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Tax Structure and Revenue Volatility

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Tax Structure and Revenue Volatility

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Abstract

In this paper, I discuss the implications of changing tax structures for the trade-off between long-run revenue growth and short-run volatility of revenues produced by tax portfolios utilized in different countries. I argue that the issue of uneven growth over years is methodologically similar to the one of uneven distribution of resources among economic units in any given year. Therefore, one can utilize the Generalized Entropy (Theil) family of inequality indices in order to quantify relative contribution of economic and noneconomic factors to revenue instability. While it is important to understand the resistance of tax systems to economic shocks, the latter might not be the main source of revenue instability, at least in OECD countries. Rather than the prevalence of unstable tax sources, the resistance of tax systems to economic shocks appears to be determined by correlation (or lack thereof) among constituent tax sources.

Keywords: revenue volatility, revenue stability, tax structure

JEL Codes: C23, C51, H21

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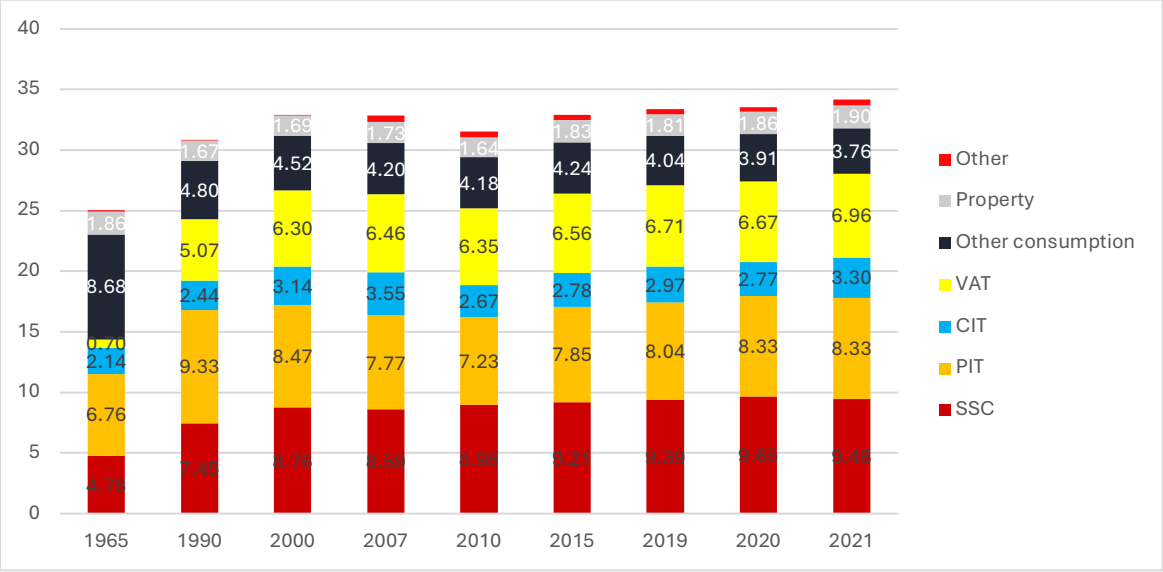
1 Introduction

Decision makers at all levels of government have to respond to changes in their external environments. For example, in the context of local governments, Groves et al. (1981, p. 11) defined "environmental factors" as "external influences" that "may create demands, provide resources, or establish limits."[1] However, coping strategies required for adapting to secular trends in those external factors are not the same as those for dealing with transient shocks. Such shocks (disturbances, perturbations, etc.) may be caused by disasters (whether natural or human-induced), trade disruptions, or economic crises more generally and other unpredictable events, such as pandemics.

Major shocks can break the ongoing trend and create a "new normal," e.g., stagnant growth of property tax revenue in the US after the Great Recession of 2007–08 (Wang and Scorsone 2020). Certain long-term trends, like climate change, can make occurrence of transient shocks more frequent and severe. Furthermore, failures to adapt to secular trends can make a jurisdiction less resilient to transient shocks, for example as a result of raiding financial reserves to postpone required structural adjustments even before a disaster strikes.

Figure 1. Evolution of Tax Revenue in OECD, % of GDP



Source: Prepared by authors using data from OECD (2023)
Note: SSC: Social security contributions; PIT: Personal Income Tax; CIT: Corporate Income Tax; VAT: Value Added Tax.

