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Redefining tax progressivity in developing countries

The Progressive Vertical Index

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Abstract: Recent evidence from developing countries shows that the bottom of the income distribution pays more taxes relative to their income than the top 1%, highlighting a lack of tax progressivity in these societies. Current measures of tax progressivity fail to indicate which part of the income distribution explains this. Following the Palma Ratio intuition, this paper introduces the concept of vertical progressivity and a new index, the Progressive Vertical Index (PVI), which assesses the relationship between the tax burdens of the top 1% and the bottom 50% of the population. Using a novel dataset on tax rates in 10 Latin American countries from 2000 to 2020, the paper tests the PVI by comparing the results with the Kakwani index. The PVI is shown to offer an intuitive and transparent instrument for measuring the comparative tax burdens of the richest and poorest groups, thereby indicating that the problem of achieving tax progressivity in developing countries lies in correctly assessing the relationship between the effective tax rates paid by the rich and poor.

Key words: income distribution, tax progressivity, effective tax rates, income inequality, Latin America

JEL classification: C23, D31, H22

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1 Introduction

The latest evidence on income and wealth inequality estimates based on household surveys, tax records, and National Accounts in developing countries shows a surge in income concentration among the top 1% of the population—without a corresponding rise in the amount of taxes paid by this group relative to their income (Alvaredo and Vélez 2014; Burdín et al. 2022; Chatterjee et al. 2021; De Rosa et al. 2024; Flores et al. 2020). Instead, it is becoming increasingly apparent that, in numerous cases, individuals with low incomes are being burdened with higher taxes than the wealthiest members of society. This observation of a lack of progressivity brings to the fore the concern that tax systems are not functioning as intended.

In association with the vertical equity principle of taxation, one can define tax progressivity as a characteristic of the tax system that reflects whether the richest members of the society are paying taxes at higher effective (average) tax rates than those at the bottom of the distribution relative to their income (Elkins 2006; Kakwani 1977; Repetti and Ring 2012). Although different studies have evaluated tax progressivity by measuring either before–after taxation Gini coefficients (i.e. effective measures of tax progressivity; see Duclos and Araar 2006; Urban 2009 for comprehensive references) or statutory tax rates (i.e. structural measures of tax progressivity; see Gerber et al. 2020; Rubolino and Waldenström 2020), the instruments used in these studies do not provide a specific evaluation of the effective tax rates paid by the richest in relation to the rates paid by those at the bottom of the distribution. In other words, none of the tax progressivity indices allows us to discuss the claim made by Gabriel Palma (Cobham and Sumner 2013; Palma 2011) for the Gini coefficient in the context of tax progressivity. Are those seeking to resolve the problem of achieving tax progressivity focused on comparing the tails of the income distribution? How do we explicitly concentrate on the relationship between tax progressivity and vertical equity?

This paper aims to answer these questions by introducing a new concept in the realm of effective measures of tax progressivity, vertical progressivity, and a new instrument for measuring it, the Progressive Vertical Index (PVI). I define vertical progressivity as a characteristic of tax systems that reflects whether the richest 1% of the population is paying more tax than the bottom 50% of the distribution in proportion to their respective incomes. I incorporate the adjective *vertical* in the concept of tax progressivity in reference to the idea of vertical equity, with the aim of establishing a benchmark for the analysis of progressivity with regard to the richest and poorest in the population.

The idea of explicitly incorporating the concept of vertical equity in the analysis of tax progressivity contributes to the debate on the role of taxes in achieving redistribution. For years, we have observed a political focus on fostering horizontal equity in tax systems and tax reforms in emerging economies without systematically analysing the effects of those reforms on vertical progressivity—i.e. on whether the richest in the population pay more or less tax than those at the bottom of the distribution. Scholars have insisted on the necessity of achieving tax neutrality (as a rule of thumb) in the design of tax reform (Mirrlees et al. 2011)[1] in the interest of economic efficiency, leaving aside tax reforms that aim more at vertical equity and progressivity, which are aligned with redistribution. Not long ago, mainstream economic and political tax analysis presented a growing consensus that progressive taxation could harm investment and consumption, negatively affecting growth and providing no clarity on the effect of taxes on redistribution (Feldstein 2012). Until

[1] According to the concept of neutrality, the tax system should tax similar activities in similar ways, broaden tax bases, and lower tax rates (Mirrlees et al. 2011).

recent years, some international organizations (mainly the IMF, World Bank, and Inter-American Development Bank) have focused their attention and recommendations on fostering horizontal equity and tax neutrality in tax reforms on a worldwide basis, defending the claim that such reforms promote economic efficiency (Focanti et al. 2016; Genschel 2016; Hallerberg and Scartascini 2017, 2019; E. Lora 2007; E.A. Lora 2012; Mahon 2004; Swank 2016). These organizations and scholars suggest focusing on the expenditure side of fiscal policies to achieve redistribution and diminish inequality (Goñi et al. 2011). Thus, the literature lacks questions about the normative and empirical consequences of making horizontal equity and neutrality the focus of tax design without systematically evaluating the effects on vertical progressivity.[2]

Recent literature shows that analysing progressivity and the tax burden of the top relative to the rest of the population is essential for determining the welfare impact of taxation (Kakwani and Son 2021), as progressive tax systems help countries expand their redistribution mechanisms (Caminada et al. 2019; Guillaud et al. 2020; Lustig 2022). The examination is crucial for developing countries with high levels of inequality, considering that lower tax progressivity tends to increase the persistence of income inequality (Sanso-Navarro and Vera-Cabello 2020). Tax progressivity also legitimizes the tax system in the fiscal contract—as a lack of progressivity and a perception of lack of redistribution serve to diminish tax morale (Andriani et al. 2022; Castañeda 2023; Castañeda et al. 2019; Ciziceno and Pizzuto 2022; Doerrenberg and Peichl 2013; OECD 2019; Prichard 2022), and help to build state capacity in the developing world (Besley and Persson 2009, 2014).

As a measure of vertical progressivity, the Progressive Vertical Index shows a country's situation in a specific year, indicating whether the wealthiest 1% have higher or lower average tax rates than the bottom group, allowing scholars and policy-makers to understand the trend over a given period, as well as to enable comparisons between countries. Additionally, for the construction of the PVI, I consider the lessons from effective and structural tax progressivity measures. In this sense, the PVI comprises two steps. The first step involves a comparison between the average tax rates of the top 1% in relation to the bottom 50%, and the second step takes into account the countries' initial levels of inequality to 'reward' those with lower levels of inequality measured by the Gini coefficient. Following the rationale of López-Calva et al. (2021) in the context of analysing income and poverty convergence conditional on the initial levels of income inequality, the adjusted PVI recognizes that countries with higher levels of inequality should tax the top 1% more to redistribute more. Moreover, following Kakwani (1977) and Suits (1977), the PVI measures the progressivity of the complete tax system, incorporating the analysis of income, consumption, and wealth taxes, thereby going beyond the work of structural measures of tax progressivity presented by Gerber et al. (2020), who consider only income tax and social security payments, and Rubolino and Waldenström (2020), who consider just income tax payments. Incorporating consumption taxes in the analysis of tax progressivity is fundamental, particularly for countries with high levels of inequality (Suits 1977), the thinking being that they collect their revenue mainly from VAT and other taxes on goods and services.

In applying the PVI to the data, I work with a novel dataset developed by De Rosa et al. (2023), which contains the effective (average) tax rates of each percentile of the population in 10 Latin

[2] The normative debate around vertical and horizontal equity concepts has evolved over 30 years. In particular, scholars have analysed and followed the main discussion between Kaplow (1989) and Musgrave (1959, 1990) about the normative importance of horizontal and vertical equity. From a distributive justice perspective, one should give more attention to the analysis of vertical equity and tax progressivity than to horizontal equity and neutrality (Elkins 2006; Repetti and Ring 2012).

American countries during the 2000–20 period.[3] Evaluating the tax progressivity of Latin American countries is important considering that the debate on the equity and efficiency—in the form of vertical and horizontal equity—of tax reforms in Latin America has mimicked the developed world pendulum discussion of the type of State that countries aim to be—as well as the debate on the extent of redistribution through taxation. Scholars distinguish the first period of tax reforms (1940–70), which focused on vertical equity and redistribution through taxes, a second period with an emphasis on efficiency, horizontal equity, and tax neutrality (1980–2000s), and a third period (to date) that showed a return of vertical equity and progressivity in tax systems (Bird 2003; Cornia et al. 2011; Mahon 2018; Mahon et al. 2015; Sanchez 2006, 2011; Sanchez-Sibony 2019).

