and Wallsten, 2006; Vemuri and Siddiqi, 2009; Lin, 2015; Gnangnon and Iyer, 2018) and public revenue[1] (Gnangnon and Brun, 2018; Gnangnon and Brun, 2019a). In a literature survey on the effects of the Internet openness, concerning specifically the international trade effects of the Internet, the Organization for Economic Cooperation and Development (OECD, 2016, p. 35) noted a consensus on the positive effect of the Internet openness on international trade, notably through its trade cost reduction effects. However, although the literature has started paying attention to the public finance effects of the Internet, very few existing empirical studies (e.g., Gnangnon and Brun, 2018, 2019a) have focused on public revenue, including tax revenue. Gnangnon and Brun (2018) showed that a lower gap between a country's Internet penetration and the world's average Internet penetration positively influences its nonresource tax revenue. Moreover, Gnangnon and Brun (2019a) uncovered that increased Internet access changes the structure of public revenue by decreasing countries' reliance on resource revenue at the benefit of nonresource revenue. However, we are unaware of any research on the impact of the Internet on tax revenue instability (hereinafter TRI).

This study aims to fill this gap in the literature by empirically investigating the effect of the Internet on TRI via the international trade channel. The rationale for examining the impact of the Internet on TRI is twofold. First, the TRI is a major source of concern for policymakers worldwide, particularly in developing countries: greater TRI leads to greater instability in public expenditure (e.g., Lim, 1983; Bleaney et al., 1995; Ebeke and Ehrhart, 2012), higher instability of public investment and government consumption, and lower level of public investment (Ebeke and Ehrhart, 2012). As a result, economic growth may suffer significantly (e.g., Afonso and Furceri, 2010; Gong and Zou, 2002). Second, as the developing countries' integration into global trade and financial markets has improved, they have become more vulnerable to external shocks (e.g., Álvarez et al., 2021; Guillaumont, 2009; Essers, 2013) that are more persistent than those affecting developed countries (e.g., Aguiar and Gopinath, 2007). Furthermore, the frequency of these shocks is much higher in developing economies than in advanced economies (e.g., Barrot

1) Other studies have focused, for example, on economic growth (e.g., Choi and Yi, 2009; Maurseth, 2018; Salahuddin and Alam, 2015; Salahuddin and Gow, 2016), foreign direct investment (FDI) inflows (e.g., Choi, 2003; Ko, 2007), inflation (e.g., Meijers, 2006; Yi and Choi, 2005), labor productivity (e.g., Najarzadeh et al. 2014), the size of the shadow economy (Elgin, 2013), corruption (e.g., Elbahnasawy, 2014; Kanyam et al., 2017; Lio et al., 2011), CO_2 emissions (e.g., Salahuddin et al., 2016), insurance growth (e.g., Benlagha and Hemrit, 2020), employment (e.g., Hjort and Poulsen, 2019), tax reform (Gnangnon, 2020a), and economic sophistication (e.g., Lapatinas, 2019).

et al., 2018; Cariolle et al., 2016; Dabla-Norris and Gündüz, 2014). These shocks have an impact on fiscal policy dynamics (e.g., Narayan and Lu, 2011; Solimano and Calderon, 2017) and may exacerbate the TRI (e.g., Dawkins and Whalley, 1997; von Haldenwang et al., 2013). The Internet penetration influences international trade and hence countries' integration into the world trade markets; thus, it could also likely influence TRI through the international trade channel.

Against this backdrop, the current paper addresses the issue of whether Internet penetration affects TRI through the international trade channel (i.e., as countries better integrate into the world trade market) by relying on a panel dataset of 142 countries over the period 1995-2017. The findings are based primarily on the two-step system generalized method of moments (GMM) estimators. They indicate that a higher Internet penetration helps reduce TRI, particularly in countries that experience greater participation in international trade. This finding applies notably to the domestic TRI and not to trade TRI, as the Internet penetration has no significant effect on trade TRI that works via the international trade channel. Additionally, greater access to the Internet induces lower TRI in countries experiencing a greater extent of tax reform and a higher degree of export product concentration.

The rest of this paper is organized into six sections. Section 2 presents a theoretical discussion of how the Internet, via the international trade channel, can affect TRI. Section 3 discusses the empirical strategy, and Section 4 interprets the empirical results. Section 5 examines another channel (i.e., tax reform) by which Internet penetration can affect TRI. Section 6 expands on the analysis by examining whether a country's level of export product concentration is vital for the effect of Internet penetration on TRI. Finally, Section 7 concludes.

II. Theoretical Motivation: Effect of the Internet on Tax Revenue Instability via the International Trade Channel

This section examines the impact of the Internet on TRI through the international trade channel, specifically the level of country participation in international trade. To that end, it first provides a brief review of the literature on the impact of the Internet on international trade before discussing how international trade may affect TRI. This discussion contributes to a better understanding of the impact of the Internet on TRI via the international trade channel.

Above the effect of the Internet on TRI through the avenue of participation in international trade, the Internet penetration can directly impact TRI. Greater access to the Internet can facilitate the digitalization of submitting tax-related information by taxpayers and the treatment of such information by tax and customs administrations (to collect tax revenue). These contribute to reducing the costs for both the government and taxpayers, and limit fraud by taxpayers. Likewise, the Internet could also enhance fiscal transparency and allow citizens to access a large set of information concerning government fiscal accounts and financial transactions, thereby enhancing tax morale, that is, the willingness of taxpayers to pay taxes. Consequently, a high Internet penetration could ensure a sustainable stream of tax revenue and significantly reduce TRI. Capasso et al. (2021) showed that tax morale is enhanced (i.e., improvement of the willingness of citizens to pay taxes) in the presence of greater fiscal transparency (the latter could be achieved through greater access to the Internet). Moreover, Agrawal and Wildasin (2020) demonstrated, among others, that technological development increases the enforcement of the (implicit) contract between taxpayers and the government.

The digitalization of tax processes (i.e., moving many processes online) also enables tax (and customs) administrations to deal more easily with crises, such as the COVID-19 pandemic (OECD, 2021). In this way, digitalization, including a higher Internet penetration, could help mitigate the adverse effects of crises on tax revenue and reduce its instability. Uyar et al. (2021) showed that the digitalization of government services strongly mitigates tax evasion in countries experiencing a high level of ICT adoption. The government could not fully control tax avoidance and fraud (in the absence of digitalization); hence, digitalization could help reduce the TRI in countries that adopt ICT, including those with a high level of access to the Internet.

On another note, Gnangnon (2020a) empirically found that a greater Internet access helps promote tax reform (i.e., lesser dependence on international trade tax revenue at the benefit of domestic tax revenue) in developing countries. Considering that a greater extent of this type of tax reform is associated with lower TRI (Gnangnon and Brun, 2019b), greater access to the Internet is expected to reduce TRI in countries where tax reform is more extensive.

Besides, literature on the effect of the Internet on international trade is growing. It has well documented the vital role of trade costs in reducing trade flows.[2] The adverse effect of information costs (i.e., acting as an informal barrier) on international trade has been emphasized by several studies (e.g., Roberts and Tybout, 1997; Belderbos and Sleuwaegen, 1998; Petropoulou, 2011; Rauch, 1996; Rauch and Casella, 2003; Rauch and Trindade, 2002; and Tang, 2006). Greater access to the Internet[3] can allow trading firms to enjoy large access to knowledge information (on potential markets, clients, suppliers, and competitors) and ideas (e.g., Arthur, 2007; Paunov and Rollo, 2016). As a result, Internet use could help reduce information costs and promote international trade for existing businesses by connecting suppliers with existing consumers located beyond the borders of the supplier's home country (or countries) and improving logistics control. This effect is especially strong in the context of global value chains, where Internet openness and digitization replace some physical trade with online trade and facilitate faster and more efficient transactions and delivery of products, services, and payments (OECD, 2016). In particular,

2) Studies on this matter include for example Baldwin (1988); Bankolea et al. (2015); Behar and Venables (2011); Fink et al. (2005); Freund (2000); Gervais and Jensen (2019); Limão and Venables (2001); Meltiz (2003); Hummels (2007); Roberts and Tybout (1997); Tang (2006) and Visser (2019).

3) The benefits and challenges of the Internet use (and the Internet openness) are documented in the OECD (2016) and Paunov and Rollo (2016).

Internet openness can benefit smaller firms' participation in international trade (e.g., Acs et al., 1994; OECD, 2016; Nicholson and Noonan, 2014) and allow informal firms with limited resources (which prevent them from benefiting more from international trade) to overcome these resource barriers and build knowledge networks (e.g., Jensen, 2007). Furthermore, greater access to the Internet can increase the number of innovating firms and promote inclusive innovation in emerging and developing countries (e.g., Paunov, 2013; OECD, 2015).

On the empirical front, Freund and Weinhold (2002) reported a strong positive impact of the Internet on trade in services growth. Similarly, Freund and Weinhold (2004) relied on a model with imperfect competition and sunk costs of entry into a foreign market and empirically revealed the Internet's contribution to promoting export growth, notably by reducing market-specific fixed costs and enhancing competition. Meanwhile, building on Freund and Weinhold's (2004) works, Lin (2015) established empirically that an increase in Internet users has a positive effect on international trade. Moreover, Clarke and Wallsten (2006) discovered that increased Internet use improves developing countries' export performance but not that of developed countries: greater Internet access in developing countries allows them to increase their exports to developed countries. According to Clarke (2008), greater access to the Internet significantly helps enterprises in low- and middle-income economies in Eastern Europe and Central Asia to enjoy higher exports. Vemuri and Siddiqi (2009) and Meijers (2012) also presented evidence of the positive effect of the Internet on international trade. However, the latter has shown that the Internet exerts a higher positive effect on international trade in nonhigh-income countries than in high-income ones.

Portugal-Perez and Wilson (2012) showed that ICT tools positively affect exports, and the magnitude of this effect increases as countries become wealthier. Choi (2010) empirically found that the number of Internet users positively influences trade in services. Along the same lines, Tay (2015) found a strong positive effect of the Internet on trade in educational services. Accordingly, Osnago and Tan (2016) observed that Internet adoption positively influences international trade. However, bilateral exports are more affected when the Internet adoption increases in the exporting country than the importing country. Meanwhile, Abeliansky and Hilbert (2017) investigated the differential effects of telecommunication quantity (data subscriptions per capita) and quality (bandwidth data speed per subscription) of fixed and mobile telephony and internet services on countries' bilateral goods exports. Their results have revealed that the bandwidth speed of phones and internet matters most for developing countries, whereas the number of phones and internet subscriptions are much relevant for developed ones. According to Gnangnon and Iyer (2018), countries that narrow the gap between their and the global average Internet penetration rate benefit from greater integration into the global trade in the commercial services market. Visser (2019) discovered a positive link between Internet penetration and the extensive and intensive margins of differentiated exports. Furthermore, the findings suggest that Internet penetration can increase exports at large margins between low-income and high-income countries, but not within each of these groups. Meanwhile, Ding (2020) analyzed the impact of the Internet on international trade from the perspective of asymmetric information, the latter being considered the root cause of a bullwhip effect. The analysis indicates that the rapid development of the Internet provides countries with a new means of controlling the bullwhip effect of asymmetric information, thereby improving supply chain efficiency.

Now, it appears clearly from the aforementioned literature review and from fact-based statistics (see, e.g., OECD, 2016) that Internet adoption promotes international trade. Thus, the effect of Internet penetration on TRI would ultimately depend on how participation in international trade affects TRI.

The TRI effect of countries' participation in international trade, including through greater trade openness, has been discussed recently by Gnangnon and Brun (2019b). On the one hand, trade openness can induce greater TRI by enhancing the countries' vulnerability to idiosyncratic shocks. The enhancement of countries' vulnerability to external shocks could occur through various avenues (see Montalbano, 2011). These include the apparent asymmetry between the process of increasing specialization and the presence of random and undiversifiable shocks in open-economy export markets (e.g., Koren and Tenreyro, 2007); commodity price volatility, particularly in developing countries (e.g., Malik and Temple, 2009; McGregor, 2017; von Arnim et al., 2018); and the inadequacy of the existing local market structures and traditional coping mechanisms to address shocks prevailing in open markets (e.g., Dercon, 2001). It also includes the boom-bust cycles of investment supported by self-fulfilling expectations, where "optimistic" expectations, "good" terms of trade, and investment boom can alternate with "pessimistic" expectations, "bad" terms of trade, and investment bust. These may explain the excessive terms of trade volatility in developing countries compared with developed ones (Razin et al., 2003) and the possible high risk of mismanagement policy in countries with weak political institutions that open to trade (e.g., Rodrik, 1999; Acemoglu et al., 2003). On the other hand, greater trade openness may be related to the volatility of aggregate outcome variables, such as aggregate income, consumption, employment, wages, and prices (e.g., Ahmed and Suardi, 2009; di Giovanni and Levchenko, 2009; Haddad et al., 2011, 2013; Kim et al., 2016; Raddatz, 2007). In turn, the volatility of aggregate outcome variables may translate into tax base instability, resulting in greater TRI. Authors, such as Cavallo and Frankel (2008), have emphasized that trade openness can trigger "sudden stops": this could render the tax base unstable and enhance TRI. Other authors such as Ozkan and Unsal (2012) have empirically demonstrated the role of trade openness in strengthening the severity of financial crises in emerging markets.

Against this background, we can argue that if greater participation in international trade is associated with TRI, greater use of the Internet (which promotes participation in international trade) can enhance TRI (H1).