[1] In particular, they categorized these external factors into those related to 1) community needs and resources, 2) external economic conditions, 3) intergovernmental constraints, 4) natural disasters and emergencies, and 5) political culture.

As illustrated with OECD data in Figure 1, over decades in many countries the balance of taxation has been shifting toward general taxes on domestic consumption, primarily the Value Added Tax (VAT). While the Personal Income Tax (PIT) revenues have been steadily declining in the OECD countries since the 1980s, Social security contributions (SSC) revenues have been growing. This can be partly explained by demographic trends in those developed countries. Immediately following the Great Recession of 2007–09, OECD countries further increased revenues from SSC. Revenues from PIT and VAT initially declined following the crisis but started to increase soon thereafter because of austerity measures and eventually surpassed their pre-crisis levels.

This evolution of the tax structures has implications for the trade-off between long-run growth and short-run volatility of revenues produced by tax portfolios utilized in different countries. While most OECD countries have exhibited an upward long-term trend in total tax revenues as a share of GDP, it shows clear up and down phases (OECD 2013). In the post-war period, tax-to-GDP ratios were growing uninterruptedly until the first oil shock (1973–74). Then, they were growing again between 1975–85 partly as a result of progressive tax "bracket creep" in the environment of high inflation that followed. The second oil shock of 1980 prompted many European governments to raise taxes to fund their social security programs and balance their budgets. Later, there were other dips and rebounds following the dot-com crash, Great Recession, and most recently the COVID pandemic.

In the next section, I attempt to review and synthesize existing literature on revenue volatility and establish links to other related issues, such as fiscal resilience and sustainability. Then, I combine two common empirical measures of revenue volatility—short-run buoyancy and deviations from the trend growth rate—into a unified analytical framework. Finally, I use panel data on 23 OECD countries over 1991–2022 to illustrate the application of this framework to quantify relative contributions of economic and noneconomic factors to revenue instability and the impact from changes in tax structures.

As becomes clear from the literature review immediately below, the issue of revenue stability is not the same as fiscal resilience. However, these two issues are conceptually and methodologically interlinked. While this paper primarily focuses on quantifying revenue volatility and understanding its driving forces, I build on the conceptual and methodological frameworks developed in other

strands of literature. It is my hope that the results of this study can contribute to our understanding of adjacent issues, such as fiscal resilience and sustainability.

2 Literature Review

In a wide range of disciplines, the lens of resilience has been used to study how various systems (ecological, economic, engineering, etc.) respond to shocks. However, the terminology used in different disciplines has not been consistent or perhaps has evolved since the earliest studies (e.g., Holling 1973). In this paper, the terms "resilience" covers all phases of a system's response to a shock, including the initial resistance ("absorption") and subsequent recovery ("rebound").[2] This is consistent with more recent literature, for example in regional economics, where resilience is defined as "a region's capacity to absorb and resist shocks as well as to recover from them." (Han and Goetz, 2015 p. 131). This broader notion is also described in the literature as "a system's overall robustness, and the rapidity and flexibility with which it recovers from an external shock" (ibid., p. 132).

Wang and Scorsone (2020) applied the concept of resilience in the field of public finance and synthesized the related literature on economic resilience and fiscal condition. In the context of state and local finance, they applied the resilience lens to examine "local capability of service provision following an external shock" (p. 717).

In particular, Wang and Scorsone identified three alternative definitions of resilience used in the literature across various disciplines. The first alternative, termed "ecological resilience," focuses on the "capacity to absorb the shock and maintain the stability of system structure." This version is more closely related to the notion of revenue stability and can be empirically measured by looking at the deviations of yearly observations from the trend line. An alternative definition, dubbed "engineering resilience," focuses on the ability to "bounce back from shocks," which could be measured as the speed of a system's return to the equilibrium state, e.g., the speed of adjustment parameter in the Error Correction Model (ECM) used by Anderson Shimul (2018). The third definition dubbed "organizational resilience" is based on the notions of "bounce forward" and "positive adaptability," which in the case of government revenues could manifest itself as changes

[2] In some earlier literature, "resilience" only referred to the initial resistance phase while the subsequent recovery was referred to as "stability" (Holling (1973). In some later economic literature, the two terms got flip-flopped. For example, Anderson and Shimul (2018) interpret their short-run buoyancy estimate as "stability" while the speed of adjustment estimate is "resilience."

in the tax structure in the anticipation of shocks. Beyond just the revenue side, this third definition could also manifest itself as building up rainy-day fund balances in anticipation of a recession or other shocks.