Assessing the progressivity of the complete tax system by considering the effective tax rates is now easier than before, as different scholars are collecting data from different countries following the methodology of Alvaredo et al. (2021): Blanchet et al. (2022); Chatterjee et al. (2021); Piketty et al. (2018); Saez and Zucman (2019).[4]

I calculate the PVI of the countries in the database of De Rosa et al. (2023). At the same time, I test the hypothesis that the problem of achieving tax progressivity is to be found in the comparison between the richest 1% and the bottom 50% of the population by contrasting the PVI with the Kakwani index, which, like the Gini coefficient, measures how much the tax burden shifts from low-income earners to high-income earners at the point where most people earn their income (Kakwani 1977, 1986). As for the arguments raised by Cobham and Sumner (2013) supporting the Palma Ratio (Palma 2011, 2014) *vis-à-vis* the Gini coefficient, the results of the PVI reflect that progressivity examination should also focus on the differences between the top 1% and the bottom 50% of the distribution—rather than on the full income distribution—as the Kakwani index does. To make the analysis comparable, I consider the PVI without the inequality adjustment.

The results reflect a 92.57% correlation between the PVI and the Kakwani index, confirming two things. First, the lack of tax progressivity in the countries analysed is primarily driven by the disparity between the tax paid by the richest 1% and by the bottom 50% of the income distribution. As with the Palma Ratio for the analysis of income inequality, the results highlight the significance of focusing on vertical progressivity in the study of tax progressivity. Second, the high correlation highlights the importance of including the inequality adjustment of the PVI to reveal the role of initial levels of inequality in tax progressivity.

The study contributes to several avenues of the existing literature. Theoretically, it provides a new concept—*vertical progressivity*—and a new index—the PVI—to measure it, revealing the normative importance of vertical equity in the systematic analysis of tax progressivity, complementing existing studies that focus on the discussion on horizontal equity and tax redistribution. Moreover, like the Palma Ratio for measuring income inequality, the PVI provides an intuitive, transparent, and valuable instrument for policy purposes in the developing world that will help the methodological discussion of tax progressivity address the significant policy problem of rising income and wealth inequality.

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[3] This working paper and the calculations are based on the dataset shared by the authors of De Rosa et al. (2024) on 8 March 2023. The last update of the dataset can be found at distribuciones.info.

[4] Although De Rosa et al. (2023, 2024) use the concept of 'effective tax rates', this concept is equivalent to the 'average tax rate' concept used for progressivity analysis. Both should be understood as the ratio of the total amount of taxes an individual pays to the total tax base, expressed as a percentage. I use the average tax rate concept in this paper.

The first of its kind in developing countries, this study shows the extent of the lack of vertical progressivity in a highly unequal region such as Latin America and suggests that a more significant contribution in tax payments from the top 1% is needed to change the trend. Finally, as shown in Appendix A, the disaggregation of the PVI into income, wealth, and indirect taxes helps to identify the origins of vertical progressivity or regressivity in each country. Further research will be needed to expand this conclusion to countries in other regions.

The index has some drawbacks that open new avenues for further analysis. As in the case of other effective measures of tax progressivity, it does not show what generates the differences in vertical progressivity across countries, e.g. whether they are due to tax compliance, state capacity, tax design, or exemptions, for example. Moreover, the PVI cannot describe progressivity within the richest 1% nor account for movements between the bottom and the richest group in different years. Yet the index constitutes a significant effort to put the focus of the analysis of tax progressivity on the richest 1%.

The paper is organized as follows. Section 2 presents the conceptual framework defining vertical progressivity and discusses how current progressivity indexes cannot systematically measure vertical progressivity and why a new instrument is necessary. Section 3 develops the theoretical and methodological bases of the PVI. This section incorporates a taxonomy for vertical progressivity and the relationship with inequality, offering examples with hypothetical cases. Section 4 tests the PVI and the Kakwani index using the De Rosa et al. (2023) database and gives more details about the characteristics of the PVI. The comparison and further analysis of the PVI highlight the importance of focusing the analysis of tax progressivity on the differences in taxes paid by the richest 1% and by the bottom 50% of the population, at least for the countries under analysis. Section 5 concludes.

2 Conceptual framework—analysis of current tax progressivity measures through the lens of vertical equity

The concept of vertical progressivity introduced in this paper aims to evaluate whether those at the top of the socioeconomic ladder are bearing a higher tax burden, and to highlight the normative importance of vertical equity for redistribution.[5] Societies that believe that income and wealth should be redistributed more equally tend to favour a vertical equity tax design (Elkins 2006; Kaplow 1989; Musgrave 1959; Repetti and Ring 2012). The above aligns with empirical studies that show that the tax system plays a role in the redistributive process of fiscal policy (see Guillaud et al. 2020 and Lustig 2022 for references).

In general, the tax progressivity examination aims to understand the relationship between the taxes paid by taxpayers and their income, comparing this relationship across the income distribution. Vertical progressivity focuses on the relationship between the taxes paid by the richest and by those at the bottom of the income distribution, where the highest levels of income inequality and lack of redistribution exist in the developing world.

Current tax progressivity measures can be seen to have pros and cons for the analysis of vertical progressivity.

[5] I consider normative in the sense of whether these concepts are goals by themselves or connected to a theory of distributive justice.

2.1 Effective measures of tax progressivity

In the world of effective tax progressivity measures, one can distinguish tax progressivity instruments from those that measure the redistributive effect of taxes (see Enami 2016; Kakwani 1986; Lustig 2022 for further analysis of the distinction between these concepts). Progressivity indices assess the distribution of tax liability. The tax burden is considered proportional if the distribution of the tax liability of individuals is distributed in proportion to their income; is considered progressive (regressive) if the richest pay a higher (lower) proportion of their income in taxes. Kakwani (1977) and Suits (1977) follow this idea, which has different desirable properties that comply with the vertical progressivity analysis. On the other hand, measures that assess the redistributive effect of taxes aim to understand how the tax system changes the distribution of income in society, including changes in the rankings (horizontal equity—reranking effect) and whether the rich pay less tax than the poor (as a percentage of their respective incomes) and have relatively more or less income after tax (vertical equity effect on redistribution) (Kakwani 1986; Kakwani and Son 2021).[6] Even though these authors analyse what they have called the vertical effect of taxation, they do so for redistribution purposes, not at the tax progressivity level. Moreover, scholars do not give a benchmark of what should be understood as rich and poor in both cases—progressivity and redistribution measures.

I focus the analysis on the Kakwani index of tax progressivity (Kakwani 1977) as it has been widely used by scholars, considering that it contains different desirable statistical properties for analysing tax progressivity (Kiefer 1984).

The Kakwani index of tax progressivity is based on the differences between the Lorenz Curves of pre-tax income and tax concentration areas, measuring the progressivity or regressivity of the complete tax structure. The concentration measure of tax progressivity gives most importance to transferring the tax burden from individuals at the modal income level in the income distribution (Kakwani 1986: 79). In other words, it measures how much the tax burden shifts from low-income to high-income earners at the point where most people earn their income (Kakwani 1977). In calculating the Kakwani index, on a scale of -1 to 1, a score of 0 is considered a proportional tax system; a progressive tax structure has a result higher than 0; a regressive tax structure receives a lower score than 0.

Gerber et al. (2020) and Rubolino and Waldenström (2020) criticize the Kakwani index, considering that it is not desirable to include pre-tax income distribution, as a tax system could appear less progressive if the pre-tax distribution is relatively even. Moreover, Rubolino and Waldenström indicate that including pre-tax distribution prevents identification of the direct effect of progressivity on inequality. Other scholars have focused their own criticisms on these effective measures of tax progressivity, based on the argument that the Gini coefficient has social welfare implications, due particularly to the fact that the index attaches most of its weights to income transfers between individuals situated closer to the mode of the income distribution and does not distribute the weights evenly or attach more weights to transfers at the tails of the income distribution (Kiefer 1984: 500).

I agree with Gerber et al. (2020) and particularly with Rubolino and Waldenström (2020) in that the effect of pre-tax distribution on tax progressivity is not self-evident because having pre-tax distribution as a function of progressivity makes us not distinguish whether the progressivity is due to the inequalities in a country or to the type of tax system. In the case of equal pre-tax income

[6] For further explanation of the redistributive effects of taxes (including vertical inequities and horizontal-reranking effects) see (Bishop et al. 2000; Enami 2016; Kakwani and Son 2021; Lambert and Ramos 1997; Lustig 2022).

distribution in a country, it would not be possible to distinguish whether the progressivity attributes of the country are due to that equal pre-tax income distribution or to the tax system design. Therefore, although all the effective measures of tax progressivity share this characteristic, a lesson for evaluating vertical progressivity could be explicitly including the pre-tax income distribution for ranking purposes, rewarding those countries that provide conditions that assure certain levels of equality (cf. López-Calva et al.'s (2021) analysis of income and poverty convergence).[7]

Following the vertical progressivity concept, a second criticism of the Kakwani (1977) index rests on its not giving a benchmark for understanding who are the richest or poorest in society. Although the concentration measure allows a distinction between the poor (those below the modal income level) and the rich (those above the modal income level), it does not allow us to clearly understand where the problem of lack of progressivity is located. As indicated before, the above is more important when considering the role of the relative weights of the Gini coefficient (Kiefer 1984).