Meanwhile, greater participation in international trade (e.g., through increased trade openness) could help reduce countries' vulnerability to idiosyncratic sectoral shocks through production and export diversification (e.g., Acemoglu and Zilibotti, 1997; Haddad et al., 2011). Consequently, countries would experience lesser fluctuations in the tax base and enjoy greater stability of tax revenue. According to Haddad et al. (2011), trade openness can enable countries (i.e., trading firms in these countries) to share international risks through implicit and explicit insurance schemes (e.g., joint ventures, international lending, production diversification, and formal insurance contracts), owing to the possibility of greater integration into a broader range of global value chains. Barthélémy et al. (2020) showed that trade openness can contribute to worldwide economic recoveries after a financial crisis. In this context, trade openness can help reduce TRI. To summarize, in scenarios where greater trade openness is associated with higher tax revenue stability, greater Internet penetration may be associated with lower TRI as countries increase their participation in international trade (H2). Finally, trade openness may not significantly affect macroeconomic volatility (e.g., Calderon et al., 2005; Kose and Yi, 2006) and hence TRI. In such a case, Internet use would not significantly affect TRI in countries that promote their participation in international trade (H3).

Overall, the discussion laid out earlier does not allow concluding on the precise direction in which the Internet could influence TRI, as countries experience greater participation in international trade (among the three hypotheses, which would dominate the others remains unclear). The issue of the effect of the Internet on TRI through the international trade channel is therefore empirical.

III. Empirical Strategy

This section first lays down the model specification to address the issue at hand. Second, it presents the development (over time) of the two indicators of key interest (TRI and Internet penetration) in the analysis. Third, it discusses the econometric method to conduct the empirical analysis.

A. Model specification

In contrast with the voluminous literature on the determinants of public revenue, including those in developing countries, very few studies have investigated the determinants of TRI (e.g., Lim, 1983; Bleaney et al., 1995; Ebeke and Ehrhart, 2012; Ebeke, 2014; Gnangnon, 2020b; Gnangnon and Brun, 2019b). Building on these few studies, we postulate a dynamic model specification where the dependent variable (i.e., TRI) is regressed on the indicator of Internet penetration and on a set of control variables. The latter include the real per capita income, denoted by "GDPC," which acts as a proxy for countries' level of economic development; the volatility of economic growth ("GRVOL"); the volatility of development aid ("ODAVOL"); the share (in percentage) of total natural resource rents in GDP (denoted "RENT"), which acts as a proxy for countries' dependence on natural resources; the volatility of inflation rate ("INFLVOL"), and a measure of terms of trade instability ("TERMSVOL"). The variable measuring countries' participation in international trade represents the channel through which the Internet is expected to influence TRI; thus, it is excluded from the baseline model specification and would be included later in the empirical analysis.

We postulate the following model specification:

$$\begin{aligned} Log(TAXINST)_{it} = \alpha_0 &+ \alpha_1 Log(TAXINST)_{it-1} + \alpha_2 INTERNET_{it} \\ &+ \alpha_3 Log(GDPC)_{it} + \alpha_4 Log(GRVOL)_{it} \\ &+ \alpha_5\ Log(ODAVOL)_{it} + \alpha_6 RENT_{it} \\ &+ \alpha_7 Log(INFLVOL)_{it} + \alpha_8 Log(TERMSVOL)_{it} \\ &+ \gamma_t + \mu_i + \omega_{it} \end{aligned} \tag{1}$$

This model is estimated using an unbalanced panel dataset comprising 142 countries[4] (the subscript i in equation (1) refers to a given country) over the period 1996-2017. The key variable of interest in the analysis is "INTERNET." It represents Internet penetration (or Internet use level) and is measured by the number of people who use the Internet in percentage of the total population. Appendix 1 describes all of the variables in model (1). Drawing, for example, from Gnangnon and Brun (2019b) and particularly from Gnangnon (2020b), we computed the indicator of TRI over nonoverlapping subperiods of 3 years. These subperiods are 1995-1997, 1998-2000, 2001-2003, 2004-2006, 2007-2009, 2010-2013, and 2014-2017 (the latter covers a 4-year subperiod rather than a 3-year subperiod). The subscript t in equation (1) refers to each of these seven subperiods. Thus, the indicator capturing TRI has been computed as the standard deviation of the annual growth rate of tax revenue (% gross domestic product [GDP]) over nonoverlapping three-year subperiods. The share of nonresource tax revenue (excluding grants and social contributions) in %GDP has been used to calculate tax revenue. The difference between total tax revenue (% GDP) (excluding social contributions) and tax revenue collected on natural resources is represented by nonresource tax revenue. The use of nonresource tax revenue (% GDP) as the primary indicator of tax revenue is dictated by the fact that excluding tax revenue

4) The analysis has excluded developed countries, qualified as "old, industrialized countries" (e.g., Australia, Austria, Canada, Denmark, France, etc.). Development aid volatility is a control variable in the analysis; thus, we have selected -for the analysis - countries that had been recipients of development aid over the period from 1997 to 2017, and for which data on other control variables is available.

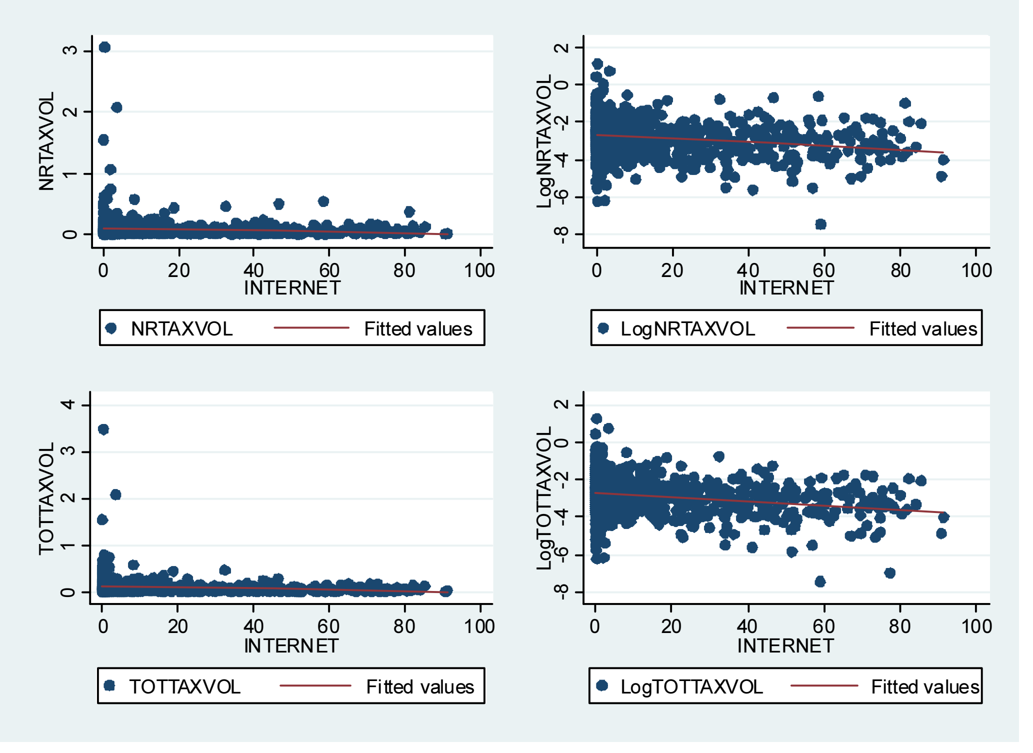
on natural resources from total tax revenue helps ensure homogeneity in the tax revenue variable across countries in the entire sample (e.g., Brun et al., 2015). To perform a robustness check, we computed the TRI using the ratio (%) of total tax revenue (excluding grants and social contributions) to GDP. Summing up, the dependent variable "TAXINST" is primarily measured by the nonresource TRI, and for robustness check, by the total TRI. α_0 to α_8 stand for parameters to be estimated. γ_t is time dummies representing global shocks affecting all countries' tax revenue and resulting in TRI. μ_i is countries' fixed effects, and ω_{it} represents a well-behaving error term.

The variables "GRVOL," "ODAVOL," "INFLVOL," and "TERMSVOL" have been computed over 3-year nonoverlapping subperiods (see Appendix 1 for more details on the computation of these variables). The natural logarithm has been applied to all volatility variables to limit their high skewness. For consistency, averages of the other variables, including "INTERNET," "GDPC," and "RENT" (which are not volatility variables) have been computed over the aforementioned seven 3-year nonoverlapping subperiods. Note that the natural logarithm has also been applied to the variable "GDPC" to reduce its distribution skewness. We present in Appendix 2 the descriptive statistics on all variables of model (1) and in Appendix 3, the lists of countries of the full sample and subsamples used in the empirical analysis. Finally, following many previous studies cited (e.g., Ebeke and Ehrhart, 2012; Ebeke, 2014; Gnangnon, 2020; Gnangnon and Brun, 2019b), we introduced the one-period lag of the dependent variable as a regressor in model (1). This helps consider the potential existence of a state dependence path in (i.e., the persistence over time of) TRI and therefore helps avoid the bias that could be introduced by the omission of this variable in the model.

Using nonoverlapping subperiods of 3-year data, we present in Figure 1, a simple correlation pattern between the variable "INTERNET" and each indicator of "TAXINST" (i.e., where the natural logarithm has not and has been applied to that indicator). The patterns between "INTERNET" and the TRI indicators (without the natural logarithm) do not show a clear-cut direction of the correlation, but they indicate outliers. Rather, in the graphs where the natural logarithm has been applied to the TRI variable, outlier problems do not exist, and the correlation pattern between the variable "INTERNET" and each TRI indicator tends to be negative. These justify why the natural logarithm has been applied to the variable "TAXINST" (the same logic applies to other volatility variables in model (1)).

In terms of the theoretical effects of control variables on TRI, we expect that in light of their more potent human resources and institutional capacity, countries with higher real per capita income (vs. relatively less advanced countries) are more likely to cope with the adverse effects of shocks on their economies and thus mitigate the intensity of TRI (see also Gnangnon and Brun, 2019b). Thus, we can expect that a rise in the real per capita income would be associated with a lower degree of TRI.

Figure 1. Scatter plot between the Internet penetration and tax revenue instability over the full sample



(Source) Author

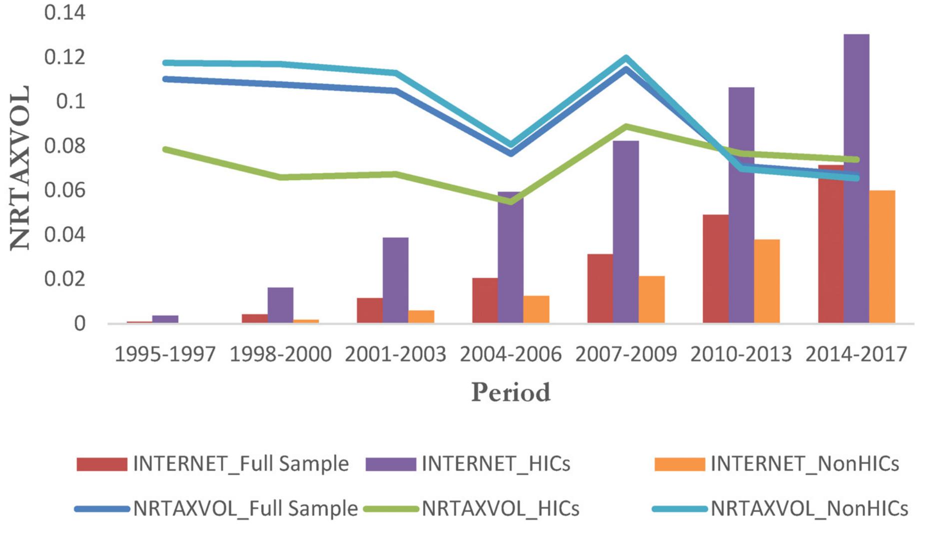
Following Gnangnon and Brun (2019b), we postulate that higher economic growth volatility, higher inflation volatility, and an increase in trade instability would translate in higher fluctuations of the tax base elements and enhance the TRI. The effect of development aid volatility on TRI has been discussed by Gnangnon and Brun (2019b): we argue here that development aid volatility could exacerbate TRI, particularly because development aid plays an important role in strengthening tax and customs administration capacities to mobilize tax revenue (Brun et al., 2011) and in improving tax compliance (e.g., Morrissey, 2015). Likewise, if development aid flows reduce the positive effects of shocks on output (e.g., Chauvet and Guillaumont, 2009), one could expect the volatility of these capital flows to induce lower output volatility in the event of shocks and hence lower the TRI. Overall, the direction of the effect of development aid volatility on TRI is a priori undetermined. Finally, in model (1), the variable "RENT" has been introduced to capture the extent to which natural resource dependence may matter for TRI. Indeed, economies that rely heavily on natural resources are less diverse and more vulnerable to the whims of the global market (e.g., Lashitew et al., 2021), which can lead to high economic volatility (e.g., Joya, 2015) and hence greater TRI.

B. Evolutionary patterns of the Internet penetration and tax revenue instability

This section completes Figure 1 by using the panel dataset over nonoverlapping subperiods of 3-year average to provide the development of Internet utilization and the indicator of the nonresource TRI over the full sample, and over three subsamples, including high-income countries (HICs), NonHICs (i.e., developing countries representing nonhigh-income countries in the full sample), and over low-income countries (LICs), and middle-income countries (MICs). Note that LICs and MICs are part of HICs. These subsamples are constructed using the World Bank's classification of countries, based on their gross national income per capita, as of July 2017 (as the end year of the period under analysis).

Figure 2 shows the development of the two indicators over the full sample and the subsamples of HICs and NonHICs. Meanwhile, Figure 3 presents the development of these two indicators over the subsamples of LICs and MICs.