Interestingly, while structural changes aimed at reducing vulnerability to future shocks could be considered part of resilience even the earlier literature, it would not be so for structural changes necessitated by past shocks as it would indicate lack of capacity to "tolerate alteration before reorganizing around a new set of structures and processes." (Alberti et al. 2003, p. 1170). Subsequent literature introduced an extended notion of "adaptive resilience," which in the case of regional economics can be defined as "the capacity of a regional economy to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time" (Martin 2012, p.10).

In the context of public finance, revenue stability is only one way to for governments to sustain service provision. Indeed, external shocks can disrupt service provision by affecting the local revenue base among other things (Miao, Hou, and Abrigo 2018). An alternative or complementary strategy could be having a budgetary stabilization fund. However, to be effective, the size of such stabilization fund should reflect the magnitude of potential revenue shocks. Thus, the extent of revenue instability matters regardless of coping strategies adopted. Furthermore, according to the resource-based view theory (RBV), availability of stable revenues in the lead up to an external shock can contribute to government resilience by enabling improvements in organizational capacity or creating a state of low vulnerability (Lee and Chen 2021).

All in all, the issue of revenue stability examined in this paper, while might be related to, is nevertheless not the same as fiscal resilience. If at all, revenue stability is only related to the initial resistance ("absorption") dimension of fiscal resilience. While fiscal resilience studies are primarily concerned with major shocks capable of disrupting government services, revenues stability studies concern with year-on-year fluctuations, which might not disrupt government services but still make them less efficient by impeding strategic allocation and optimal use of resources.

It is not surprising that most of the revenue stability literature focuses on the state and local budgets in the United States (e.g., Dye and McGuire 1991, Kwak 2013, Seegert 2015). Indeed, most of these government units are bound by balanced budget requirements, have limited borrowing

capacity and lack tools for economic stabilization that would be available at the national level. However, outside the United States, many of these settings can sometimes be found at the national level due to participation in monetary unions and associated fiscal surveillance.

Some US-focused studies attempted to explain revenue stability with the extent of revenue diversification, commonly measured using the Hirschman–Herfindahl Index (HHI).[3] They topically find that that revenue diversification improves revenue stability and fiscal stress management at the local level (e.g., Hendrick 2002).

When constructing their tax revenue diversification index (RDI) in the international setting, Compaoré et al. (2020) opted for the Theil T index (introduced in the next section as I1) over HHI. However, similarly to HHI, the Theil index captures only the relative shares of various categories of revenue classification without considering any possible correlation between different categories of revenues. Similarly to the US-focused studies, Compaoré et al. (2020) found that revenue diversification is associated with lower tax revenue volatility in their sample of 127 countries over 2000–15.

Some scholars pointed out that diluting the concentration of the tax system dominated by one particular type of tax, as would be manifested with high values of HHI or Theil indices, might not improve revenue stability if the new type of tax is highly correlated with the currently utilized sources of revenue. On the contrary, further increasing the concentration of the tax system on the same money maker by adding previously untaxed components to its tax base might actually improve revenue stability if these additions are negatively correlated with the existing tax base. This was eloquently articulated by Dye and McGuire, (1991, footnote 2) in the context of broadening state sales taxes in the United Sates:

> *Adding a more variable component to a less variable base does not necessarily result in an increase in measured variability for the expanded base. The variability of the expanded base depends on the covariance of the original base and the addition to the base. For example, if the added component varies in a pro-cyclical fashion, while the original base varies in a counter-cyclical fashion, then the measured variability of the expanded base would be less than the measured variability of either the original base or the added component. This is in fact the case with personal business services and the representative narrow base. The*

[3] Suyderhound (1994), Hendrick (2002), Schunk and Porka (2005), Carroll (2005, 2009), Kilby (2014).

variability of the expanded base is less than the variability of the representative narrow base.

Others pointed out that revenue stability might not be the primary consideration for decision makers in determining tax structures (Oates 1991, Carrol 2009). Indeed, while the CIT might be one of the most volatile taxes, it is quite popular with politicians because of the obfuscation it creates for the ultimate incidence of the tax burden (Bird 2002).