2.2 Structural measures of tax progressivity

Although one can situate the vertical progressivity analysis in the effective measures of tax progressivity, it is worth analysing structural measures of tax progressivity for further understanding of the properties that an index requires for examining vertical progressivity.

Gerber et al. (2020) offer a measure of tax progressivity capacity that follows the Kakwani-Gini-oriented index but does not rely on the pre–post tax income distributions—answering the previously mentioned criticism. However, their instrument does not comply with the definition of vertical progressivity as they do not analyse the difference between the top and bottom of the distribution, instead evaluating the tax system's impact on the complete income distribution (Lorenz Curve analysis). Moreover, the Gerber et al. index does not comply with our second requirement that the analysis should focus on the whole tax system. These authors focus on evaluating some instruments of the tax system—mainly personal income taxes and social contributions—leaving aside other instruments that should be included in the analysis (such as VAT, property taxes, and others reported at the OECD level). I disagree with Gerber et al. when they argue that VAT should not be included in the analysis of tax progressivity, as its exclusion does not give us a complete picture of the average tax rates paid by both groups of the analysed population (Alvaredo et al. 2021; Kakwani 1977; Piketty et al. 2018; Suits 1977).

In theory, including income and wealth taxes in the examination of tax progressivity should positively affect the tax system's progressivity. By design, these taxes are expected to collect more from the richest than from the bottom of the distribution. Moreover, incorporating consumption taxes into the analysis of tax progressivity at the bottom of the distribution is fundamental, particularly for countries with high levels of inequality (Suits 1977). The bottom of the population in these countries has low wages and is usually exempted from income tax, and almost all their income is affected by VAT (OECD 2024; Thomas 2022). Moreover, as shown in Table 1, VAT has been transformed into one of the most crucial revenue collection mechanisms in several developing countries. Therefore, not considering VAT in the analysis gives us a myopic picture of both groups' overall tax effort in revenue collection.

[7] Although this applies to effective measures, structural measures can also account for this problem, given that it is difficult to account for whether the variation in the structural average rate progression is driven by tax rate or income changes (Rubolino and Waldenström 2020: online appendix).

Table 1: Comparative perspectives on tax revenue as a percentage of total taxation

Region	PIT	SSC	VAT	OGS	CIT	Other
OECD – average	24.07	26.64	20.18	11.90	9.01	8.19
LAC – average	9.75	18.42	27.50	20.95	15.59	7.79
Asia-Pacific (28) – average	16.04	6.34	23.10	27.54	18.77	8.21
Africa (31) – average	18.48	8.05	27.79	22.62	19.31	3.76

Note: PIT = personal income tax, SSC = social security contributions, VAT = value added taxes, OGS = other goods and services taxes, CIT = corporate income tax. According to the original source, the data include information from 28 countries from the Asia-Pacific region and 31 from Africa, contained in the OECD's 2022 Revenue Statistics publication for each region.

Source: author's construction based on data from the Revenue Statistics Database (OECD 2022).

In a recent publication, Rubolino and Waldenström (2020) presented a structural measure to measure tax progressivity, finding that reducing tax progressivity increased top income shares in some Western countries due to tax reforms between 1980 and 1990. This method exploits the disparities in statutory tax rates between those at the top of the income distribution and the average taxpayer. One lesson from their method is that it is unaffected by inequality—as they evaluate structural tax progressivity first and the impact on pre-tax income distribution subsequently. However, the authors concentrate their analysis on income taxes, leaving aside other taxes, not meeting one of the requirements for testing vertical progressivity. Finally, the evaluation of statutory tax rates, on their own, does not allow us to see whether avoidance could be playing some role in the lack of progressivity, and further steps are needed in the analysis—as in the case of effective measures. It could be the case that legislation establishes a statutory income tax rate of 90% for top taxpayers and a 10% for average taxpayers. However, because of tax base erosion, tax avoidance, or evasion, the average tax rate paid by the top income taxpayers could be much lower than 90% (Alstadsæter et al. 2019).

2.3 An index to measure vertical progressivity

According to the previous analysis, to measure the definition of vertical progressivity, we need an index that considers the lessons from current effective and structural measures of tax progressivity indices. Thus, the required index needs the following main features: (1) it should focus the analysis on the comparison of the average tax rates of the richest of the society with those of the bottom of the population; (2) it should incorporate a definition of 'the richest' and 'the bottom' of the population; (3) it should consider the analysis of direct, indirect, and wealth taxes; (4) it should consider the pre-tax income distribution as a second step of evaluation, rewarding countries with lower levels of inequality.

The following section introduces a new index of tax progressivity that incorporates these four characteristics.

3 The Progressive Vertical Index (PVI)

This section presents the Progressive Vertical Index (PVI), a new tax progressivity index for measuring vertical progressivity. In a two-step process (see Equations [1] and [2] below), the PVI calculates the ratio of the average tax rates paid by the top 1% of the population to the average paid by the bottom 50% (from percentiles 0.1 to .50) of the distribution in country i at time t (first

step—Equation [1]) and presents an adjustment considering the initial level of inequality of each country (second step—Equation [2]).[8]

$$PVI_{i,t} = \frac{Average\ total\ tax\ rates\ of\ top\ 1\%_{i,t}}{Average\ total\ tax\ rates\ bottom_{i,t}} \quad (1)$$

The PVI considers that countries have vertical regressivity when they obtain a score of less than 1. That result reflects that the richest in the society are paying less tax than those at the bottom. On the other hand, the PVI considers that a country has vertical progressivity when its score is higher than 1, meaning that the richest are paying more tax than the bottom 50%. The PVI considers that a country has proportional vertical progressivity when its score is equal to 1.

Table 2 shows an example of different hypothetical countries measured over two years. In Year 1, Kavon and Leafar have the same average tax rate for the richest 1% and the bottom 50% of the population, whereas, in Year 2, Leafar taxes the richest more heavily. In the first year, Kavon and Leafar have the same PVI, but in Year 2, Leafar improves its position. However, the PVI considers both countries as having vertical regressivity because the richest are paying less tax than the bottom of the population in both years. The cases of Regor and Taram are examples of vertical progressivity because, in both years, they tax more heavily the richest 1% of the population, obtaining a result higher than 1. Moreover, Regor improves its PVI score during the second year.

Table 2: Illustration of the application of the PVI in hypothetical countries

Country	Year	Average tax rate top 1%	Average tax rate bottom 50%	PVI	Interpretation
Kavon	1	18%	24%	0.75	Vertical regressivity
Kavon	2	18%	24%	0.75	Vertical regressivity
Leafar	1	18%	24%	0.75	Vertical regressivity
Leafar	2	19%	23%	0.83	Vertical regressivity
Regor	1	21%	18%	1.17	Vertical progressivity
Regor	2	22%	17%	1.29	Vertical progressivity
Taram	1	21%	18%	1.17	Vertical progressivity
Taram	2	21%	18%	1.17	Vertical progressivity

Source: author's construction based on hypothetical examples.

Up to this stage, the PVI introduces a ratio of the average tax rates paid by the richest 1% to the bottom 50% of the income distribution, generating an intuitive explanation of a country's trends in terms of how many times more (less) tax the richest pay in comparison with the bottom 50% in different years.

A problem that could arise with the PVI relates to analyses of large sample countries. Imagine that the average tax rate of the bottom 50% of citizens of Kavon is 1%, and the average tax rate of the richest is 2%. In this hypothetical example, Kavon will have a PVI of 2, and we should therefore consider the country to have vertical progressivity. However, no one would consider those average tax rates as progressive. This could happen if we tried to calculate the PVI using large databases for countries that have very different average tax rates, e.g. comparing countries from Africa or Latin America with those in Europe. In these cases, and depending on the research objectives, I

[8] As it is typically considered in the literature of tax progressivity, I consider the average tax rate as the ratio of total taxes paid to the total pre-tax income declared by the taxpayer. The concept of total taxes paid refers to the sum of income, consumption, and wealth taxes paid by taxpayers. Each researcher should justify the construction of the average tax rates paid by the top 1% and bottom 50% of the population.

recommend standardizing the average tax rates in the data following a zeta-score or a min–max standardization. Moreover, theoretically one could assume that the bottom 50% of the population were paying 0% of the average rate, which would invalidate the PVI's calculation. That theoretical scenario notwithstanding, all countries in the world have some taxation, and including the complete tax system in the analysis of the PVI precludes such a scenario in reality.