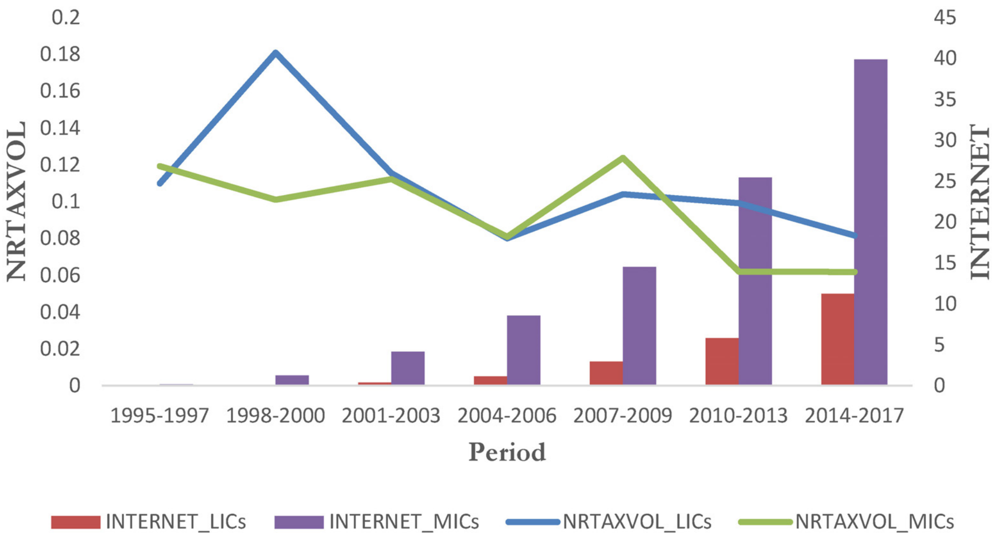
Figure 2. Development of the Internet penetration and the instability of nonresource tax revenue over the full sample and subsamples of HICs and NonHICs



(Source) Author

Figure 2 shows that nonresource tax revenue strongly fluctuated significantly over time across the full sample. Until 2010-2013, the nonresource TRI over NonHICs (i.e., developing countries) was greater than that of HICs, and the pattern reversed between 2010-2013 and 2014-2017. Furthermore, the nonresource TRI in both HICs and NonHICs followed similar patterns to the nonresource TRI across the entire sample, although the nonresource TRI follows a more similar pattern to that of the full sample than the nonresource TRI over HICs. Indeed, the nonresource TRI in NonHICs declined from 0.117 in 1995-1997 to 0.08 in 2004-2006, and then rebounded to reach 0.12 in 2007-2009. Nonresource TRI subsequently declined progressively to reach 0.065 in 2014-2017. For HICs, the nonresource TRI steadily fell from 0.066 in 1995-1997 to 0.055 2004-2006, and then increased to 0.089 in 2007-2009. It subsequently moved downward to 0.074 in 2014-2017.

Figure 3. Development of the Internet penetration and the instability of nonresource tax revenue over the full sample and subsamples of LICs and MICs



(Source) Author

For the internet penetration indicator, we note that over the full sample and HICs and developing countries, the Internet penetration steadily increased over time, on average, from 0.485% in 1995-1997 to 40.86% in 2014-2017. This pattern hid different figures in HICs and developing countries. For HICs, the Internet penetration was 74.5% in 2014-2017 against 2.09% in 1995-1997, whereas in developing countries, it moved from 0.14% in 1995-1997 to 34.3% in 2014-2017.

Figure 3 shows that, as in Figure 2 for developing countries, Internet penetration increased steadily over time in both LICs and MICs, although unsurprisingly, it was much higher in MICs than in LICs. In LICs, it moved from 0.009% in 1995-1997 to 11.26% in 2014-2017, whereas in MICs, it reached 39.9% in 2014-2017 against 0.17% in 1995-1997. Simultaneously, nonresource tax revenue strongly fluctuated over the entire period. However, the nonresource TRI showed different patterns in LICs and MICs. From 1995-1997 to 2001-2003, and toward the end of the period (i.e., from 2010-2013 to 2014-2017), the TRI is higher in LICs than in MICs. However, the pattern reversed over the other subperiods, because from 2001-2003 to

2004-2006, LICs and MICs experienced almost the same degree of the nonresource TRI, and from 2004-2006 to 2007-2009, the nonresource TRI became higher in MICs than in LICs.

C. Econometric approach

To obtain reliable results from the estimation of model (1) (and as its different variants described below), we must choose an appropriate econometric estimator. One feature of this model is that a number of its variables may be endogenous, owing to the bidirectional causality between some regressors and the TRI variables. These include the key variable of interest, namely, Internet penetration rate, volatility of development aid, and the share of natural resources in GDP. The following is the rationale behind the possibility of reverse causality for each variable. Concerning the *Internet penetration* variable, policymakers could build Internet-related infrastructure and promote Internet usage if the latter helped reduce TRI. Meanwhile, TRI may deprive governments of the financial resources needed to deal with the negative effects of shocks on the economy, resulting in greater economic growth volatility. Meanwhile, although development aid volatility might affect TRI, donor-countries might be willing to reduce the level of volatility of development aid flows to help recipient-countries ensure the stability of their tax revenue. Finally, greater TRI might limit countries' capacity to rely on (stable and predictable) financial resources that would help invest in the diversification of their economies, hence reducing their economies' dependence on natural resources.

We first estimate a static specification of model (1) (i.e., model (1) from which we remove the lagged dependent variable) using two standard econometric estimators, including the within fixed effects (denoted "FE") estimator and the feasible generalized least squares (denoted "FGLS") estimator. In the static specification of model (1), we have used a one-period lag of each of the three endogeneity variables ("INTERNET," "GRVOL," and "RENT") to mitigate their potential endogeneity. The results of these estimations are presented in columns [1] and [2] of Table 1.

However, a static specification of model (1) may suffer from the endogeneity problem arising from the absence of the one-period lag of the dependent variable as a regressor (to capture the state dependence nature of the TRI indicator) in the model. Therefore, we proceed with the analysis by employing the GMM approach, specifically the two-step system GMM estimator, to estimate the dynamic specification of model (1), that is, model (1) as it currently exists (see also Ebeke and Ehrhart, 2012; Ebeke, 2014; Gnangnon, 2020; Gnangnon and Brun, 2019b who have used this estimator in their analysis). The two-step system GMM estimator, proposed by Blundell and Bond (1998), is particularly suitable for dynamic panel datasets that feature many individuals (here, countries) relative to the period (e.g., Roodman, 2006) and where variables exhibit persistence over time. Its use involves estimating a system of equations that includes an equation in both differences and levels, where the lagged first differences are used as instruments for the levels equation and lagged levels are used as instruments for the first-difference equation. This estimator can handle the endogeneity problem arising from the correlation between the one-period lag of the dependent variable and countries' specific effects, and the endogeneity (here, reverse causality) of the aforementioned regressors. The two-step system GMM estimator is preferred over Arellano and Bond's (1991) first difference GMM estimator because instruments from the latter are generally weak, especially when variables are persistent. Furthermore, when the panel dataset is unbalanced (as in the current study), the use of the two-step system GMM estimator (rather than the difference GMM estimator) is recommended (e.g., Roodman, 2009).

Table 1. *Effect of the Internet Penetration on Nonresource Tax Revenue Instability Estimators: FE and FGLS*

Variables	FE	FGLS (with panel-specific first order Autocorrelation)
	Log(NRTAXVOL)	Log(NRTAXVOL)
	(1)	(2)
$INTERNET_{t-1}$	**-0.00662*** **	**-0.00945*** **
	(0.00148)	**(0.000971)**
Log(GDPC)	-0.0262	-0.00994
	(0.155)	(0.0123)
$Log(GRVOL)_{t-1}$	-0.0450	-0.00702
	(0.0351)	(0.0165)
$Log(ODAVOL)_{t-1}$	0.0225***	0.0548***
	(0.00795)	(0.0108)
$RENT_{t-1}$	0.00579**	0.0244***
	(0.00290)	(0.00130)
Log(INFLVOL)	0.125***	0.140***
	(0.0134)	(0.00597)
Log(TERMSVOL)	0.0711***	0.0232***
	(0.0164)	(0.00899)
Constant	-2.509**	-2.880***
	(1.184)	(0.112)
Observations-Countries	677-142	673-138
Within R^2	0.0496	
Pseudo R-squared		0.4601

Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. The Pseudo R^2 has been calculated for the regression based on the FGLS estimator, as the correlation coefficient between the dependent variable and its predicted values.

Three diagnostic tests are used to determine the suitability of the two-step system GMM estimator: (1) the Arellano-Bond test of the first-order serial correlation in the first-differenced error term (AR (1)); (2) the Arellano-Bond test of the second-order autocorrelation in the first-differenced error term (AR (2)); and (3) the Sargan/Hansen test of over-identifying restrictions (OID). The latter is useful in evaluating the validity of the instruments used in the regressions.

Furthermore, the number of countries used in the analysis must be higher than the number of instruments in the regressions to ensure that the aforementioned diagnostic tests would not lose power (e.g., Bowsher, 2002; Roodman, 2009). The regressions based on the two-step system GMM technique have used three lags of the dependent variable and three lags of the endogenous variables as instruments, where the variables "INTERNET," "GRVOL," "2ODAVOL," and "RENT" have been considered as endogenous.

The empirical analysis based on the two-step system GMM (where the nonresource TRI measures the variable "TAXINST") has been conducted as follows. In column [1] of Table 2, we present the outcomes of the estimation of model (1), as it stands.

Next, we assess the effect of the Internet penetration on the nonresource TRI across subsamples, including LICs, MICs, and HICs. To perform the analysis, we constructed three dummies denoted as "LIC," "MIC," and "HIC" for LICs, MICs, and HICs, respectively. Each dummy takes the value of "1" when a country of the full sample belongs to the relevant category, and "0" otherwise. Each dummy is then introduced once in model (1) in addition to the interaction between the dummy and the variable "INTERNET." Consequently, we estimate three different specifications of model (1), with each dummy and its interaction with the variable capturing the Internet penetration. Notably, we have not simultaneously included these dummies (i.e., two of them to avoid the multicollinearity problem) and their respective interaction with the variable "INTERNET" in model (1). Doing so would not generate estimates that allow us to obtain the direct net effect of the Internet penetration on nonresource TRI in LICs, MICs, and HICs, but rather the effect relative to that of the omitted dummy. Results of the estimations are presented in columns [2] to [4] of Table 2.

Column [5] of Table 2 reports the estimates resulting from the estimation of model (1) specification that allows investigating (more broadly) how the effect of Internet penetration on TRI varies across countries in the full sample (i.e., for different values of real per capita income). The estimated model specification is the dynamic model (1), in which the interaction between the variables "real per capita income" and "INTERNET" are introduced. Countries with higher real per capita income are more likely to deal with TRI better than less advanced countries. Therefore, if Internet penetration is negatively associated with TRI (most notably through its effect on international trade), it may have a greater negative effect on TRI as countries' real per capita income rises.

Table 2. *Effect of the Internet Penetration on Nonresource Tax Revenue Instability for varying Levels of Real per Capita Income/Participation in International Trade* ***Estimator:*** *Two-Step System GMM*

Variables	Log(NRTAXVOL)	Log(NRTAXVOL)	Log(NRTAXVOL)	Log(NRTAXVOL)	Log(NRTAXVOL)
	(1)	(2)	(3)	(4)	(5)
$Log(NRTAXVOL)_{t-1}$	0.0802***	0.0902***	0.0955***	0.0964***	0.0886***
	(0.0247)	(0.0271)	(0.0275)	(0.0285)	(0.0234)
INTERNET	**-0.00442****	**-0.00672*****	**-0.00789****	**-0.00540****	**0.0210***
	(0.00200)	**(0.00225)**	**(0.00393)**	**(0.00258)**	**(0.0109)**
INTERNET*LIC		**0.0291****			
		(0.0132)			
INTERNET*MIC			**0.000956**		
			(0.00409)		
INTERNET*HIC				**-0.00511**	
				(0.00358)	
INTERNET*Log(GDPC)					**-0.00307****
					(0.00128)
LIC		-0.448*			
		(0.233)			
MIC			0.350**		
			(0.152)		
HIC				-0.233	
				(0.241)	
Log(GDPC)	-0.115**	-0.161**	-0.0950*	-0.0517	-0.0743*
	(0.0452)	(0.0696)	(0.0515)	(0.0568)	(0.0404)
Log(GRVOL)	0.126**	0.0975*	0.0962*	0.128**	0.140***
	(0.0491)	(0.0530)	(0.0506)	(0.0516)	(0.0391)
Log(ODAVOL)	0.156***	0.162***	0.189***	0.196***	0.173***
	(0.0367)	(0.0393)	(0.0406)	(0.0437)	(0.0241)
RENT	0.0272***	0.0249***	0.0247***	0.0247***	0.0246***
	(0.00267)	(0.00299)	(0.00285)	(0.00319)	(0.00222)
Log(INFLVOL)	0.105***	0.115***	0.0994***	0.0990***	0.0936***
	(0.0263)	(0.0317)	(0.0309)	(0.0307)	(0.0254)
Log(TERMSVOL)	0.0517	0.0414	0.0540	0.0343	0.0371
	(0.0327)	(0.0341)	(0.0340)	(0.0359)	(0.0273)
Constant	-1.712***	-1.221**	-1.943***	-2.075***	-1.999***
	(0.321)	(0.556)	(0.368)	(0.404)	(0.313)
Observations-Countries	646-142	646-142	646-142	646-142	646-142
Number of Instruments	77	75	75	75	88
AR1 (P-Value)	0.0000	0.0000	0.0000	0.0000	0.0000
AR2 (P-Value)	0.6707	0.6719	0.7710	0.7031	0.6523
OID (P-Value)	0.7527	0.9453	0.8927	0.9246	0.9314

Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. In the two-step system GMM estimations, the "INTERNET," "TRADE," "OPEN," "GRVOL," "ODAVOL," and "RENT" have been considered as endogenous. The other variables have been considered as exogenous. The GMM regressions have used a maximum of 3 lags of the dependent variable as instruments and a maximum of 3 lags of the endogenous variables as instruments. Time dummies have been included in these regressions.