Finally, the issue of revenue stability was also studied in the long strand of literature on revenue buoyancy starting with Groves and Kahn (1952), who focused on the stability of tax revenues at the state and local data, again from the United States. Revenue buoyancy is framed as the sensitivity of tax revenues to economic fluctuations, measured as the percentage change in tax revenue associated with a one percent change in the tax base. Sobel and Holcombe (1996) later pointed out the importance of distinguishing between "short-run variability and long-run growth" and suggested that, for the same dependent variable, one can obtain two very different estimates of short- and long-run buoyancy respectively. Later, the analytical framework of tax buoyancy was applied in the international settings, especially in the context of monetary unions and fiscal surveillance (Koester and Priesmeier 2017, Dudine and Jalles 2017, Deli et al. 2018, Lagravinese et al. 2020, Cornevin et al. 2023).

3 Empirical Methodology and Analysis

Empirical literature has mostly settled on measuring revenues volatility in terms of deviations of year-to-year changes from the trend growth rate. This empirical measure has been referred to by a variety of names, such as "cyclical variability of tax revenues" (Dye and McGuire, 1991), "revenue instability" (Bleaney et al. 1995, Gnangnon and Brun 2019), "revenue volatility" (Seegert 2015, Kwak 2013), and other names (Williams et al. 1973, White 1983, and Ladd and Weist 1991). However, some scholars chose to measure revenues stability by estimating short-run buoyancy with respect to economic fluctuations (e.g., Anderson and Shimul 2018). Immediately below, I introduce an analytical framework combining both empirical measures, that is short-run buoyancy and deviations from the trend growth rate.

For any variable y_j measured at time period j, let us denote the difference in logarithms as

$$\dot{y} = \ln(y_j) - \ln(y_{j-1}) = \ln\left(\frac{y_j}{y_{j-1}}\right) \approx \%\Delta y \qquad (1)$$

From calculus, we know that the percentage change $\%\Delta y=(y_j-y_{j-1})/y_{j-1}$ would be the first order approximation for such difference in logarithms. In the case of annual data, we can think of this percentage change as an annual rate of growth.

Using this notation, the deviations of year-to-year changes from the trend growth rate can expressed as $\left(\dot{T}_j - \overline{\dot{T}}\right)$, where the annualized trend growth rate is calculated using the following formula:

$$\overline{\dot{T}} = \frac{1}{J}\sum_j \dot{T}_j = \frac{1}{J}\sum_j\{\ln(T_j) - \ln(T_{j-1})\} = \frac{1}{J}\{\ln(T_J) - \ln(T_1)\} \quad (2)$$

To summarize the prevalence of these annual deviations from the trend growth rate into some indicator of revenue volatility, one can follow one of the existing approaches used for measuring statistical dispersion, such as variance or standard deviation. For analytical tractability, in this paper I opted for the Generalized Entropy (Theil) family of indices I_c, defined for the continuum of real values *c*, which was initially developed for measuring inequality (Theil 1967, Shorrocks 1980, Shorrocks 1982, Shorrocks 1984):

$$I_c = \frac{1}{Jc(c-1)}\sum_j\left\{\left(\frac{Y_j}{\overline{Y}}\right)^c - 1\right\} \quad (3)$$

Indeed, the issue of uneven growth across years is methodologically similar to the one of uneven distribution of resources among economic units in any given year. Because of equity concerns, the distribution of the economic product might be just as important for decision makers as its overall size. Similarly, for reason of sound planning and liquidity, predictable annual changes in revenues might be as important for decision makers as the long-term growth of revenues.

Besides this conceptual justification, the Generalized Entropy indices also have a number of attractive features instrumental for this study. First, for c=2, it becomes half the variance over mean squared, i.e., half the square of the common measure of statistical dispersion known as the coefficient of variation (CoV):

$$I_2 = \frac{1}{2J\overline{Y}^2}\sum_j\left(Y_j - \overline{Y}\right)^2 = \frac{1}{2}\frac{VAR(Y)}{\overline{Y}^2} = \frac{1}{2}(CoV)^2 \quad (4)$$