Continuing with the analysis, one could extend Gerber et al.'s (2020) and Rubolino and Waldenström's (2020) criticism of the Kakwani index of tax progressivity to Equation [1] of the PVI. Equation [1] of the PVI implicitly includes pre-tax income in determining average tax rates. Thus, the result of Equation [1] could suggest that the tax system of a country classifies as vertically progressive—where the richest 1% has an average tax rate higher than that of the bottom 50%—when result is due to the initial level of pre-tax income inequality. As shown in Table 2, the PVI does not reflect differences between Kavon and Leafar, on the one hand, and Regor and Taram, on the other, in Year 1. Should we conclude that they have the same vertical progressivity?

To address that weakness, Equation [2] adjusts the PVI with each country's pre-tax inequality (Gini coefficient) each year.[9] This adjustment reflects each country's redistributive effort that allows it to obtain higher levels of vertical progressivity, following the rationale of López-Calva et al. (2021) when considering the effect of inequality on growth and poverty reduction.

$$PVI_{i,t} = \frac{Average\ total\ tax\ rates\ of\ top\ 1\%_{i,t}}{Average\ total\ tax\ rates\ bottom_{i,t}} * (1 - Gini_{i,t}) \qquad (2)$$

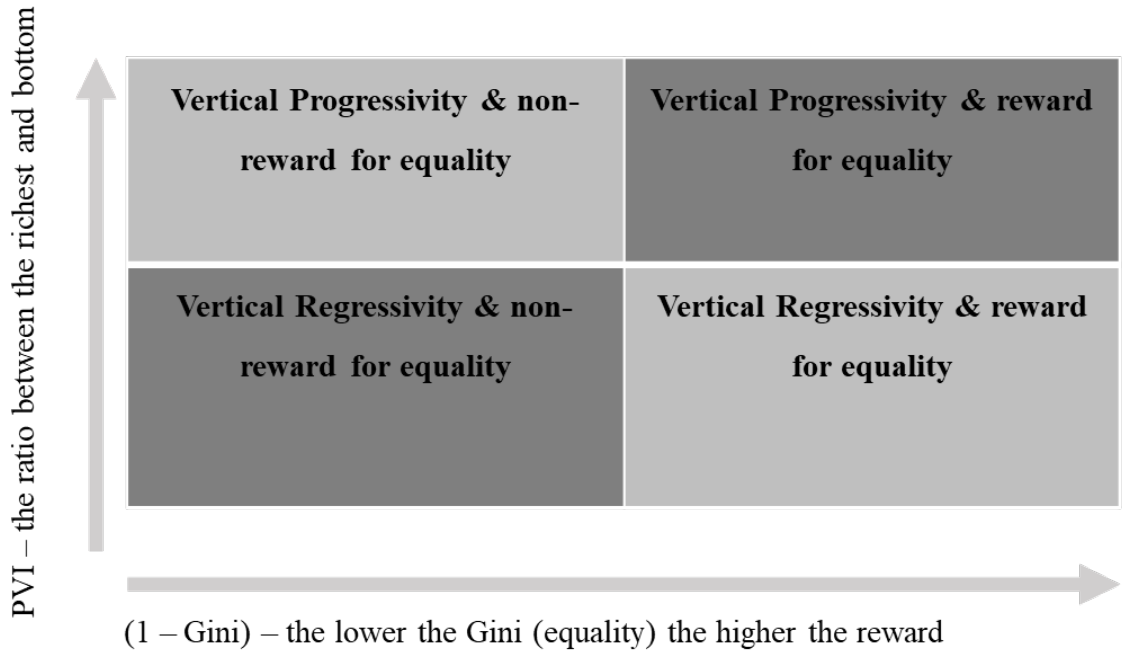
The adjusted PVI reflects the fact that in theory a perfectly equal country (with a Gini of 0) will maintain the PVI score obtained, while an unequal country that lacks efforts in redistribution will get a lower adjusted PVI score. An equal country where the rich pay more tax than the bottom of the population will rank at the top of the PVI, rewarding the country's efforts to be more equal than others. In this case, the PVI 'respects' the original distribution, at least in the short term.[10]

As shown in Figure 1, combining vertical progressivity or regressivity with equal/unequal scores produces four categories of PVI. The countries with the highest (lowest) adjusted PVI scores will be situated in the top right (bottom left) corner of the matrix, with a combination of vertical progressivity (regressivity) and an equal (unequal) environment. In between, we will find countries that can achieve vertical progressivity scores but have higher levels of inequality (upper left corner of the matrix) or vertical regressivity scores with lower levels of inequality (right bottom of the matrix). Although a country with a Gini coefficient of 0.65 is more equal than another with a coefficient of 0.60, that does not imply that the former is an 'equal' country; qualifying a country as more equal or more unequal will depend on the data and the countries. Moreover, the PVI considers a country more equal than others when they have a (1-Gini) result higher than the average of the analysed countries in the selected period, i.e. when they are more equal than the average population.

[9] The Gini coefficient should be calculated using the same income with which the average tax rate of the different percentiles of the population is calculated.

[10] As highlighted by Rubolino and Waldenström (2020), one could expect that in the long term inequality will somehow affect the rankings.

Figure 1: Vertical progressivity and Gini relationship



Source: author's construction.

Going back to the example illustrated in Table 2, the PVI adjusted with the pre-tax level of inequality allows us to understand the differences between Kavon and Leafar (one pair of countries) and between Regor and Taram (the second pair of countries) in Year 1 and also to compare their scores in Year 2 (Table 3). It was previously discussed that Kavon and Leafar have vertical regressivity and that, in Year 1, they obtained the same score. However, Kavon has a higher Gini coefficient than Leafar, and the adjusted PVI recognizes the effort Leafar is making in generating higher levels of redistribution. Therefore, when the PVI is calculated considering the pre-tax Gini coefficient, Kavon obtains a lower score than Leafar. Similarly, Regor and Taram do not show differences in their PVI in Year 1. However, when the PVI is adjusted with the pre-tax Gini coefficient, Regor is rewarded, as it is more equal than Taram.

Table 3: Progressive Vertical Index adjusted with initial inequality

Country	Year	Average tax rate top 1%	Average tax rate bottom 50%	PVI	(1- Gini)	PVI * (1-Gini)	Interpretation
Kavon	1	18%	24%	0.75	0.35	0.26	VR - more unequal
Kavon	2	18%	24%	0.75	0.35	0.26	VR - more unequal
Leafar	1	18%	24%	0.75	0.57	0.43	VR - more equal
Leafar	2	19%	23%	0.83	0.57	0.47	VR - more equal
Regor	1	21%	18%	1.17	0.57	0.67	VP - more equal
Regor	2	22%	17%	1.29	0.57	0.74	VP - more equal
Taram	1	21%	18%	1.17	0.35	0.41	VP - more unequal
Taram	2	21%	18%	1.17	0.35	0.41	VP - more unequal

Note: VR = vertical regressivity, VP = vertical progressivity. The characteristic of considering a country as equal or unequal is given by whether it has a higher (1-Gini) result than the average (1-Gini) of the population in the respective year.

Source: author's construction based on hypothetical examples.

Moreover, the adjusted PVI allows us to make intra-country and inter-country comparisons over time. For simplicity, I assume that the pre-tax Gini remains equal in the two years. In the example,

in Year 2, Leafar and Regor improve their position relative to themselves and with respect to Kavon and Taram because they can apply a higher tax burden to the richest 1% and a lower tax burden to the bottom 50% of the population. The case of Leafar is notable because the equality reward allows the country to obtain a higher score than Taram—which is a more unequal country—in Years 1 and 2, irrespective of the fact that Leafar has a lower PVI without adjustment.

The PVI is intended to reflect how the tax system works in terms of vertical progressivity, indicating whether the wealthiest 1% of the population has higher or lower average tax rates than the bottom group, considering the initial inequality of each country.

I acknowledge that the construction of the PVI will depend on data limitations regarding the top and bottom of the distribution.[11] Moreover, some drawbacks of the PVI are that it does not identify *why* one group is paying more than the other; e.g. the PVI will not be able to show whether the richest are paying less tax than the bottom half of the population because they have more tax avoidance opportunities or evade more taxes, or because the tax design has narrow bases. This will be a subject of further research. Moreover, as the PVI relies on a threshold at the top and the bottom of the distribution, it would not be possible to observe the progressivity within each group—i.e. the PVI does not give granular information on whether the percentile 0.01 of the income distribution is paying more or less tax than the percentile 0.08; it shows the average tax paid by the top 1% group. Finally, the PVI does not explain who are entering or quitting one or the other group at different points in time; e.g. it will not be possible to detect a person in percentile 51 in Year 1 who enters the bottom 50% in Year 3. The PVI takes a picture of the progressivity of the groups at a moment in time.