Table 3 presents the estimates resulting from the estimation of another variant of model (1) that allows us to investigate whether the effect of Internet penetration on TRI is dependent on countries' level of participation in international trade. That is, how does the effect of Internet penetration on TRI evolve for varying degrees of countries' participation in international trade? One commonly used indicator of countries' participation in international trade in the empirical literature is the ratio of the sum of the country's exports and imports of goods and services to its GDP. However, this measure does not accurately reflect the full extent of a country's integration into the global trade market: a country may have a higher ratio of the sum of its exports and imports of goods and services to GDP without actually experiencing greater integration into the global trade market.

Therefore, we use the indicator proposed by Squalli and Wilson (2011), who combined both countries' share of exports and imports in GDP and their share in the world trade. In other words, our indicator of participation in international trade (denoted by "TRADE") is for a given country: the sum of exports and imports of goods and services to its GDP is adjusted by the proportion of the country's trade level relative to the average world trade (see Squalli and Wilson, 2011: p. 1758). To explore empirically whether (and if so how) the effect of the Internet penetration on TRI works through countries' level of participation in international trade, we estimate another variant of model (1) in which both "TRADE" and its interaction with the variable "INTERNET" are included. Note that we have applied the natural logarithm to the variable "TRADE" to reduce its skewness. These two variables have been considered endogenous in the regression. The variable "TRADE" has endogeneity (notably reverse causality) because countries that face a high degree of TRI due to, *among other things*, their greater exposure to shocks (because of their increasing level of participation in international trade) may be willing to adopt measures restricting their participation in international trade to eventually stabilize their tax revenue. In addition to estimating the variant of model (1) with the variable "TRADE" and its interaction with "INTERNET," we run another regression of model (1) where "TRADE" is replaced with "OPEN" (the standard measure of trade openness, i.e., the ratio of the sum of the country's exports and imports of goods and services to its GDP) that is interacted with "INTERNET." Columns [3] and [4]of Table 3 also contain this regression's outcomes. Note that the variable "OPEN" is not expressed in percentage to obtain estimates that would be easily interpretable. However, before estimating the outcomes reported in columns [3] and [4] of Table 3, we must first determine whether participation in international trade is a channel through which Internet penetration can affect TRI. To do so, we estimate two variants of model (1), one of which includes the indicator of international trade participation ("TRADE" or, alternatively, "OPEN") but does not interact with the variable capturing Internet penetration. In theory, if the effect of Internet penetration on TRI works through the trade channel, then including the trade indicator in the baseline model (1) should either reduce the estimate of the variable capturing Internet penetration (see column [1] of Table 2) or render it nonstatistically significant. The outcomes of the estimation of these two variants of model (1) are presented in columns [1] and [2] of Table 2.

Table 3. *Effect of the Internet Penetration on Nonresource Tax Revenue Instability for varying Levels of the Participation in International Trade* ***Estimator:*** *Two-Step System GMM*

Variables	Log(NRTAXVOL)	Log(NRTAXVOL)	Log(NRTAXVOL)	Log(NRTAXVOL)
	(1)	(2)	(3)	(4)
$Log(NRTAXVOL)_{t-1}$	0.0825***	0.0734***	0.0798***	0.0720***
	(0.0248)	(0.0251)	(0.0203)	(0.0185)
INTERNET	-0.00157	-0.00279	**-0.0194*****	**-0.00760*****
	(0.00158)	(0.00171)	**(0.00696)**	**(0.00236)**
Log(TRADE)	-0.0255		0.0530*	
	(0.0274)		(0.0282)	
OPEN		-0.261**		-0.0243
		(0.103)		(0.0996)
INTERNET*Log(TRADE)			**-0.00194****	
			(0.000842)	
INTERNET*OPEN				**0.00560****
				(0.00272)
Log(GDPC)	-0.149***	-0.144***	-0.125***	-0.147***
	(0.0507)	(0.0404)	(0.0318)	(0.0260)
Log(GRVOL)	0.219***	0.213***	0.196***	0.186***
	(0.0345)	(0.0401)	(0.0266)	(0.0234)
Log(ODAVOL)	0.131***	0.137***	0.121***	0.103***
	(0.0296)	(0.0273)	(0.0172)	(0.0233)
RENT	0.0300***	0.0303***	0.0257***	0.0283***
	(0.00254)	(0.00246)	(0.00221)	(0.00188)
Log(INFLVOL)	0.0933***	0.0854***	0.0762***	0.107***
	(0.0227)	(0.0229)	(0.0187)	(0.0159)
Log(TERMSVOL)	-0.0128	0.0274	0.0234	0.0357
	(0.0236)	(0.0258)	(0.0200)	(0.0221)
Constant	-1.985***	-1.474***	-1.344***	-1.658***
	(0.544)	(0.293)	(0.470)	(0.195)
Observations-Countries	621-138	621-138	62-138	621-138
Number of Instruments	91	91	105	105
AR1 (P-Value)	0.0000	0.0000	0.0000	0.0000
AR2 (P-Value)	0.3352	0.2947	0.3809	0.3512
OID (P-Value)	0.6435	0.6613	0.5673	0.6774

Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. In the two-step system GMM estimations, the "INTERNET," "TRADE," "OPEN," "GRVOL," "ODAVOL," and "RENT" have been considered as endogenous. The other variables have been considered as exogenous. The GMM regressions have used a maximum of 3 lags of the dependent variable as instruments and a maximum of 3 lags of the endogenous variables as instruments. Time dummies have been included in these regressions.

Notably, we also undertake a robustness check analysis of previous findings using the two-step system GMM technique, and "TAXINST" is measured by the total TRI. Table 4 presents the outcomes of the estimation of different specifications of the dynamic model (1) where the total TRI measures "TAXINST." The first regression entails the estimation of model (1) (see results in column [1] of Table 4). The second regression involves estimating a version of model (1) that contains the interaction between the variables measuring the Internet penetration and real per capita income. The regression results are reported in column [2] of Table 4, and they aid in understanding how the Internet's impact on TRI varies across countries in the full sample. The third estimation entails determining whether the Internet's effect on TRI works through the international trade channel. (See the results in Table 4 columns [3] and [4]). To that effect, we estimate another specification of model (1) that includes our main variable of participation in international trade, that is, "TRADE" (in Logs), along with its interaction with "INTERNET." As in Table 3, we also present here the outcomes obtained by estimating model (1), in which we replace "TRADE" with "OPEN" (the standard measure of trade openness) that is interacted with "INTERNET."

Table 4. *Effect of the Internet Penetration on the Instability of Total Tax Revenue* ***Estimator:*** *Two-Step System GMM*

Variables	Log(TOTTAXVOL)	Log(TOTTAXVOL)	Log(TOTTAXVOL)	Log(TOTTAXVOL)
	(1)	(2)	(3)	(4)
$Log(TOTTAXVOL)_{t-1}$	0.0928***	0.0978***	0.0631***	0.0745***
	(0.0305)	(0.0341)	(0.0215)	(0.0223)
INTERNET	**-0.0106*****	**0.0341****	**-0.0248*****	**-0.0152*****
	(0.00345)	**(0.0174)**	**(0.00543)**	**(0.00236)**
INTERNET*Log(GDPC)		**-0.00487****		
		(0.00203)		
INTERNET*Log(TRADE)			**-0.00215*****	
			(0.000577)	
INTERNET*OPEN				**0.0100*****
				(0.00210)
Log(TRADE)			0.0629***	
			(0.0243)	
OPEN				-0.137*
				(0.0705)
Log(GDPC)	-0.0715	-0.0473	-0.113***	-0.101***
	(0.0564)	(0.0449)	(0.0365)	(0.0340)
Log(GRVOL)	0.191***	0.173***	0.259***	0.157***
	(0.0512)	(0.0484)	(0.0299)	(0.0274)
Log(ODAVOL)	0.0849**	0.103***	0.0700***	0.0530***
	(0.0389)	(0.0353)	(0.0242)	(0.0206)

Table 4. *Continued*

Variables	Log(TOTTAXVOL)	Log(TOTTAXVOL)	Log(TOTTAXVOL)	Log(TOTTAXVOL)
	(1)	(2)	(3)	(4)
RENT	0.0212***	0.0210***	0.0258***	0.0254***
	(0.00351)	(0.00340)	(0.00269)	(0.00232)
Log(INFLVOL)	0.127***	0.114***	0.0633***	0.114***
	(0.0307)	(0.0329)	(0.0229)	(0.0189)
Log(TERMSVOL)	-0.0163	0.0593*	-0.0132	0.0237
	(0.0337)	(0.0309)	(0.0261)	(0.0233)
Constant	-2.043***	-2.168***	-1.524***	-1.929***
	(0.407)	(0.385)	(0.468)	(0.307)
Observations-Countries	654-140	654-140	623-136	623-136
Number of Instruments	82	75	107	107
AR1 (P-Value)	0.0000	0.0000	0.0000	0.0000
AR2 (P-Value)	0.4167	0.4393	0.1841	0.2089
OID (P-Value)	0.7544	0.7764	0.6507	0.6479

Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. In the two-step system GMM estimations, the variables "INTERNET," "TRADE," "OPEN," "GRVOL," "ODAVOL," and "RENT" and the interaction variables have been considered as endogenous. The other variables have been considered as exogenous. The GMM regressions have used a maximum of 3 lags of the dependent variable as instruments and a maximum of 3 lags of the endogenous variables as instruments. Time dummies have been included in these regressions.

Columns [1] and [2] of Table 5 show the results of the estimation of two specifications of model (1), where the dependent variable TRI is replaced with the instability of the two major components of nonresource tax revenue: the nonresource domestic TRI (denoted "DOMTAXVOL") and trade TRI (denoted "TRTAXVOL"). These regressions help examine the effect of Internet penetration on nonresource domestic TRI and on trade TRI. In each specification of these models, we introduce the instability of the other component of nonresource tax revenue to control for the interplay between the instability of each component of nonresource tax revenue. In fact, the trade TRI may positively influence the nonresource domestic TRI, and vice-versa. As a result, in the specification of model (1), where the dependent variable is the nonresource domestic TRI, we include as a regressor the variable capturing the trade TRI. Likewise, in the specification of model (1), where the dependent variable is trade TRI, we include the nonresource domestic TRI as a regressor. We do these for all regressions presented in the following, where the dependent variable is measured by the instability of each component of nonresource tax revenue.

Columns [3] and [4] of Table 5 contain estimates that allow us to assess whether the effect of Internet penetration on nonresource domestic TRI, on the one hand, and trade TRI, on the other hand, works through countries' participation in international trade. To obtain these estimates, we introduce the variable "TRADE" and its interaction with "INTERNET" in the specifications of model (1), whose results are provided in columns [1] and [2] of Table 5.

Table 5. *Effect of the Internet Penetration on the Instability of the Main Components of Nonresource tax Revenue, including through the Trade Openness Channel* ***Estimator:*** *Two-Step System GMM*

Variables	Log(DOMTAXVOL)	Log(TRTAXVOL)	Log(DOMTAXVOL)	Log(TRTAXVOL)
	(1)	(2)	(3)	(4)
One-period lag of the dependent variable	0.0752***	0.0489***	0.121***	0.0712***
	(0.0176)	(0.0180)	(0.0209)	(0.0195)
INTERNET	**-0.00512*****	**0.00361****	-0.0162***	-0.00320
	(0.000947)	**(0.00152)**	(0.00365)	(0.00834)
Log(TRTAXVOL)	0.175***		0.179***	
	(0.0174)		(0.0192)	
Log(DOMTAXVOL)		0.207***		0.162***
		(0.0276)		(0.0320)
INTERNET*Log(TRADE)			**-0.00137*****	**-0.000711**
			(0.000484)	**(0.000959)**
Log(TRADE)			-0.00834	0.00454
			(0.0159)	(0.0343)
Log(GDPC)	0.186***	-0.0684**	0.165***	-0.0765**
	(0.0235)	(0.0333)	(0.0271)	(0.0332)
Log(GRVOL)	0.135***	0.0337	0.129***	0.105***
	(0.0255)	(0.0315)	(0.0297)	(0.0377)
Log(ODAVOL)	-0.0707***	0.125***	-0.0324**	0.115***
	(0.0159)	(0.0352)	(0.0147)	(0.0263)
RENT	0.0129***	0.0125***	0.0158***	0.0142***
	(0.00171)	(0.00200)	(0.00200)	(0.00235)
Log(INFLVOL)	0.0570***	0.160***	0.0440***	0.112***
	(0.0112)	(0.0246)	(0.0149)	(0.0249)
Log(TERMSVOL)	-0.0105	0.0939***	-0.0636***	0.0982***
	(0.0180)	(0.0263)	(0.0228)	(0.0268)
Constant	-3.429***	-0.978***	-3.319***	-0.914*
	(0.221)	(0.263)	(0.313)	(0.511)
Observations-Countries	486-128	489-128	466-123	471-124
Number of Instruments	97	97	94	94
AR1 (P-Value)	0.0000	0.0000	0.0000	0.0000
AR2 (P-Value)	0.9116	0.7803	0.7828	0.5263
OID (P-Value)	0.4278	0.3769	0.5819	0.4479

Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. In the two-step system GMM estimations, the variables "INTERNET," "TRADE," "GRVOL," "ODAVOL," and "RENT" and the interaction variables have been considered as endogenous. The tax revenue instability regressors have been treated as predetermined. The other variables have been considered as exogenous. The GMM regressions have used a maximum of 3 lags of the dependent variable as instruments and a maximum of 3 lags of the endogenous variables as instruments. Time dummies have been included in these regressions.