Second, all Generalized Entropy indices, including I_2, are amenable to additive decomposition by various components of the variable of interest Y_j as established by Shorrocks (1982). To illustrate this decomposability, let us consider the annual rate of growth of nominal tax revenues $\dot{T}$ and construct the Generalized Entropy index I_2:

$$I_2 = \frac{1}{2J\bar{\dot{T}}^2}\sum_j \left(\dot{T}_j - \bar{\dot{T}}\right)^2 = \frac{1}{2}\frac{VAR(\dot{T})}{\bar{\dot{T}}^2} \quad (5)$$

Applying the product rule for logarithms, we can derive that the growth rate of the nominal tax revenues T= Y *(T /Y) is a sum of growth rates for the national income Y and tax-to-GDP ratio t=T/Y respectively:

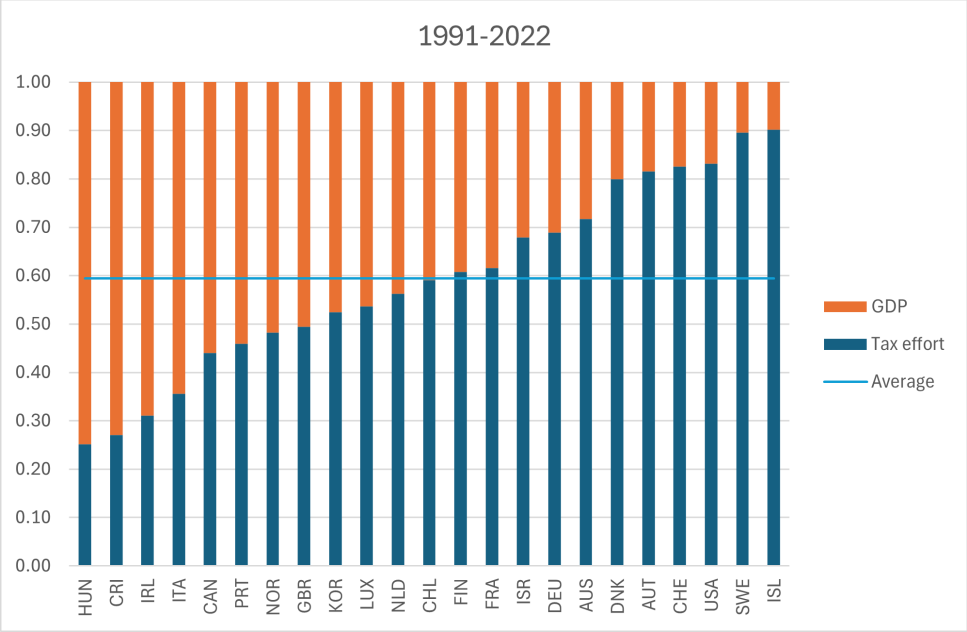
$$\dot{T} = \dot{Y} + \dot{t} \quad (6)$$

If plug this sum into the formula for variance $VAR(\dot{T})$ in equation (5), we get

$$I_2 = \frac{1}{2\bar{\dot{T}}^2}VAR(\dot{T}) = \frac{1}{2\bar{\dot{T}}^2}COV(\dot{Y} + \dot{t}, \dot{T}) = \frac{1}{2\bar{\dot{T}}^2}COV(\dot{Y}, \dot{T}) + \frac{1}{2\bar{\dot{T}}^2}COV(\dot{t}, \dot{T}) \quad (7)$$

Thus, the volatility of nominal tax revenues can be decomposed into two components: one related to economic (GDP) fluctuations $\dot{Y}$ while the other is related to the fluctuations in the tax-to-GDP ratio ("Tax Effort"). The relative contributions from these two sources of tax volatility are illustrated in Figure 2 using data from 23 OECD countries over 1991–2022. One can see vast differences in terms of the share of tax volatility associated with economic fluctuations, which ranges from 10 percent in Iceland to 75 percent in Hungary. However, on average economic fluctuations account for only 40 percent of tax volatility with the rest driven by non-economic factors, including discretionary tax changes ("Tax Effort").