4 The Progressive Vertical Index in practice

In this section, I show the application of the PVI to some Latin American countries. I first compare the workings of the PVI with those of the Kakwani index of tax progressivity and test the argument as to whether the problem of achieving tax progressivity is located in the difference between the average tax paid by the rich and that paid by those at the bottom of the distribution (as the PVI suggests), or not. The comparison shows the validity of Gerber et al.'s (2020) and Rubolino and Waldenström's (2020) criticism of the Kakwani index, arguing as they do the importance of applying the Gini coefficient adjustment to the PVI analysis. For the comparison, I use the PVI without the equality reward (first step), considering that the Kakwani index departs from a basis that does not adjust for equality (the main criticism of Gerber et al. (2020)). Subsequently, I focus on the Gini coefficient adjustment, giving further details of the characteristics of the PVI and its efficacy in measuring tax progressivity.

4.1 Comparison of the PVI with the Kakwani index in Latin American countries

The Kakwani index is useful for testing the argument as to whether the problems of tax progressivity in unequal economies, such as those of Latin America, are attributable to the differences between the richest and the bottom of the population (as the PVI measures). Although the Kakwani index relies on the differences between the Lorenz Curves of income and tax concentration areas, it is valuable for understanding the progressivity of the complete tax structure

[11] As will be shown for the case of Latin America, I use the average tax rate of percentiles 20–50 of the income distribution and not that of the bottom 50%.

and comparing it with the first stage of the PVI calculation, which focuses the analysis on vertical progressivity.

The PVI highlights that scholars and policy-makers should also prioritize the analysis of progressivity in the upper bound of the population with respect to the bottom, since the lack of progressivity in unequal countries, such as those of Latin America, is due to the relationship between those groups. As in the case of the Palma Ratio in the analysis of income inequality, the PVI serves as an intuitive and analytical tool to illustrate how the vertical progressivity/regressivity of a country's tax system works before analysing the outcome of the tax system in terms of redistribution.

For testing vertical progressivity in Latin America, I use a novel dataset developed by De Rosa et al. (2023), which contains the average tax rates of each percentile of the population of 10 countries in Latin America over the 2000–20 period. The 10 countries the dataset covers are Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Peru, and Uruguay. These countries represent approximately 88% of Latin America and the Caribbean's GDP and 79% of its population (Comisión Económica para América Latina y el Caribe 2023). Despite the above, I concentrate the analysis on the period 2000–19, not considering the year 2020 because during Covid-19 we observe different trends in tax revenue collection depending on the country's ability to respond to the crisis (Comisión Económica para América Latina y el Caribe 2020, 2021).

De Rosa et al. (2023, 2024) calculate the percentile average income of each country in the database, from 1% to 99.9% of the income distribution, following the methodology contained in the Distributional National Accounts Guidelines (Alvaredo et al. 2021), applied by Blanchet et al. (2022), Chatterjee et al. (2021), Piketty et al. (2018), and Saez and Zucman (2019). For instance, to calculate the income of the different percentiles of the distribution, the authors combine data from household surveys and tax records. In this connection, it should be noted that some countries do not have tax information for some years, so the availability of data depends on whether the country had a household survey in those years. For example, in the case of Chile, the dataset contains data for the years where the CASEN (household survey) existed.

Later, De Rosa et al. (2023, 2024) used the OECD tax database to calculate the total tax revenue of each country and estimated how much of each type of tax revenue collected by each country corresponds to each percentile of the income distribution. Taxes include personal income tax, corporate income tax, payroll tax, immovable property tax, wealth tax, estate or inheritance and gift taxes, other property taxes, general taxes on goods and services, other taxes on goods and services, and a category named 'other taxes'. Finally, the authors follow the above-mentioned guidelines imputing all the taxes to the pre-income calculations of the income distribution. As the guidelines explain, the pre-income calculations exclude the value of social contributions, as they are already included in pre-tax income (to avoid the risk of double counting). Alvaredo et al. (2021) indicate a final caveat for the methodology. As described by these authors, this method of imputing the taxes to the different percentiles of the distribution makes some strong assumptions; for example, in the case of consumption taxes, the methodology assigns all the taxes to the consumers without considering producer elasticities. The De Rosa et al. (2023) database gives the average tax rates of each tax for percentiles 1 to 99.9.[12]

Although the PVI theoretically considers the ratio between the richest 1% and the bottom 50% of the population, when applying the PVI to the database of De Rosa et al. (2023), I consider those

[12] In the De Rosa et al. (2023) dataset the variable 'effective tax rate' reflects the total average tax rates. For more information on the variables refer to https://www.distribuciones.info/descarga.html.

people situated between percentiles 20 and 50 as 'the bottom', excluding those between percentiles 1 and 19 due to data limitations. Several countries in the database do not have information on some percentiles, and the ones that have information show, in some cases, that percentiles below 20 have extremely large average tax rates. There may be different reasons for this (e.g. the surveys may not be capturing the complete picture, such as informal income and state subsidies received by the people in the bottom 20%). Moreover, I consider the average tax rate of 1% of the population, calculating the weighted average tax rates of the percentiles 99.0, 99.1, 99.2 (…), 99.9.

To calculate the Kakwani index, I used De Rosa et al.'s (2023) database and the Abdelkrim and Duclos (2013) STATA package.[13] I estimate the total tax paid by each percentile of the population, considering the average income of each percentile and the total average tax rate. As in the case of the PVI calculation, I exclude the data of percentiles 1 to 19 and calculate the average tax rate of the top 1% of the population. Although the database contains income and average tax rates on each percentile, the Gini coefficient and tax concentration can be estimated with those averages and generate a weighted average of percentiles 99.0, 99.1, 99.2 (…), 99.9. The results of the Gini calculations based on average income resemble those of De Rosa et al. (2023) based on microdata. Therefore, I use the average tax paid as the reference indicator for calculating the concentration index, taking the average income of each percentile as the ranking position.

As previously mentioned, the Kakwani index is designed to measure the progressivity of the complete tax structure, considering the average tax rates of the different population percentiles. To this end, a score of 0 is considered proportional; a progressive tax structure has a result higher than 0; a regressive tax structure receives a score below 0.

Table 4 shows the comparisons between the PVI without the Gini adjustment (Equation [1]) and the Kakwani index, selecting different periods for each country of the database.

As predicted, the comparison between the Kakwani index and the PVI reflects that the analysis of tax progressivity should give more focus to the relation between the top 1% and the bottom 50%. This relationship summarizes the problems of achieving tax progressivity in unequal countries. The PVI and Kakwani index calculation correlates by 92.57%, showing that, in most cases, the PVI and Kakwani index make similar predictions of progressivity. I find different interpretations (vertical progressivity vs progressivity) in 5 of 151 observations.

The Kakwani index sheds light on the progressivity/regressivity of the complete income distribution but does not indicate where we should focus the analysis. In this sense, the high correlation between the Kakwani and the PVI clarifies that the biggest challenge to progressivity in Latin American countries is addressing the discrepancies in average tax rates paid by the top 1% and the bottom 50% of the income distribution. These results highlight that the analysis of tax progressivity should also be focused on vertical progressivity and that the PVI is an adequate instrument for performing the examination.

[13] The formula for calculating the Kakwani index is $K=-[G\_pre-C]$, where *K* is Kakwani, *G pre* is Gini pre-tax income, and *C* is the concentration index. For further discussion, refer to Section 2.