IV. Analysis of Empirical Outcomes

Starting with the estimates in Table 1, we observe that the coefficient of "INTERNET" is always negative and significant at the 1% level, although the magnitude of the estimate varies across the three columns. Control variables in both columns have similar signs and are significant at the 5% level. It appears that, as expected, development aid volatility, a greater reliance on natural resources, and inflation volatility are all positively and significantly associated with nonresource TRI. However, the volatility of trade terms exacerbates the nonresource TRI (at the 1% level). Incidentally, economic growth volatility and real per capita income have no significant effect on nonresource TRI (at the conventional significance levels).

Looking at the estimates in Tables 2-6, we can see that the conditions for the consistency of the two-step system GMM estimator are met (see the bottom of all columns of the Tables). The p-values of the AR(1) and AR(2) tests are, as expected, lower than 0.1 (i.e., the 10% level of statistical significance), and higher than 0.1; the p-value of the OID test is always higher than 0.1; the number of countries also always exceeds the number of instruments used in the regressions; and finally, the coefficient of the dependent variable's one-period lag is always positive and significant at the 1% level, indicating the relevance of considering model (1) in the dynamic form in the analysis.

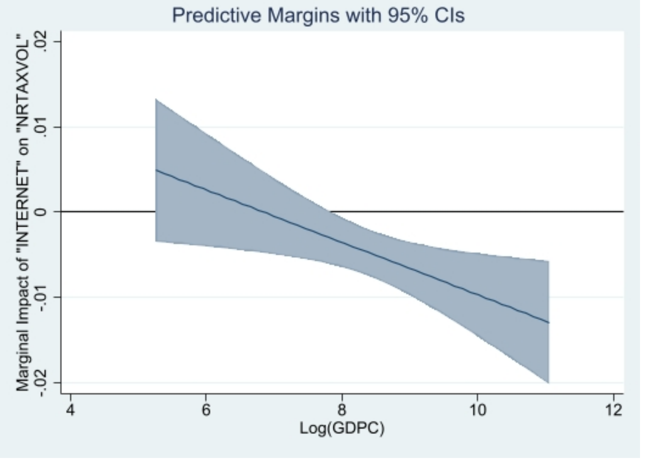
Taking up now the estimates in Table 2, we find in column [1] that the coefficient of "INTERNET" (0.0044) is negative and significant at the 5% level. This outcome confirms our expectation that Internet access could reduce TRI through, for example, cost reduction for taxpayers and tax and customs administrations, lower tax avoidance and fraud, and a greater extent of tax reform. Nonetheless, the magnitude of this coefficient (in absolute value) is lower than the coefficients of the same variable in Table 1. According to the results of our preferred estimator, the two-step system GMM approach, a one-point increase in Internet penetration is associated with a 0.44% (= 0.0044*100) decrease in the degree of nonresource TRI.

Moreover, control variable estimates in the five columns of Table 2 are quite similar. Looking at column [1] of the Table, we note that at the 5% level, the nonresource TRI is positively driven by an increase in real per capita income, higher economic growth volatility, higher volatility of development aid, increased reliance on natural resources, and higher inflation volatility. However, the terms of trade instability have no significant effect (at the conventional levels) on nonresource TRI.

Results in columns [2]-[4] of Table 2 suggest that the net effects of the Internet penetration on the total nonresource TRI in LICs, MICs, and HICs amount to 0.022 (= -0.00672+0.0291), -0.008, and -0.005, respectively. These findings suggest that increased Internet access enhances nonresource TRI in LICs but decreases it in MICs and HICs, with a greater negative effect on nonresource TRI in MICs than in HICs. This unusual positive TRI effect of Internet penetration in LICs can be explained by these countries' limited (both human and institutional, e.g., tax and customs administrations) capacity to deal with the challenges underpinning total TRI, even in the context of increasing Internet use.

Simultaneously, the estimates in column [5] of Table 2 reveal that the interaction term of ["INTERNET*Log (GDPC)"] is negative and significant at the 1% level, whereas the coefficient of "INTERNET" is positive, but significant only at the 10% level. Hence, taken jointly, these two outcomes suggest that at the 5% level, the Internet exerts a higher negative effect on nonresource TRI, and the magnitude of this negative effect rises as countries gain higher real per capita income. Put differently, less advanced countries have a lower nonresource TRI effect of the Internet than relatively advanced countries do. This finding aligns with our theoretical expectation. We display in Figure 4, at the 95% confidence intervals, the marginal impact of the Internet penetration on nonresource TRI for varying levels of the real per capita income. The figure shows that this marginal impact can take positive and negative values, and decreases as the real per capita income rises. However, it is not statistically significant for values of the real per capita income lower than US$2,460.7 [= exponential (7.8082095))]. This suggests that in countries whose real per capita income is lower than US$2,460.7 (i.e., in particular, LICs), the Internet penetration has no significant effect on nonresource TRI. For the rest of the world, however, Internet penetration has a positive and significant effect on nonresource TRI, with the magnitude of this effect increasing as real per capita income increases.

Figure 4. Marginal Impact of "INTERNET" on "NRTAXVOL" for varying levels of the real per capita income



(Source) Author

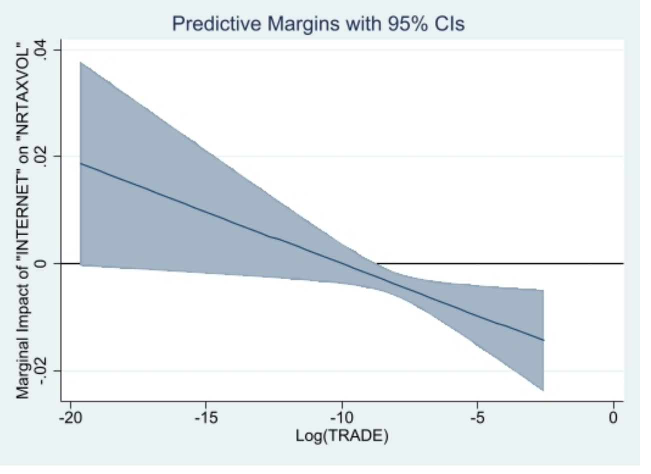
5) This number is obtained from the Stata software when constructing the graph.

Results in column [1] of Table 3 indicate that both the coefficients of "INTERNET" and "TRADE" are not significant at the conventional significance levels. This implies that including the indicator "TRADE" in the baseline specification cancels out the significant effect of Internet penetration on TRI. As a result, we could consider "TRADE" to be a channel through which Internet penetration influences the nonresource TRI. When the estimates in column [2] of Table 3 are considered, the same conclusion can be reached. In fact, the results in Table 3 column [2] show that, although the coefficient of "INTERNET" becomes statistically insignificant at the conventional significance levels, the coefficient of "OPEN" is negative and significant at the 5% level. This demonstrates that adding "OPEN" cancels out the significant effect of Internet penetration on TRI.

Outcomes in column [3] of Table 3 suggest a negative and significant coefficient (at the 1% level) of the variable "INTERNET" and a negative and significant (at the 5% level) interaction term of ["INTERNET*Log (TRADE)"]. Based on these two outcomes, we conclude that the Internet's impact on nonresource TRI is always negative (regardless of a country's level of participation in international trade). Furthermore, the magnitude of this negative effect increases with the degree of countries' participation in international trade.

These signify that the effect of the Internet on nonresource TRI genuinely translates through the international trade channels, and countries that enhance their participation in international trade enjoy lower nonresource TRI, owing to a rise in the Internet penetration rate. Overall, H2 set out in Section 2 appears to dominate the other two hypotheses, as far as the effect of the Internet on nonresource TRI through the international trade channel is concerned. This is confirmed in Figure 5 showing, at the 95% confidence interval, the marginal impact of the Internet penetration on nonresource TRI for varying degrees of countries' participation in international trade. We observe that although this marginal impact decreases as the degree of participation in international trade, it is significant only when it takes negative values. In particular, it is significant for values of the indicator "TRADE" higher than 0.00015 [= exponential (-8.832828)]. Hence, the greater the participation in international trade (as far as the values of "TRADE" is higher than 0.00015), the higher the magnitude of the negative effect of the Internet penetration on the nonresource TRI. Otherwise, for values of "TRADE" lower than 0.00015, the Internet penetration exerts no significance on the TRI.

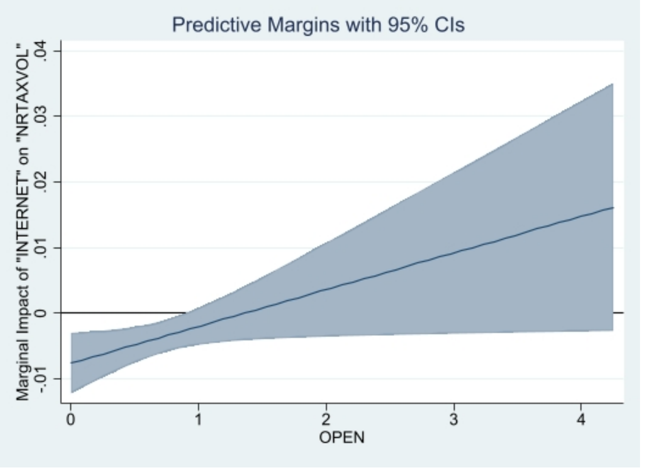
Figure 5. Marginal impact of "INTERNET" on "NRTAXVOL" for varying degrees of participation in international trade (measured by the variable "TRADE")



(Source) Author

The findings in column [4] of Table 3 (i.e., those obtained when using the standard trade openness variable) contradict, to some extent, the ones in column [1]. We note, in particular, that although "INTERNET" has a negative and significant coefficient (at the 1% level), the interaction variable ["INTERNET*OPEN"] holds a coefficient that is positive and significant at the 5% level. As a result, as countries further open up to international trade, Internet penetration has a positive effect on nonresource TRI, particularly when the degree of trade openness exceeds 1.36 (= 0.00760/0.00560), , that is, 136%. Per standard descriptive statistics reported in Appendix 2, values of "OPEN" range between 0.006 and 4.16, that is, between 0% and 416%. This outcome runs in contrast with those in column [1] of Table 3 and reveals the limitations of using the standard indicator of trade openness to measure countries' participation in international trade (see Squalli and Wilson, 2011). Control variables show estimates that agree with those in Table 2. Nonetheless, we try to obtain a better picture of this finding by depicting in Figure 6 the marginal impact of the Internet penetration on nonresource TRI for varying degrees of countries' trade openness at the 95% confidence intervals. From this figure, we obtain that this marginal impact is statistically significant at the 5% level only for degrees of trade openness lower than 0.94 (i.e., 94%). Particularly for degrees of trade openness lower than this threshold, Internet penetration reduces the nonresource TRI, but the magnitude (in absolute value) of this negative effect grows as trade openness decreases. For degrees of trade openness higher than 0.94, the Internet penetration does not significantly affect the nonresource TRI.

Figure 6. Marginal impact of "INTERNET" on "NRTAXVOL" for varying levels of trade openness (measured by the variable "OPEN")



(Source) Author

The results in Table 4 are consistent with those in Tables 2 and 3. In column [1] of Table 4, we observe a negative and significant coefficient (at the 1% level) of "INTERNET," which confirms the previous findings that Internet usage helps reduce TRI and notably here, the total TRI. In terms of the magnitude of the impact, a one-point increase in the Internet penetration rate is associated with a 1.06% (= 0.0106*100) decline in the total TRI. According to the control variables in column [1] of Table 4, real per capita income and terms of trade volatility do not appear to have a significant influence on the total TRI. However, the latter is positively and significantly (at the 5% level) driven by higher economic growth volatility, higher development aid volatility, increased reliance on natural resources, and higher inflation volatility. Estimates in Table 4 column [2] show a negative and significant (at the 5% level) coefficient of the interaction variable ["INTERNET*Log(GDPC)"] and a positive and significant (at the 1% level) coefficient of "INTERNET." Based on these two findings, we conclude that the total effect of the Internet on the total TRI changes sign (i.e., becomes negative) and decreases above a certain level of real per capita income, which equals US$1,098.9 [= exponential (0.0341/0.00487)]. Thus, countries with real per capita income lower than US$1,098.9 experience a positive effect of the Internet on the total TRI. For this group of countries, the lower the real per capita income, the greater the positive effect of the Internet on the total TRI. The explanation given for the positive effect of the Internet on TRI in LICs also applies here. The Internet always has a negative effect on the total TRI in countries with a real per capita income greater than US$1,098.9, and the magnitude of this negative effect grows as the real per capita income increases.