Figure 2. Decomposition of Tax Revenue Volatility into Economic (GDP) and Non-economic (Tax Effort) Components



Such decomposition of revenues volatility can be unpacked further by looking at the underlying factors driving economic fluctuations. Indeed, changes in the nominal GDP are made up of changes in real GDP per capita, inflation and population growth:

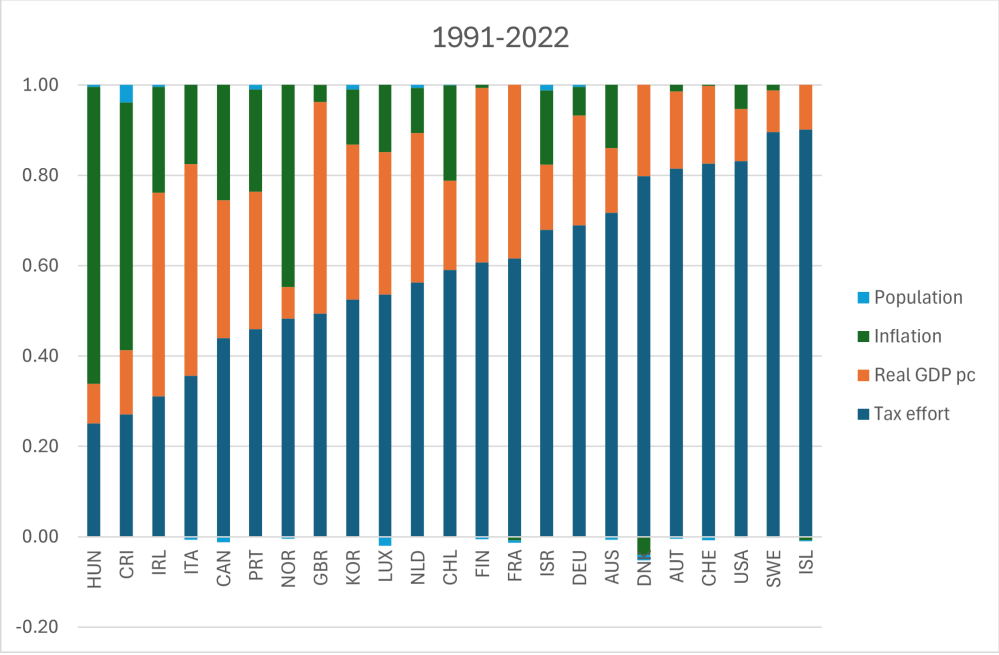
$$T= (T/Y)*Y= (T /Y)*[Y/(N*P)]*P *N= t*y*P*N \quad (8)$$

where

- T stands for nominal tax revenues
- Y stands for nominal GDP
- t = T/Y stands for the tax-to-GDP ratio
- y = Y/(N*P) stands for GDP in constant prices per capita
- N stands for the country's population
- P stands for the price level

According to Figure 3, among the OECD countries where economic fluctuations account for a major part of tax volatility, it is often driven by inflation (e.g., Hungary, Costa Rica, and Norway) as opposed to real changes in GDP.

Figure 3. Detailed decomposition of tax revenue volatility



Next, we need to acknowledge that the contribution of each external factor to tax revenue volatility reflects both the volatility in that underlying factor as well as the sensitivity of the tax system to fluctuations in that particular factor. As pointed out by Seegert (2015, p. 902) in the context of US states, "Tax revenue volatility is a function of both economic uncertainty and the tax portfolio a state government holds."

The sensitivity of the "tax portfolio" to economic fluctuations is typically estimated in the empirical literature as the short-run buoyancy of nominal tax revenues T_j with respect to the economic product Y_j. This short-run buoyancy, which we will denote[4] as $E_Y[T]$, is in practice approximated with an estimate of the slope **b** in the regression of the differences in logarithms:

$$\ln(T_j) - \ln(T_{j-1}) = \mathrm{a} + \mathrm{b}\left[\ln(Y_j) - \ln(Y_{j-1})\right] + \varepsilon_j. \quad (9)$$

Using our notation for differences in logarithms, this regression equation becomes

$$\dot{T}_j = \mathrm{a} + \mathrm{b}\dot{Y}_j + \varepsilon_j \quad (10)$$

From econometrics, we know that, in the case of a single regressor, the slope **b** can be estimated using the following formula:

$$b = \frac{COV(\dot{Y},\dot{T})}{VAR(\dot{Y})} \approx E_Y[T] \quad (11)$$

By plugging this slope estimate into the formula for the decomposition of variance (7), we get

$$VAR(\dot{T}) = COV(\dot{Y},\dot{T}) + COV(\dot{t},\dot{T}) \approx E_Y[T]VAR(\dot{Y}) + E_t[T]VAR(\dot{t}) \quad (12)$$