Table 4: Comparison between PVI without adjustment and Kakwani index in selected years

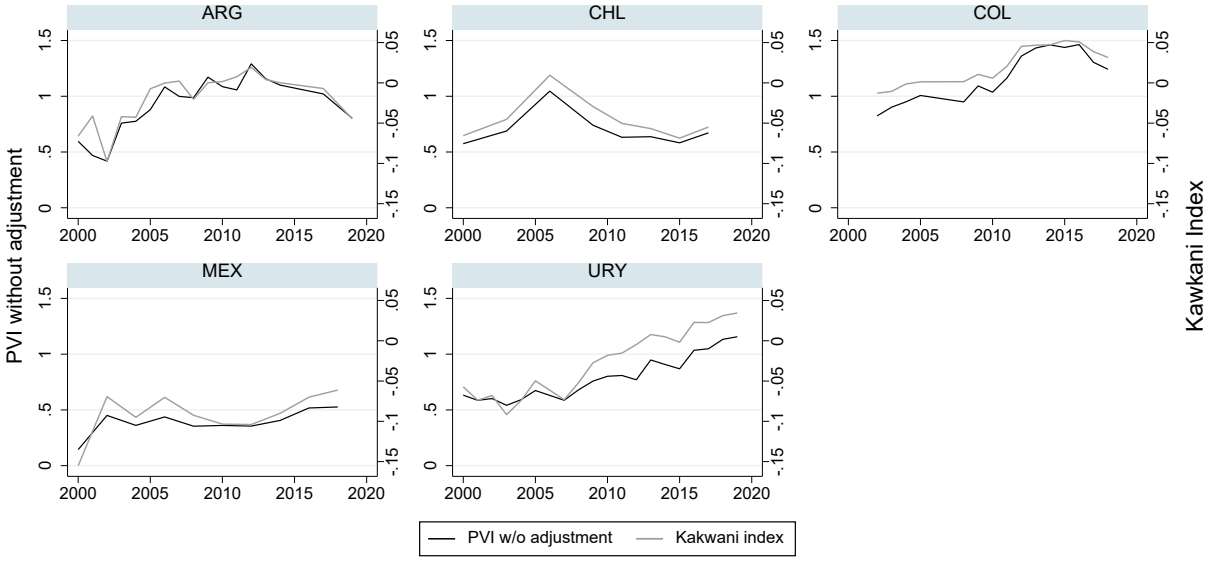
Country	Year	PVI	Interpretation	Kakwani	Interpretation
ARG	2000	0.5956	VR	-0.0661	Regressive
ARG	2006	1.0840	VP	-0.0003	Regressive
ARG	2011	1.0573	VP	0.0076	Progressive
ARG	2017	1.0207	VP	-0.0070	Regressive
BRA	2001	0.5729	VR	-0.0845	Regressive
BRA	2006	0.7278	VR	-0.0489	Regressive
BRA	2011	0.6835	VR	-0.0577	Regressive
BRA	2017	0.6850	VR	-0.0511	Regressive
CHL	2000	0.5749	VR	-0.0655	Regressive
CHL	2006	1.0461	VP	0.0095	Progressive
CHL	2011	0.6323	VR	-0.0503	Regressive
CHL	2017	0.6717	VR	-0.0548	Regressive
COL	2002	0.8242	VR	-0.0128	Regressive
COL	2008	0.9493	VR	0.0015	Progressive
COL	2011	1.1640	VP	0.0207	Progressive
COL	2017	1.3046	VP	0.0388	Progressive
CRI	2011	0.5773	VR	-0.0649	Regressive
CRI	2017	0.6902	VR	-0.0484	Regressive
ECU	2001	0.6390	VR	-0.0632	Regressive
ECU	2006	0.8915	VR	-0.0117	Regressive
ECU	2011	1.2233	VP	0.0323	Progressive
ECU	2017	1.1377	VP	0.0213	Progressive
MEX	2002	0.4506	VR	-0.0693	Regressive
MEX	2006	0.4371	VR	-0.0702	Regressive
MEX	2012	0.3551	VR	-0.1040	Regressive
MEX	2018	0.5265	VR	-0.0612	Regressive
PER	2000	0.3856	VR	-0.1166	Regressive
PER	2006	0.6828	VR	-0.0411	Regressive
PER	2011	0.8177	VR	-0.0213	Regressive
PER	2017	0.5874	VR	-0.0683	Regressive
SLV	2001	0.7757	VR	-0.0404	Regressive
SLV	2006	0.2183	VR	-0.0889	Regressive
SLV	2012	0.3312	VR	-0.0633	Regressive
SLV	2017	0.2115	VR	-0.0504	Regressive
URY	2000	0.6324	VR	-0.0572	Regressive
URY	2007	0.5864	VR	-0.0731	Regressive
URY	2011	0.8090	VR	-0.0153	Regressive
URY	2017	1.0483	VP	0.0226	Progressive

Note: ARG = Argentina, BRA = Brazil, CHL = Chile, COL = Colombia, CRI = Costa Rica, ECU = Ecuador, MEX = Mexico, PER = Peru, SLV = El Salvador, URY = Uruguay. VR = vertical regressivity, VP = vertical progressivity.

Source: author's calculations using De Rosa et al. (2023) dataset.

To further illustrate each index's main caveats and characteristics and determine whether it is true that the biggest challenge to progressivity is in measuring the differences between taxes paid by the 1% and the bottom 50% of the distribution, I select five countries in the database: Argentina, Chile, Colombia, Mexico, and Uruguay. Figure 2 shows the results of the PVI and the Kakwani indexes, comparing each country from 2000 to 2019 for the years available. This comparison gives us a better understanding of what happens in each country during the period (intra-country comparison) and how each country compares with others (inter-country comparison). Moreover, it visually shows the large correlation between the indices results.

Figure 2: Comparison between PVI (without Gini adjustment) and Kakwani index for selected countries



Note: ARG = Argentina, CHL = Chile, COL = Colombia, MEX = Mexico, URY = Uruguay. There is a positive correlation between the two variables for the countries, statistically significant at the 1% level. For the case of Argentina, the correlation is 92%, Chile 98%, Colombia 99%, Mexico 97%, and Uruguay 97%.

Source: author's construction using De Rosa et al. (2023) dataset.

Colombia has the highest vertical progressivity score under the PVI and a progressivity score under the Kakwani index but has decreasing progressivity in both indexes between 2016 and 2019. Argentina presents improvements in progressivity in both indexes, with a slight upward trend that comes to an end in 2012. Uruguay is the most notable case, as it has improved its PVI and Kakwani indexes since 2007, achieving a vertical progressivity score (under the PVI) and progressivity (under Kakwani) during the last three years. Chile reflects vertical regressivity and a regressivity score during the period, but in 2006, the country had vertical progressivity under the PVI and progressivity under the Kakwani index. Finally, Mexico reflects vertical regressivity scores and regressivity, which slightly improved between 2012 and 2018.

We observe that both indexes follow very similar trends in progressivity, confirming that both the PVI without adjusting for inequalities and the Kakwani index resemble their predictions.[14] The comparison reinforces the argument that in the Latin American countries tested, the issues of tax progressivity are based on the differences in average tax rates paid by the richest and the bottom of the distribution. It also highlights the importance of incorporating the equality reward in the second step of the analysis.

4.2 Analysis of the characteristics of the PVI

It is now time to apply the inequality adjustment to the PVI (Equation [2]). In Section 2, I mentioned that the Kakwani index does not reflect the impact of pre-tax income distribution on the calculations of the progressivity of the tax system—one of the main criticisms raised by Gerber et al. (2020) and Rubolino and Waldenström (2020). These criticisms can be extended to the first stage of analysis of the PVI, as the high levels of correlation showed. Thus, the inequality adjustment of the PVI addresses these criticisms and includes the Gini coefficient for ranking

[14] The correlation is 96.47% when El Salvador is excluded from the analysis. This country shows a correlation of 51%, statistically significant at the 1% level. According to De Rosa et al. (2024), data from this country have some limitations.

purposes, rewarding those countries with lower levels of inequality and recognizing that they need less progressivity in their tax systems to achieve higher levels of redistribution than countries with higher levels of inequality.

I apply Equation [2] from the previous section and consider the Gini coefficient based on the database's weighted average income per percentile. To calculate the Gini coefficient, I use the STATA package of Abdelkrim and Duclos (2013) and a weighted average of the income distribution contained in De Rosa et al. (2023). As shown in Table 5, the reward for equality changes the ranking of the countries with respect to the ranking obtained using the PVI without adjustment.