Estimates in column [3] of Table 4 indicate that the coefficients of both "INTERNET" and ["INTERNET*Log (TRADE)"] are negative and significant at the 1% level. Taken together, these two findings imply that, regardless of a country's level of participation in international trade, the Internet always results in lower total TRI. Furthermore, as countries increase their participation in international trade, the magnitude of the Internet's negative effect on total TRI grows. Overall, the effect of the Internet on the total TRI genuinely translates through the international trade channel, and countries that increase their participation in international trade benefit from a greater negative effect of Internet usage on the total TRI. These findings, once again, support H2 laid out in section 2. Conversely, column [4] of Table 4, where the standard trade openness is interacted with "INTERNET," show estimates that display similar patterns to those in column [2] of Table 3. That is, the effect of the Internet penetration on nonresource TRI increases as the degree of trade openness (traditional indicator of trade openness) increases. As noted earlier, these findings certainly highlight the limitations of using the standard trade openness indicator as a measure of countries' participation in international trade.

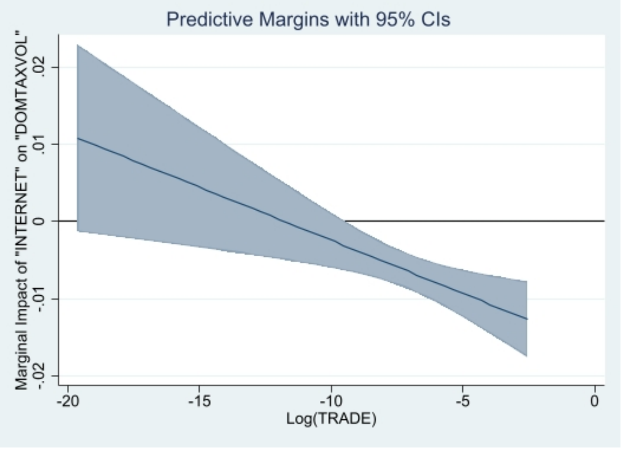
Estimates of control variables in columns [2] and [3] of Table 4 are largely consistent with those in column [1].

We will now look at the estimates in Table 5. Although Internet penetration dampens the nonresource TRI (see column [1] of Table 2), the results in columns [1] and [2] of Table 5 show that greater Internet access reduces the nonresource domestic TRI while increasing the trade TRI. The negative effect of Internet penetration on nonresource domestic TRI outweighs in absolute value the positive trade TRI effect of Internet penetration. Moreover, these explain why the net effect of Internet penetration on total nonresource TRI is negative. Incidentally, we note that higher trade TRI induces greater nonresource domestic TRI (see column [1] of Table 5) and vice-versa (see column [2] of Table 5).

Turning to columns [3] and [4] of the same Table, we find that the coefficients of the interaction variable ["INTERNET*Log (TRADE)"] are negative and significant at the 1% level (see column [3]) and not statistically significant at the conventional significance levels (see column [3]). These findings imply that increased Internet access has a negative effect on nonresource domestic TRI as countries improve their participation in international trade, with the magnitude of this negative effect increasing as participation in international trade increases. In contrast, the effect of Internet penetration on trade TRI is unrelated to countries' level of participation in international trade. This is because the Internet has no significant effect on trade TRI as countries increase their participation in international trade. Table 5 columns [3] and [4] confirm the findings in the previous two columns that trade TRI and domestic TRI are interdependent. The estimates of control variables in Table 5 line up with those in Table 2.

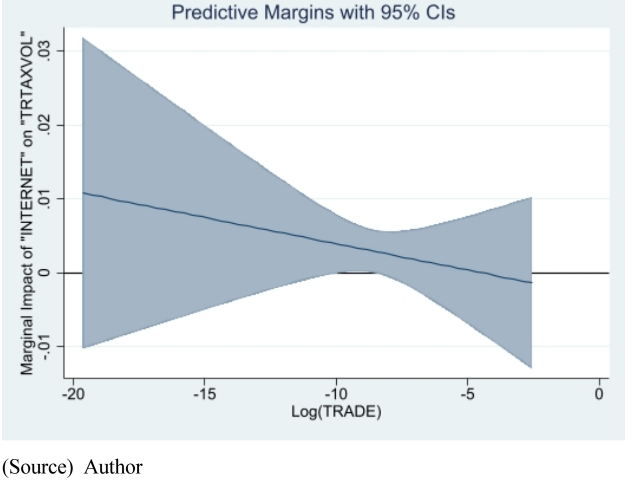
We display in Figure 7, at the 95% confidence intervals, the marginal impact of the Internet penetration on nonresource domestic TRI for varying degrees of countries' participation in international trade. This figure shows that for the levels of countries' participation in international trade lower than 0.000073 [= exponential (-9.529713)], the Internet penetration has no significant effect on nonresource domestic TRI. For higher degrees of participation in international trade, the Internet penetration reduces the nonresource domestic TRI, and the magnitude of this reducing effect increases as the degree of participation in international trade increases. Figure 8 shows, at the 95% confidence intervals, the marginal impact of the Internet penetration on trade TRI for varying degrees of countries' participation in international trade. As obtained earlier, the Internet penetration does not significantly affect trade TRI for varying degrees of countries' participation in international trade.

Figure 7. Marginal impact of "INTERNET" on "DOMTAXVOL" for varying degrees of participation in international trade (measured by the variable "TRADE")



(Source) Author

Figure 8. Marginal impact of "INTERNET" on "TRTAXVOL" for varying degrees of participation in international trade (measured by the variable "TRADE")



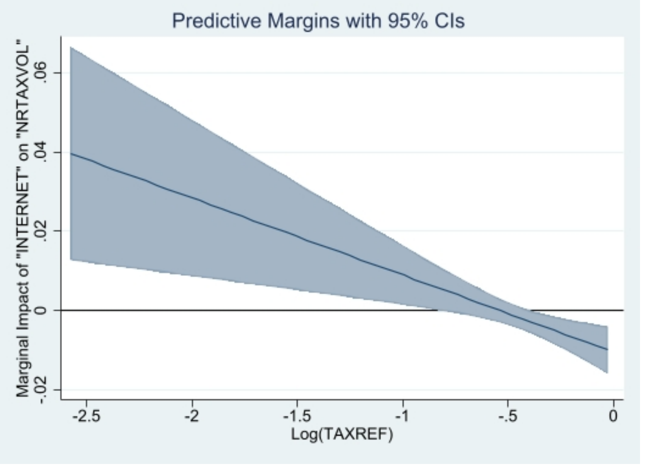
(Source) Author

V. Does the Effect of Internet Penetration on the Instability of Tax Revenue Work through the Tax Reform Channel?

In section 2, we noted the possibility that the Internet penetration could affect TRI through its effect on tax reform. The latter entails a change in the structure of total nonresource tax revenue by reducing the reliance on trade tax revenue to benefit domestic tax revenue. We hypothesized that greater access to the Internet would reduce TRI in countries experiencing a greater extent of tax reform. This hypothesis is also strengthened by the fact that Gnangnon (2020a) has obtained that the Internet penetration induces a greater extent of tax reform in countries that experience greater trade openness. To test this hypothesis, we estimate a variant of model (1) that includes the variable measuring the extent of tax reform (denoted "TAXREF") and the interaction between this variable and the variable "INTERNET." The outcomes of this estimation are presented in column [1] of Table 6. We also estimate the same variant of model (1) but by replacing the variable representing the total nonresource TRI with the instability of each component of the latter. The outcomes obtained from these regressions are presented in columns [2] and [3] of Table 6.

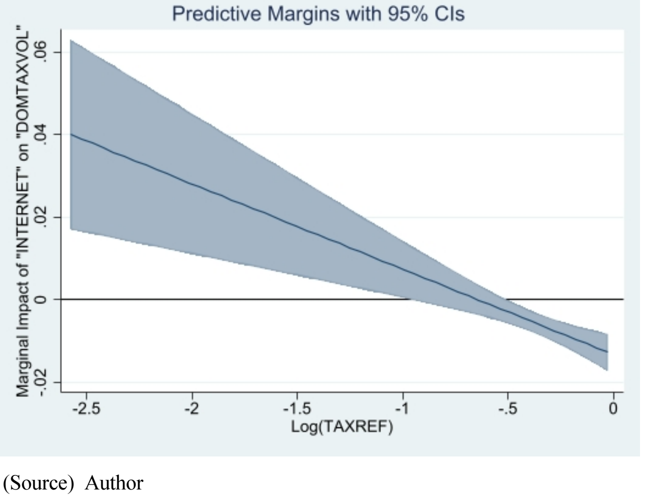
We discover across all columns of Table 6 that, in addition to the coefficients of the dependent variable's one-period lag being significant at the 10% level, all requirements for the two-step system GMM approach are met (see the bottom Table 6). Concerning estimates, we obtain from column [1] of Table 6 that the coefficient of "INTERNET" and the interaction term of ["INTERNET*Log (TAXREF)"] are both negative and significant at the 1% level. We conclude that, as expected, the Internet penetration reduces the nonresource TRI in countries that are experiencing a greater extent of tax reform. In other words, the magnitude of the dampening TRI effect of Internet penetration increases consistently as countries strengthen their implementation of tax reform. The extent of tax reform becomes greater. The same findings are obtained in column [2], which helps assess whether the extent of tax reform matters for the effect of the Internet access on nonresource TRI. We also conclude that Internet penetration contributes to lower nonresource domestic TRI in countries that implement tax reform, and the magnitude of this negative effect consistently increases as tax reform implementation is improved. To obtain a better picture of these findings in columns [1] and [2] of Table 6, we present in Figure 9 the marginal impact of the Internet penetration on nonresource (total) TRI for varying levels of tax reform at the 95% confidence intervals. Likewise, we provide in Figure 10, the marginal impact of the Internet penetration on nondomestic TRI for varying degrees of tax reform at the 95% confidence intervals. Figure 9 shows that the marginal impact of Internet penetration on nonresource TRI can be both positive and negative. It falls as the scope of tax reform expands, but it is not always statistically significant. For the extent of tax reform lower than 0.454 [= exponential (-0.7901409)], the Internet penetration induces a greater nonresource TRI, whereas for levels of tax reform higher than 0.682 [= exponential (-0.3822312)], the penetration of the Internet dampens the nonresource TRI, with the magnitude of this dampening effect increasing as countries undergo greater tax reform. However, Internet penetration has no significant effect on the nonresource TRI in countries where the extent of tax reform ranges between 0.454 and 0.682.

Figure 9. Marginal impact of "INTERNET" on "NRTAXVOL" for varying levels of the extent of tax reform



(Source) Author

Figure 10. Marginal impact of "INTERNET" on "DOMTAXVOL" for varying levels of the extent of tax reform



(Source) Author

Table 6. *Effect of the Internet Penetration on the Instability of the Main Components of Nonresource Tax Revenue*
Estimator: *Two-Step System GMM*

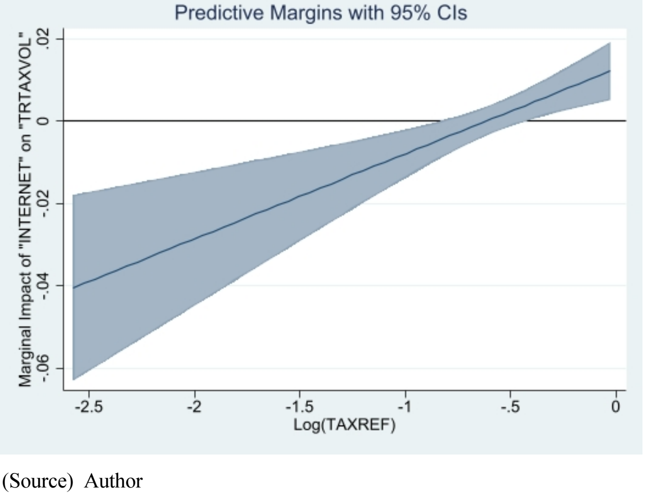
Variables	Log(NRTAXVOL)	Log(DOMTAXVOL)	Log(TRTAXVOL)
	(1)	(2)	(3)
One-period lag of the dependent variable	0.0570*	0.0791***	0.0344*
	(0.0296)	(0.0231)	(0.0177)
INTERNET	**-0.0104*** **	**-0.0133*** **	**0.0127*** **
	(0.00318)	**(0.00239)**	**(0.00374)**
INTERNET*Log(TAXREF)	**-0.0194*** **	**-0.0207*** **	**0.0207*** **
	(0.00641)	**(0.00530)**	**(0.00569)**
Log(TAXREF)	-0.311*	0.122	-0.444***
	(0.159)	(0.102)	(0.147)
Log(TRTAXVOL)		0.165***	
		(0.0185)	
Log(DOMTAXVOL)			0.153***
			(0.0376)
Log(GDPC)	-0.0823***	0.178***	-0.0867**
	(0.0298)	(0.0212)	(0.0414)
Log(GRVOL)	0.108**	0.0992***	0.0477
	(0.0430)	(0.0239)	(0.0467)
Log(ODAVOL)	0.0933***	-0.0610***	0.105***
	(0.0202)	(0.0151)	(0.0400)
RENT	0.0201***	0.0167***	0.0114***
	(0.00276)	(0.00192)	(0.00319)
Log(INFLVOL)	0.107***	0.0531***	0.0828***
	(0.0222)	(0.0188)	(0.0238)
Log(TERMSVOL)	0.0634**	-0.0186	0.111***
	(0.0305)	(0.0290)	(0.0321)
Constant	-2.224***	-3.314***	-1.174***
	(0.302)	(0.234)	(0.296)
Observations-Countries	567-133	486-128	489-128
Number of Instruments	78	94	94
AR1 (P-Value)	0.0000	0.0000	0.0000
AR2 (P-Value)	0.7315	0.9580	0.6378
OID (P-Value)	0.8403	0.4289	0.4338

Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. In the two-step system GMM estimations, the variables "INTERNET," "TAXREF," "OPEN," "GRVOL," "ODAVOL," and "RENT" and the interaction variables have been considered as endogenous. The tax revenue instability regressors have been considered as predetermined. The other variables have been considered as exogenous. The GMM regressions have used a maximum of 3 lags of the dependent variable as instruments and a maximum of 3 lags of the endogenous variables as instruments. Time dummies have been included in these regressions.