In other words, tax revenue volatility can be decomposed into two parts: economic volatility modulated by the sensitivity of the tax system to these economic factors plus non-economic volatility modulated by the sensitivity of the tax system to these non-economic factors. Again, this decomposition of revenue volatility can be unpacked further by looking at the underlying factors driving economic fluctuations as in equation (8):

$$VAR(\dot{T}) \approx E_y[T]VAR(\dot{y}) + E_P[T]VAR(\dot{P}) + E_N[T]VAR(\dot{N}) + E_t[T]VAR(\dot{t}) \quad (13)$$

[4] Generally, $E_x[f(x)]$ denotes the point elasticity operator for function f(.) with respect to argument x. However, in the public finance literature, the term "tax elasticity" is used for the counterfactual tax change holding the tax policy constant while, in the case of the actually observed changes in tax revenues, the term "tax buoyancy" is used to allow for both automatic and discretionary tax revenue responses.

where

- $\dot{T}$ stands for the annual change in nominal tax revenues
- $\dot{y}$ stands for the annual change in real GDP per capita
- $\dot{P}$ stands for the annual change in the price level (inflation)
- $\dot{N}$ stands for the annual change in population size
- $\dot{t}$ = T/Y stands for the annual change in in tax-to-GDP ratio

Finally, we can further unpack the sensitivity of the tax system to the economic fluctuations into components related to specific types of taxes. Thus, if the total tax revenue T=ΣTk is a sum of parts coming from different types of taxes Tk, then we can decompose the buoyancy estimate EY[T] as following:

$$EY[T] = EY[\Sigma Tkij] = \Sigma\ (Tkij/T)^* EY[Tk]$$

Thus, the buoyancy of total revenues is a sum of respective buoyancies of different types of taxes weighted by their shares in the total tax revenues. According to this formula, diversification of the tax system by reducing the share Tk/T of tax k and increasing the share Tl/T of tax l can reduce tax revenue volatility only if the new tax (l) is less sensitive to economic fluctuations than the old tax k, i.e., only if EY[Tl]< EY[Tk]. Otherwise, the new tax will make the tax system even more volatile. This consideration is missed entirely when revenue diversification is measured based on the tax shares alone, as in the following examples:

- Herfindahl-Hirschman (HHI) index (e.g., Suyderhound,1994): $HHI = \Sigma\ (T^k_{ij}/T\ )^2$
- Theil T index (e.g., Compaoré et al. 2020): $I_1 = (1/J)\Sigma(T^k_{ij}/T)\ln(T^k_{ij}/T)$

According to the empirical literature, the estimates of short-run buoyancy vary substantially among main categories of tax classification in the IMF's Government Finance Statistics Manual (IMF 2014). For an illustration, I can cite results produced Belinga et al. (2014) using a pooled mean group (PMG) estimator for a balanced panel of 22 OECD countries between 1965–2012. This is the same group of countries that was used to produce graphs in this study. According to the results of Belinga et al., main categories of taxes can be ranked by descending value of their short-run buoyancy (provided in parentheses) as following: CIT (1.96), PIT (1.10), General Sales Taxes (0.92), SSC (075), Excises (0.51), Taxes on Immovable Property (statistically indistinguishable

from zero). According to these estimates and the tax trends revealed in Figure 1, the shift away from excises to VAT since the 1960s might have made tax systems in OECD countries more sensitive to economic fluctuations. At the same time, the shift away from PIT to SSC might have made tax systems in OECD somewhat less sensitive to economic fluctuations.

4 Conclusions and Policy Implications

In this study, I attempted to review and synthesize existing literature on revenue volatility and establish links to adjacent issues, such as fiscal resilience and sustainability. In particular, I introduced an analytical framework combining two common empirical measures of revenue volatility: short-run buoyancy and deviations from the trend growth rate. This analytical framework utilized the Generalized Entropy family of inequality indices in order to quantify relative contributions of economic and noneconomic factors to revenue volatility. Within this analytical framework, I derived the relationship between tax structures and revenue volatility. I illustrated the application of this framework using panel data on 23 OECD countries over 1991–2022. This illustration suggests that, while it is important to understand the resistance of tax systems to economic shocks, the latter might not be the main source of revenue instability. Furthermore, rather than the prevalence of unstable tax sources, the resistance of tax systems to economic shocks appears to be determined by correlation (or lack thereof) among different types of taxes.

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