Table 5: Comparison between PVI without adjustment and PVI with equality reward

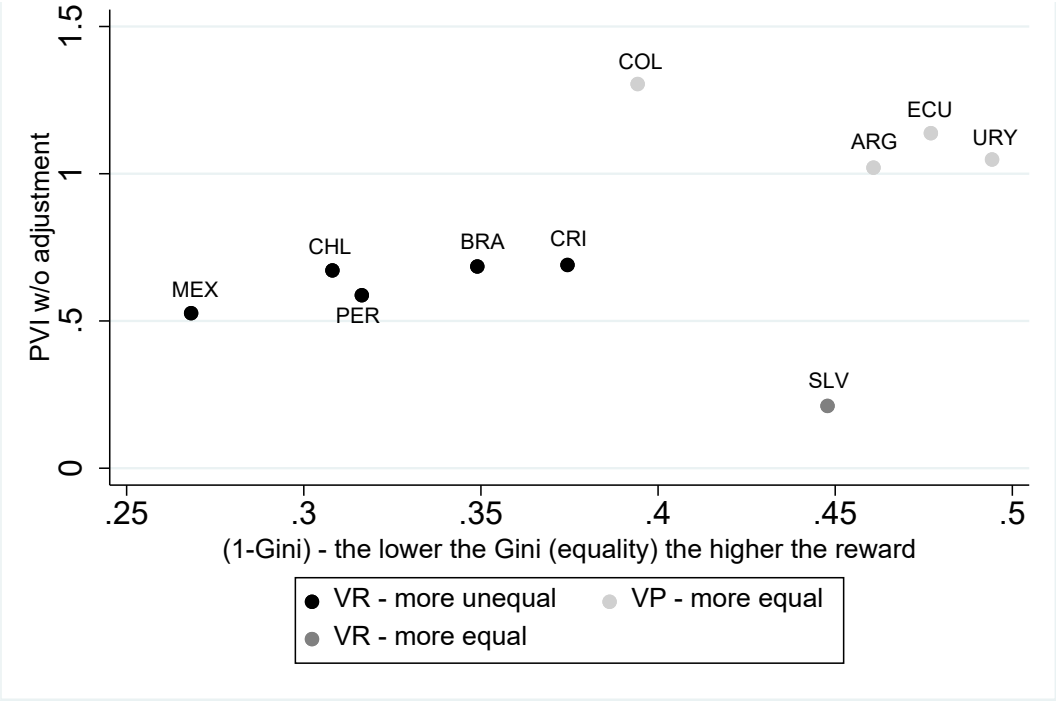
Country	Year	PVI (1)	Ranking (1)	(1-Gini)	PVI (2)	Ranking (2)	Progressivity
MEX	2000	0.1441	9	0.2631	0.0379	9	VR-unequal
PER	2000	0.3856	8	0.3526	0.1359	8	VR-unequal
CHL	2000	0.5749	7	0.3072	0.1766	7	VR-unequal
ARG	2000	0.5956	5	0.4259	0.2536	4	VR-equal
URY	2000	0.6324	4	0.4205	0.2659	3	VR-equal
BRA	2001	0.5729	6	0.3160	0.1811	6	VR-unequal
ECU	2001	0.6390	3	0.3606	0.2304	5	VR-equal
SLV	2001	0.7757	2	0.3931	0.3049	1	VR-equal
COL	2002	0.8242	1	0.3384	0.2789	2	VR-unequal
SLV	2006	0.2183	9	0.4038	0.0881	9	VR-unequal
PER	2006	0.6828	6	0.3223	0.2201	7	VR-unequal
CHL	2006	1.0461	2	0.3040	0.3180	3	VP-unequal
ARG	2006	1.0840	1	0.4834	0.5240	1	VP-equal
URY	2007	0.5864	7	0.4034	0.2366	6	VR-unequal
BRA	2006	0.7278	5	0.3256	0.2370	5	VR-unequal
ECU	2006	0.8915	4	0.4250	0.3172	4	VR-unequal
MEX	2006	0.4371	8	0.3298	0.1442	8	VR-unequal
COL	2008	0.9493	3	0.3573	0.3392	2	VR-unequal
CRI	2011	0.5773	8	0.3813	0.2201	7	VR-unequal
CHL	2011	0.6323	7	0.2772	0.1753	8	VR-unequal
BRA	2011	0.6835	6	0.3304	0.2258	6	VR-unequal
URY	2011	0.8090	5	0.4705	0.3806	4	VR-equal
PER	2011	0.8177	4	0.3499	0.2861	5	VR-unequal
ARG	2011	1.0573	3	0.4967	0.5252	2	VP-equal
COL	2011	1.1640	2	0.3688	0.4293	3	VP-unequal
ECU	2011	1.2233	1	0.4731	0.5787	1	VP-equal
SLV	2012	0.3312	10	0.4386	0.1452	9	VR-unequal
MEX	2012	0.3551	9	0.2739	0.0973	10	VR-unequal
SLV	2017	0.2115	10	0.4478	0.0947	10	VR-unequal
PER	2017	0.5874	8	0.3164	0.1859	8	VR-unequal
CHL	2017	0.6717	7	0.3081	0.2069	7	VR-unequal
BRA	2017	0.6850	6	0.3490	0.2391	6	VR-unequal
CRI	2017	0.6902	5	0.3744	0.2584	5	VR-unequal
ARG	2017	1.0207	4	0.4608	0.4703	4	VP-unequal
URY	2017	1.0483	3	0.4943	0.5182	2	VP-equal
ECU	2017	1.1377	2	0.4770	0.5427	1	VP-equal
COL	2017	1.3046	1	0.3942	0.5143	3	VP-unequal
MEX	2018	0.5265	9	0.2682	0.1412	9	VR-unequal

Note: ARG = Argentina, BRA = Brazil, CHL = Chile, COL = Colombia, CRI = Costa Rica, ECU = Ecuador, MEX = Mexico, PER = Peru, SLV = El Salvador, URY = Uruguay. PVI (1) = first equation of PVI. Ranking (1) = ranking of the PVI scores according to Equation [1]. PVI (2) = second equation of PVI. Ranking (2) = ranking of the PVI scores according to Equation [2]. VR = vertical regressivity, VP = vertical progressivity. The characteristic of considering a country as equal or unequal is given by whether it has a higher (1-Gini) result than the average (1-Gini) of the population in the respective year.

Source: author's calculation using De Rosa et al. (2023) dataset.

Moreover, as discussed in Section 3, the PVI generates four categories of vertical progressivity, combining vertical progressivity (regressivity) with equal–unequal scores. Figure 3 shows the above-mentioned categories for the 10 countries of the De Rosa et al. (2023) database during 2017. We observe that Mexico, Chile, Peru, Brazil, and Costa Rica are placed in the bottom left of the matrix because they have a Gini coefficient higher than the average and a PVI without adjustment lower than 1. Colombia, Argentina, Ecuador, and Uruguay are placed in the top right of the matrix because they have vertical progressivity and have a lower level of inequality than the average. El Salvador shows vertical regressivity and a lower level of inequality than the average.

Figure 3: PVI and Gini relationship in 10 countries in Latin America in 2017

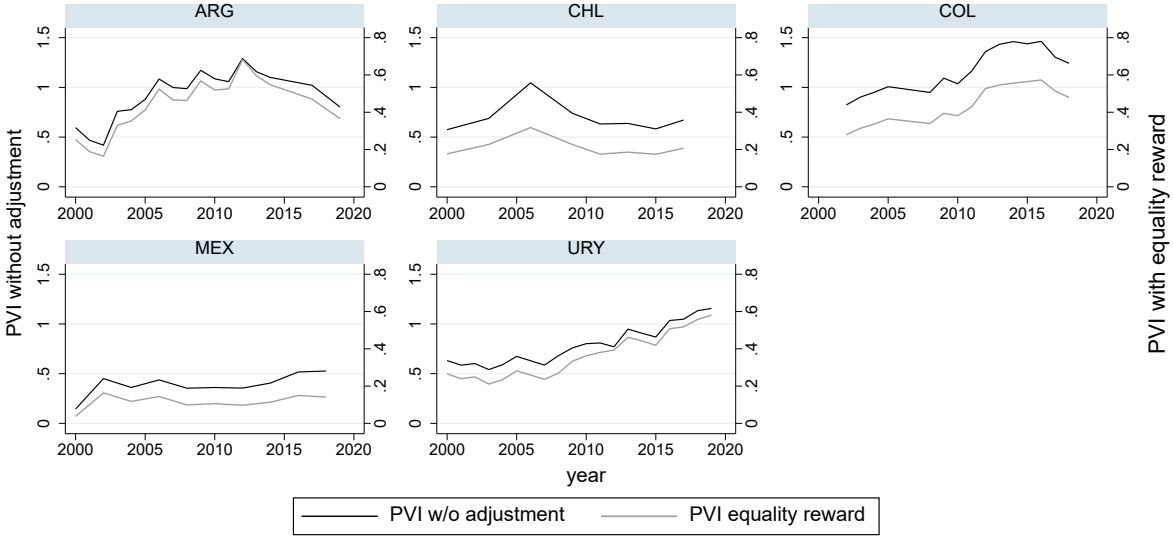


Note: ARG = Argentina, BRA = Brazil, CHL = Chile, COL = Colombia, CRI = Costa Rica, ECU = Ecuador, MEX = Mexico, PER = Peru, SLV = El Salvador, URY = Uruguay. PVI w/o adjustment = first equation of the PVI. VR = vertical regressivity, VP = vertical progressivity. The characteristic of considering a country as equal or unequal is given by whether it has a higher (1-Gini) result than the average (1-Gini) of the population in the respective year.

Source: author's calculation using De Rosa et al. (2023) dataset.