Figure 10 depicts a pattern that is nearly identical to Figure 9. As a result, the interpretation of Figure 9 applies equally to Figure 10, with the exception that Internet penetration causes greater nonresource domestic TRI for tax reform levels less than 0.39 [= exponential (-0.943107)], but dampens it for tax reform levels greater than 0.616 [= exponential (-0.4842086)]. For tax reform levels ranging from 0.39 to 0.616, Internet penetration has no significant effect on the nonresource domestic TRI.

In contrast with the findings in columns [1] and [2] of Table 6, we note in column [3] that the coefficients of "INTERNET" and the interaction term of ["INTERNET*Log (TAXREF)"] are all positive and significant at the 1% level. This implies that Internet penetration increases the trade TRI in countries that improve their tax reform implementation (i.e., those that experience a greater extent of tax reform), and the magnitude of the Internet's positive trade TRI effect grows as the extent of tax reform increases. Figure 11 shows, at the 95% confidence intervals, the marginal impact of the Internet penetration on trade TRI for varying tax reform levels. The pattern in this Figure is the inverse of the ones observed in Figures 9 and 10 (described earlier). In particular, the marginal impact of Internet penetration on trade TRI has both positive and negative values, but it grows as the degree of tax reform increases. However, it is not significant when the magnitude of tax reform falls between 0.43 [= exponential (-0.8411296)] and 0.648 [= exponential (-0.4332199)]. As a result, Internet penetration reduces the trade TRI for lower degrees of tax reform, even when the latter is than 0.43. It increases the trade TRI when the extent of tax reform exceeds the value of 0.648, but has no effect on the trade TRI when the levels of tax reform are between 0.43 and 0.48.

Figure 11. Marginal impact of "INTERNET" on "TRTAXVOL" for varying levels of the extent of tax reform



(Source) Author

Overall, although Internet penetration has a greater reducing effect on the total nonresource TRI in the context of greater tax reform, this finding reflects both a dampening effect of Internet penetration on the domestic TRI, as countries strengthen their implementation of tax reform, and an increasing trade TRI effect of Internet penetration, as the extent of tax reform improves.

The results of the control variables agree with those in Table 2. Furthermore, we observe an interdependence between domestic TRI and trade TRI, whereby an increase in trade TRI drives an increase in domestic TRI, and vice-versa.

VI. Further Analysis

According to the previous section's analysis, increased Internet penetration reduces TRI due to its positive effect on countries' participation in international trade. The current section extends the analysis by investigating whether a country's level of export product concentration (which also reflects a country's participation in international trade) matters for the effect of the Internet on TRI. Thus, countries' participation in international trade is measured here by their level of export product concentration (diversification), rather than their degree of trade openness.

As previously stated, increased Internet access represents an important means for industries to improve knowledge diffusion and learning about new technologies, which can help accelerate the rate of innovation (e.g., Conley and Udry, 2010). Through its inclusive innovation effect in emerging and developing countries, the Internet also contributes to increasing the number of innovating firms (e.g., Paunov, 2013; OECD, 2015). Furthermore, by introducing new products or expanding the range of products that a country can produce and export (e.g., Krugman, 1979; Dollar, 1986; Grossman and Helpman, 1989), and by improving export product quality (e.g., Flam and Helpman, 1987; Grossman and Helpman, 1991), innovation can promote export product diversification. Some studies (e.g., Antimiani and Costantini, 2013; Atkenson and Burstein, 2010) have discussed the behavior of exporting firms with innovative activities. It, therefore, appears that greater access to the Internet could promote the expansion of export product baskets, including sophisticated products. Chen (2013) used a dataset of 105 countries over the period 1975-2001 and provided empirical evidence that innovation (measured by patents counts) stimulates both the extensive margins (i.e., the number of products exported from a country) and the intensive margins (i.e., the export value of each product from a country). Interestingly, Lapatinas (2019) demonstrated empirically that the Internet contributes to greater export product sophistication.

Meanwhile, numerous studies have demonstrated that export product diversification helps dampen countries' vulnerability top shocks, including reducing the volatility of aggregate output (e.g., di Giovanni et al., 2014; Haddad et al., 2013; Malik and Temple, 2009) and the volatility of firms' output (e.g., Kramarz et al. 2020; Vannoorenberghe et al. 2016).

Overall, although the Internet adoption could promote export product diversification through its positive effect on innovation, greater export product diversification could also be associated with lower volatility of aggregate output and the volatility of firms' output. Meanwhile, as shown earlier (see discussion and the empirical findings concerning the effect of economic growth volatility on TRI), output volatility is itself an important source of TRI. In light of this, we postulate that increased Internet penetration could help mitigate TRI in countries with greater export product diversification (thanks, *inter alia*, to the expansion of access to the Internet). We test this hypothesis by estimating a variant of model (1) in which we replace the variable capturing economic growth volatility (as this is the channel through which we expect export product diversification to influence TRI) with an indicator of export product diversification and its interaction with the variable capturing Internet penetration. Notably, this model specification contains the indicator of participation in international trade, that is, the variable "TRADE." By including this variable in this variant of model (1), we capture the effect of the Internet penetration on TRI that passes essentially through countries' level of export product concentration, regardless of their degree of trade openness.

We employ two distinct export product diversification indicators (or concentration). The first is the International Monetary Fund's (IMF) THEIL index of export product concentration (denoted by "THEIL"), which was developed by building on the definitions and methods used by Cadot et al. (2011) (see Appendix 1 for further details on this index). The second export product concentration indicator (denoted by "HHI") is a Herfindahl-Hirschmann-based index of export product concentration calculated by the United Nations Conference on Trade and Development (UNCTAD), with values ranging from 0 to 1. An increase in the values of both "THEIL" and "HHI" indicates greater export product concentration, whereas the declining values of these indices (e.g., when values move toward zero) show a more homogeneous distribution of export products among a series of products (i.e., a greater degree of export product diversification).

Note that our main index of export product concentration is "THEIL," whereas "HHI" has been used for robustness check analysis. Thus, the variant of model (1) just described is estimated using alternatively "THEIL" and "HHI" as indicators of export product concentration, with the dependent variable "NRTAXVOL," and alternatively "TOTTAXVOL" used for robustness check analysis. The outcomes of these estimates are provided in Table 7.

Table 7. *Effect of the Internet Penetration on Nonresource Tax Revenue Instability/Total Tax Revenue for varying Levels of Export Product Concentration* ***Estimator:*** *Two-Step System GMM*

Variables	Log(NRTAXVOL)	Log(TOTTAXVOL)	Log(NRTAXVOL)	Log(TOTTAXVOL)
	(1)	(2)	(3)	(4)
One-period lag of the dependent variable	0.0679***	0.0982***	0.0399**	0.0755***
	(0.0171)	(0.0191)	(0.0185)	(0.0214)
INTERNET	-0.00219	0.00382	-0.00405*	-0.00562**
	(0.00246)	(0.00234)	(0.00208)	(0.00223)
INTERNET*THEIL	**-0.00214*** **	**-0.00394*** **		
	(0.000667)	**(0.000695)**		
INTERNET*HHI			**-0.0151*** **	**-0.0147** **
			(0.00509)	**(0.00613)**
THEIL	0.0753***	0.0399		
	(0.0248)	(0.0278)		
HHI			0.989***	0.612***
			(0.181)	(0.187)
Log(TRADE)	-0.0205	-0.0763***	-0.000856	-0.0298
	(0.0163)	(0.0190)	(0.0161)	(0.0191)
Log(GDPC)	0.0676**	0.0822***	0.0423	0.0439*
	(0.0265)	(0.0315)	(0.0287)	(0.0250)
Log(ODAVOL)	0.0746***	0.0257	0.0355**	-0.00621
	(0.0177)	(0.0207)	(0.0171)	(0.0213)
RENT	0.0214***	0.0230***	0.0140***	0.0153***
	(0.00191)	(0.00178)	(0.00261)	(0.00210)
Log(INFLVOL)	0.170***	0.187***	0.128***	0.165***
	(0.0126)	(0.0147)	(0.0143)	(0.0144)
Log(TERMSVOL)	0.0250	-0.00963	0.0544**	-0.00354
	(0.0233)	(0.0218)	(0.0224)	(0.0211)
Constant	-3.697***	-4.237***	-3.382***	-3.626***
	(0.347)	(0.400)	(0.328)	(0.352)
Observations-Countries	613-135	615-133	619-137	621-135
Number of Instruments	105	105	105	105
AR1 (P-Value)	0.0000	0.0000	0.0000	0.0000
AR2 (P-Value)	0.6113	0.3865	0.4347	0.3620
OID (P-Value)	0.3683	0.3900	0.5756	0.5923

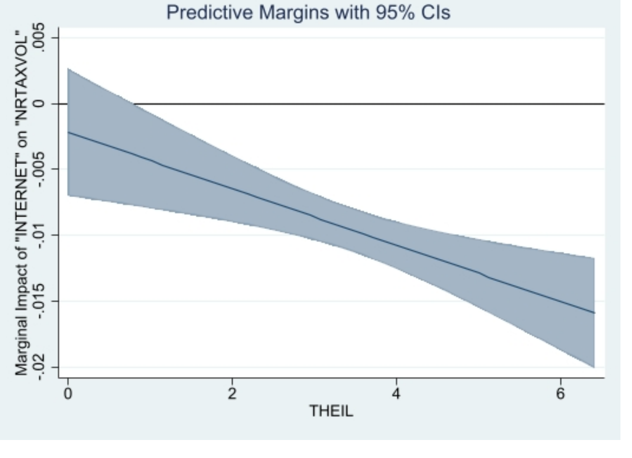
Note. *p-value < 0.1; **p-value < 0.05; ***p-value < 0.01. Robust standard errors are in parenthesis. In the two-step system GMM estimations, the variables "INTERNET," "TRADE," "OPEN," "GRVOL," "ODAVOL," and "RENT," the tax revenue instability regressors, and the interaction variables have been considered as endogenous. The other variables have been considered as exogenous. The GMM regressions have used a maximum of 3 lags of the dependent variable as instruments and a maximum of 3 lags of the endogenous variables as instruments. Time dummies have been included in these regressions.

We first note from this Table that in addition to the state-dependence[6] nature of tax revenue volatility variables, all requirements for the two-step system GMM approach are met (see results at the bottom of Table 7). Interestingly, we have obtained across the first two columns of the Table that the coefficients of the variable "INTERNET" are not statistically significant at the conventional significance levels. In contrast, the coefficients of the interaction variables between the variable "INTERNET" and the export product concentration index (i.e., THEIL) are statistically significant at the 1% level. These findings suggest that Internet access reduces TRI in countries with a high level of export product concentration, with the magnitude of the negative effect of Internet penetration on TRI increasing with the level of export product concentration (regardless of whether the latter is measured by the nonresource TRI or total TRI). One interpretation of this result could be that improved Internet access enables countries with a high level of export product concentration to diversify their export product basket, thereby reducing their TRI (under the dampening effect of export product diversification on output volatility).

These findings are supported by the results in columns [3] and [4] of Table 7, where the coefficients of the interaction variable ["INTERNET*HHI"] are negative and significant at the 1% level for the outcome reported in column [3], and negative and significant at the 5% level for the outcome reported in column [4].

Figure 12 shows, at the 95% confidence intervals, the marginal impact of the Internet penetration on nonresource TRI for varying degrees of export product concentration measured by the "THEIL" index. We observe that this marginal impact is always negative, but not always statistically

Figure 12. Marginal impact of "INTERNET" on "NRTAXVOL" for varying degrees of export product concentration ("THEIL" index)



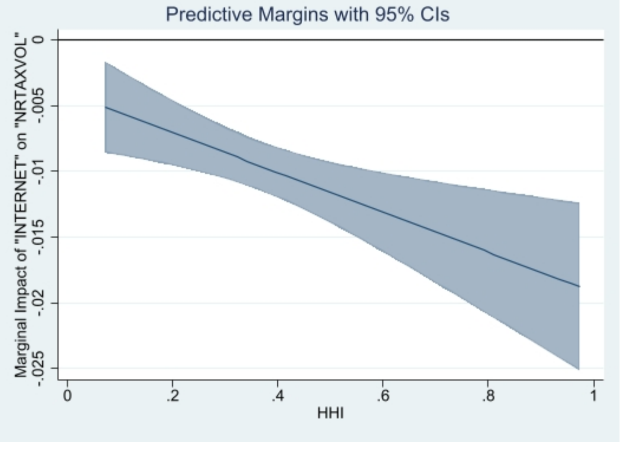
(Source) Author

6) The coefficients of the dependent variable are always significant at least at the 5% level in the four columns of the Table.

significant, although it decreases as the level of export product concentration rises. For degrees of export product concentration ("THEIL" index) lower than 0.77, the Internet penetration has no significant effect on the nonresource TRI.

Internet penetration has a negative and significant effect on the nonresource TRI at higher levels of export product concentration, and the magnitude of this effect (in absolute value) increases as the level of export product concentration increases. This finding is supported by Figure 13, which depicts the marginal impact of Internet penetration on nonresource TRI for varying degrees of export product concentration as measured by the "HHI" index at 95 percent confidence intervals. Figure 13 shows that the marginal impact is always negative and significant, and that it decreases as the level of export product concentration increases. In other words, regardless of the degree of export product concentration (as measured by "HHI"), the effect of Internet penetration on nonresource TRI is always negative. Furthermore, the magnitude of the Internet’s dampening effect on nonresource TRI is greater in less diverse countries than in more diverse countries (in terms of export products).

Figure 13. Marginal impact of "INTERNET" on "NRTAXVOL" for varying degrees of export product concentration ("HHI" index)



(Source) Author

Finally, the estimates of control variables in Table 4 are consistent with those obtained in Table 2.

VII. Conclusion

This paper examined the effect of Internet penetration on TRI, specifically through the international trade channel, using a sample of 142 countries from 1995 to 2017. The findings indicate that the Internet use has a negative and significant impact on TRI (regardless of whether the latter is measured by nonresource TRI or by the total TRI). Surprisingly, the empirical results suggest that the negative effect of the Internet on TRI operates via the international trade channel: the magnitude of the negative effect of the Internet on TRI increases as countries improve their level of participation in international trade. Moreover, greater access to the Internet dampens the TRI in countries that are experiencing a higher extent of tax reform, and a greater export product concentration, with the magnitude of this negative tax revenue effect of the Internet penetration increasing as the extent of tax reform improves, and the degree of export product concentration rises.

The Internet adoption has associated potential benefits (but also challenges) in the current world of increasing digitization of economies (see, e.g., OECD, 2016). Among these benefits are increased country participation in international trade and improved tax reform and tax revenue performance, including in developing countries. This study adds to the few existing studies on the effect of the Internet on public finances (including tax revenue and the extent of tax reform) by showing that countries' participation in international trade could matter for the TRI effect of the Internet access.

An avenue for future research could be to explore whether the effect of the Internet penetration on TRI depends on adopting the value-added tax (VAT) system. The issue is particularly relevant because, on the one hand, the VAT system has contrasting effects on tax revenue. Keen and Lockwood (2010) have shown that the adoption of the VAT system is associated with higher tax revenue collection, whereas a recent study by Alavuotunki et al. (2019) challenged these findings by establishing that the adoption of the VAT system has been associated with lower tax revenue. Meanwhile, even though Ebeke and Ehrhart (2011) established empirically that the VAT system's adoption helps reduce the TRI, whether Internet access affects the adoption of the VAT system remains unclear. Overall, the question of whether the VAT system matters for the effect of Internet penetration on TRI in countries merits a deep empirical analysis in another research paper.

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Appendix

Appendix 1. *Definition and Source of Variables*

Variable	Definition	Source
NRTAXVOL	This is the measure of the instability of nonresource tax revenue (excluding social contributions). Nonresource tax revenue is the difference between total tax revenue (% GDP) (excluding social contributions) and tax revenue collected on natural resources (the latter include a significant component of economic rent, primarily from oil and mining activities). The instability of nonresource tax revenue has been calculated as the standard deviation of annual growth rate of nonresource tax revenue (% GDP) over nonoverlapping subperiods of 3-year data.	Author's calculation based on data from the UNU-WIDER database. UNU-WIDER Public Revenue Dataset could be found online at: https://www.wider.unu.edu/project/government-revenue-dataset
TOTTAXVOL	This is the measure of the instability of total tax revenue. Total tax revenue (% GDP) (excluding social contributions) represents the difference between total public revenue (% GDP) (excluding grants, and excluding social contributions) and nontax revenue (% GDP). It has been calculated as the standard deviation of annual growth rate of tax revenue (% GDP) over nonoverlapping subperiods of 3-year data.	Author's calculation based on data from the UNU-WIDER database. UNU-WIDER Public Revenue Dataset could be found online at: https://www.wider.unu.edu/project/government-revenue-dataset
INTERNET	This is the indicator of the Internet penetration. It measures the number of individuals using the Internet, in percentage of the total population.	World Development Indicators (WDI)
TRADE	This is the indicator of a country's participation in international trade. It is basically the measure of trade openness suggested by Squalli and Wilson (2011). It is calculated the ratio of the sum of a country's exports and imports of goods and services to its GDP, adjusted by the proportion of a country's trade level relative to the average world trade (see Squalli and Wilson, 2011: p. 1758).	Author's calculation based on data extracted from the WDI
TAXREF	This the index of convergence of the tax structure of a given developing country toward the developed countries' tax structure. Following for example, see Gnangnon (2020a), Gnangnon and Brun (2019b,c,d), it has been computed using the semi-metric Bray-Curtis dissimilarity index (Bray and Curtis, 1957) as follows: $$d_{it} = \frac{\lvert DIRTAX_{it} - DIRTAXAve_t \rvert + \lvert INDIRTAX_{it} - INDIRTAXAve_t \rvert + \lvert TRTAX_{it} - TRTAXAve_t \rvert}{\left[(DIRTAX_{it} + DIRTAXAve_t) + (INDIRTAX_{it} + INDIRTAXAve_t) + (TRTAX_{it} + TRTAXAve_t)\right]} \quad (2),$$ where d_{it} represents the dissimilarity index between a given developing country's tax structure (for a given year) and the tax structure of developed countries. DIRTAX, INDIRTAX, and TRTAX stand respectively for the direct tax revenue ratio, the indirect tax revenue ratio, and the trade tax revenue ratio for a given developing country in a year t. For developed countries[7)], DIRTAXAve, INDIRTAXAve, and TRTAXAve are respectively the average (over all developed countries, in a given year) of the direct tax revenue ratio; the indirect tax revenue ratio; and the trade tax revenue ratio. For each of these tax revenue variables, we have excluded the natural resource revenue components. Values of the indicator "TAXREF" range between 0 and 1, with a rise in these values reflecting greater tax structure convergence, i.e., greater tax reforms.	Author's calculation using data from the UNU-WIDER database. UNU-WIDER Public Revenue Dataset could be found online at: https://www.wider.unu.edu/project/government-revenue-dataset
DOMTAXVOL	This is the measure of the instability of the total nonresource domestic tax revenue (% GDP). Total nonresource domestic tax revenue (% GDP) includes direct and indirect tax revenue). It has been calculated as the standard deviation of annual growth rate of the total nonresource domestic tax revenue (% GDP) over nonoverlapping subperiods of 3-year data.	Author's calculation based on data from the UNU-WIDER database. UNU-WIDER Public Revenue Dataset could be found online at: https://www.wider.unu.edu/project/government-revenue-dataset

Appendix 1. *Continued*

Variable	Definition	Source
TRTAXVOL	This is the measure of the instability of the international trade tax revenue (% GDP). It has been calculated as the standard deviation of annual growth rate of the international trade tax revenue (% GDP) over nonoverlapping subperiods of 3-year data.	Author's calculation based on data from the UNU-WIDER database. UNU-WIDER Public Revenue Dataset could be found online at: https://www.wider.unu.edu/project/government-revenue-dataset
THEIL	This is the variable capturing the export product concentration computed by the International Monetary Fund (IMF) using the THEIL Index and following the definitions and methods used in Cadot et al. (2011). Higher values of this variable indicate an increase in the level of export product concentration, while lower values of this index show a rise in the degree of overall export product concentration (i.e., greater export product diversification).	Details on the calculation of this Index could be found online: International Monetary Fund (IMF)'s Diversification Toolkit - See data online at: https://data.imf.org/?sk=3567E911-4282-4427-98F9-2B8A6F83C3B6
HHI	This is the export product concentration index computed by the United Nations Conference on Trade and Development (UNCTAD), using the Herfindahl-Hirschmann Index. Its values are normalized so as to range between 0 and 1. An index value closer to 1 indicates a country's exports are highly concentrated on a few products. On the contrary, values closer to 0 reflect exports are more homogeneously distributed among a series of products.	United Nations Conference on Trade and Development (UNCTAD) Database. See online: http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=120
GRVOL	This is the measure of the volatility of economic growth rate. It has been calculated as the standard deviation of annual economic growth rate (growth rate of real GDP) over nonoverlapping subperiods of 3-year.	Author's calculation based on economic growth rate data extracted from the WDI of the World Bank.
TERMSVOL	This is the measure of terms of trade volatility. Terms of trade represent the ratio of the export price index to import price index. Terms of trade volatility has been calculated as the standard deviation of annual terms of trade growth over 3-year nonoverlapping subperiods.	Author's calculation based on terms of trade data extracted from the WDI.
INFLVOL	Inflation volatility is calculated as the standard deviation of inflation rate over nonoverlapping subperiods of 3-year.	Author's calculation based on inflation data extracted from the WDI
ODAVOL	Inflation volatility is calculated as the standard deviation of the growth rate of development aid (in real values, i.e., US Dollar, 2017, Constant Prices) rate over nonoverlapping subperiods of 3-year.	Author's calculation based on inflation data extracted from the OECD
OPEN	This is the measure of trade openness. It is the ratio of exports and imports of goods and services (current $US) to GDP (current $US). To facilitate the interpretation of estimations' outcomes, this variable is not expressed in percentage, i.e., the original variable collected from WDI has been divided by 100.	Author's calculation based on trade openness data from the WDI
RENT	Total natural resources rents (% of GDP)	WDI
GDPC	GDP per capita (constant 2010 $US)	WDI

7) The list of developed countries (Old Industrialized countries) used to compute the index of convergence in tax structure index for developing countries in the analysis includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden Switzerland, United Kingdom and United States of America.

Appendix 2. *Descriptive Statistics on Variables Used in the Model*

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
NRTAXVOL	677	0.088	0.172	0.002	3.055
TOTTAXVOL	660	0.089	0.184	0.001	3.471
INTERNET	674	16.341	18.352	0.002	77.300
TRADE	649	82.143	43.611	0.598	415.773
OPEN	649	0.821	0.436	0.006	4.158
TAXREF	590	0.605	0.148	0.076	0.975
THEIL	666	3.654	1.195	0.000	6.354
HHI	673	0.374	0.212	0.075	0.958
DOMTAXVOL	547	0.150	0.163	0.004	1.676
TRTAXVOL	587	0.192	0.522	0.004	11.582
GDPC	677	4909.393	6249.131	192.174	47432.610
INFLVOL	677	3.572	7.752	0.101	116.751
TERMSVOL	677	0.104	0.084	0.000	0.596
GRVOL	676	2.620	4.459	0.007	96.049
ODAVOL	661	1.674	21.773	0.000	554.265
RENT	676	8.505	11.708	0.000	69.542

Appendix 3. *Lists of Countries Contained in the Full Sample and the Subsamples*

Full sample				LICs	HICs
Albania	Ecuador	Madagascar	Solomon Islands	Burkina Faso	Antigua and Barbuda
Algeria	Egypt, Arab Rep.	Malawi	South Africa	Burundi	Aruba
Angola	El Salvador	Malaysia	Sri Lanka	Central African Republic	Bahamas, The
Antigua and Barbuda	Equatorial Guinea	Maldives	St. Kitts and Nevis	Chad	Barbados
Argentina	Eritrea	Malta	St. Lucia	Congo, Dem. Rep.	Brunei Darussalam
Armenia	Eswatini	Marshall Islands	St. Vincent and the Grenadines	Eritrea	Chile
Aruba	Ethiopia	Mauritania	Sudan	Ethiopia	Croatia
Azerbaijan	Fiji	Mauritius	Suriname	Gambia, The	Cyprus
Bahamas, The	Gabon	Mexico	Tajikistan	Guinea	Hong Kong SAR, China
Bangladesh	Gambia, The	Micronesia, Fed. Sts.	Tanzania	Guinea-Bissau	Israel
Barbados	Georgia	Moldova	Thailand	Haiti	Korea, Rep.
Belarus	Grenada	Mongolia	Togo	Liberia	Kuwait
Belize	Guatemala	Morocco	Tonga	Madagascar	Macao SAR, China
Benin	Guinea	Mozambique	Trinidad and Tobago	Malawi	Malta
Bhutan	Guinea-Bissau	Myanmar	Tunisia	Mozambique	Mauritius
Bolivia	Guyana	Namibia	Turkey	Niger	Palau
Bosnia and Herzegovina	Haiti	Nepal	Turkmenistan	Rwanda	Panama
Botswana	Honduras	Nicaragua	Uganda	Sierra Leone	Saudi Arabia
Brazil	Hong Kong SAR, China	Niger	Ukraine	Sudan	Seychelles
Brunei Darussalam	India	Nigeria	Uruguay	Tajikistan	Singapore
Burkina Faso	Indonesia	North Macedonia	Uzbekistan	Togo	Slovenia
Burundi	Iran, Islamic Rep.	Pakistan	Vanuatu	Uganda	St. Kitts and Nevis
Cambodia	Iraq	Palau	Venezuela, RB	Yemen, Rep.	Trinidad and Tobago
Central African Republic	Israel	Panama	Vietnam		Uruguay
Chad	Jamaica	Papua New Guinea	West Bank and Gaza		
Chile	Jordan	Paraguay	Yemen, Rep.		
China	Kazakhstan	Peru	Zambia		
Colombia	Kenya	Philippines	Zimbabwe		
Comoros	Kiribati	Rwanda			
Congo, Dem. Rep.	Korea, Rep.	Samoa			
Congo, Rep.	Kuwait	Sao Tome and Principe			
Costa Rica	Kyrgyz Republic	Saudi Arabia			
Cote d'Ivoire	Lao PDR	Senegal			
Croatia	Lebanon	Serbia			
Cuba	Lesotho	Seychelles			
Cyprus	Liberia	Sierra Leone			
Dominica	Libya	Singapore			
Dominican Republic	Macao SAR, China	Slovenia			

Note. Countries in the full sample that are not in the categories of Low-income countries (LICs) and High-Income Countries (HICs) are de facto in the category of Middle-Income Countries (MICs).