Figure 4 compares the results of Equations [1] and [2] for Argentina, Chile, Colombia, Mexico, and Uruguay to further clarify the effects of considering the equality reward. The countries with higher levels of inequality have more differences between their progressivity score obtained in the first calculation of the PVI and the score obtained considering the equality reward. Therefore, countries with lower initial inequality obtain higher adjusted PVI scores, approaching their original PVI score.

Figure 4: PVI without and with Gini adjustment



Note: ARG = Argentina, CHL = Chile, COL = Colombia, MEX = Mexico, URY = Uruguay. There is a positive correlation between the two variables for the countries, statistically significant at the 1% level. For the case of Argentina, the correlation is 92%, Chile 98%, Colombia 99%, Mexico 97%, and Uruguay 97%.

Source: author's construction using De Rosa et al. (2023) dataset.

Compared with the PVI without inequality adjustment, Colombia, Argentina, and Uruguay continue to report better vertical progressivity than the other two countries, but the order has changed in recent years. The Gini adjustment gives Argentina—a country with a better (i.e. lower) Gini coefficient—a higher ranking during most periods. Colombia—a country with a high inequality index measured by Gini—has been surpassed by Uruguay during the last few years. Uruguay shows the same increasing path observed in the PVI without adjustment, and the Gini adjustment makes this country obtain a better result. In the case of Uruguay, having a better ranking could reflect the country's efforts to implement redistributive reforms in the last decade. Finally, the adjusted PVI does not reward Chile and Mexico, considering their high levels of inequality.

Finally, one can observe the main components of the PVI: the main taxes that explain the vertical progressivity of each country. Table A1 in the Appendix splits the PVI's components—the different average tax rates of the taxes contained in the De Rosa et al. (2023) database—in the countries of the database, grouping the taxes into three categories: income, wealth, and indirect taxes. I generate a specific ratio of the average tax rates paid by the richest 1% with respect to the bottom concerning income, wealth, and indirect taxes. The sum of these categories reflects the total PVI without inequality adjustment. Table A1 allows us to understand the vertical progressivity of each country better, considering which taxes are paid more, either by the bottom or by the richest in the selected countries. This highlights the importance of including all taxes in the progressivity analysis, particularly the importance of VAT in developing countries (Suits 1977).

Overall, the PVI results show that, despite the 2000–19 tax reforms focusing on vertical equity in Latin America, the selected countries (except Uruguay) have not systematically improved their vertical progressivity. On the contrary, some have reduced their vertical progressivity (Colombia and Argentina) and others have kept their inertia (Chile and Mexico).

With respect to developing countries, one can agree with other scholars that, despite the efforts of different countries in pushing towards higher vertical progressivity, the inertia of the tax systems and political economy considerations in many countries often make it challenging to translate those

results into higher average tax rates paid by the richest of the population (Bird and Zolt 2015; Burdín et al. 2022; Fairfield 2013; Flores-Macías 2018; Goñi et al. 2011). Further research that looks closer at trends and attempts to explain variations in the taxes that compose the PVI (indirect, direct, and wealth taxes) could reveal more caveats to this analysis of vertical progressivity and the variables that promote or neglect vertical progressivity.

5 Conclusion

The paper incorporates a new concept for the analysis of tax progressivity, vertical progressivity, and a new instrument for measuring the concept, the Progressive Vertical Index, allowing a systematic analysis of the tax system's progressivity, concentrating the analysis on the richest 1% and the bottom 50% of the population.

Using a new database by De Rosa et al. (2023) with data from 10 countries in Latin America that represent approximately 88% of Latin America and the Caribbean's GDP and 79% of its population, I test the two stages of the PVI. As the first stage of calculating the PVI does not consider the equality reward, I compare the PVI results with those of the Kakwani index of tax progressivity, finding a correlation of 92.57% for these countries. The comparison confirms that the problems of achieving tax progressivity in these unequal parts of the world are evident in the lower average tax rates paid by those at the top compared with those at the bottom of the distribution. Moreover, the first stage of the PVI reports an intuitive result: the ratio of the average total tax rates of the richest 1% of the distribution to that of the bottom 50%, showing a contrast with the Kakwani index of tax progressivity in how the two indices communicate to non-expert audiences. Extending the criticism made by Cobham and Sumner (2013) of the use of the Gini coefficient to the debate on tax progressivity, a regressive 0.05 result on the Kakwani index in Chile in 2017 says little to a non-technical audience, whereas the equivalent PVI score of 0.67 can be directly translated into the statement that the average tax rate of the richest 1% of the population is 0.33 times less than that of the poorest 50%.

The second stage of the PVI calculation incorporates the equality effect for ranking purposes, rewarding countries that have lower levels of inequality and recognizing that they need less progressivity in their tax systems to achieve higher levels of redistribution than countries with higher levels of inequality. The PVI adjusted by the equality reward presents an innovative taxonomy to group countries within a matrix of four results: positive/negative vertical progressivity and equal/unequal initial income distribution. For the case of the 10 countries of Latin America, the results show that, despite different governments between 2000 and 2019 focusing tax reforms on increasing vertical equity, the selected countries (except Uruguay) have not systematically improved their vertical progressivity.

The PVI is a simple, innovative, and versatile tool for analysing tax progressivity, as it acknowledges theoretical considerations of structural and effective measures of progressivity. It is worth noting that, although the PVI shows the trend of each country, it opens avenues for new research as it does not tell us the reasons for the differences between countries categorized as having vertical progressivity or vertical regressivity. Nevertheless, the PVI will help scholars and policy-makers respond to questions in terms of understanding why some countries have upward or downward trends, and how tax reforms explain these changes over time.

Some limitations open the opportunity for further applications of the PVI. For example, it is not possible to establish why countries obtain high or low progressivity results—whether the differences are due to tax compliance, state capacity, tax design, exemptions, or other factors. It

will be a matter for further research to understand the factors that generate changes in the PVI score. Nevertheless, the PVI is an invaluable tool for the analysis of tax progressivity concerning the richest 1% and the bottom 50%.

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Appendix: ratio of direct, indirect, and wealth taxes

To understand the workings of the PVI, I calculate the ratio of taxes paid by each group. I construct three ratios: for income tax, for wealth taxes, and for indirect taxes. I create a category of income, wealth, and indirect taxes, considering the average tax rates contained in the De Rosa et al. (2023) database. This means that I calculate the ratio of average income, wealth taxes and indirect tax rates paid by the top 1% to those paid by the bottom of the population (Table A1).

The category of income taxes contains the sum of the average tax rates of corporate income taxes, personal income taxes, and payroll taxes. The category of wealth taxes contains the sum of wealth taxes, estate taxes, other property taxes, and immovable property taxes. Finally, indirect taxes contain the sum of goods and services taxes. I do not incorporate the OECD category 'other taxes', which represents only a small percentage of the total average tax rates of the database.

Table A1: PVI considering income, indirect, and wealth taxes in countries and years of the database

Country	Year	Income taxes	Wealth taxes	Indirect taxes	Country	Year	Income taxes	Wealth taxes	Indirect taxes
ARG	2000	10.88	3.71	0.06	ECU	2001	8.78	3.63	0.07
ARG	2001	11.49	7.47	0.03	ECU	2003	7.95	2.79	0.08
ARG	2002	10.03	9.48	0.03	ECU	2005	8.18	3.63	0.10
ARG	2003	11.04	7.90	0.07	ECU	2006	8.77	3.19	0.12
ARG	2004	12.99	7.38	0.08	ECU	2007	11.07	3.83	0.08
ARG	2005	14.57	9.67	0.09	ECU	2008	10.97	4.19	0.12
ARG	2006	18.44	13.74	0.12	ECU	2009	12.01	4.73	0.12
ARG	2007	18.08	14.75	0.10	ECU	2010	13.48	4.52	0.11
ARG	2008	18.86	16.50	0.10	ECU	2011	12.61	3.83	0.17
ARG	2009	20.52	18.30	0.10	ECU	2012	15.91	3.55	0.15
ARG	2010	16.48	19.94	0.10	ECU	2013	16.89	4.12	0.13
ARG	2011	17.77	18.12	0.11	ECU	2014	15.18	3.86	0.14
ARG	2012	20.58	20.06	0.16	ECU	2015	14.48	4.71	0.18
ARG	2013	18.35	14.65	0.13	ECU	2016	13.51	8.55	0.19
ARG	2014	13.27	15.66	0.12	ECU	2017	15.77	4.30	0.16
ARG	2017	16.88	13.08	0.09	ECU	2018	19.74	6.01	0.16
ARG	2019	8.30	11.72	0.09	ECU	2019	17.85	5.99	0.19
BRA	2001	14.01	7.05	0.07	MEX	2000	2.48	1.12	0.03
BRA	2002	15.40	6.13	0.08	MEX	2002	7.75	4.09	0.09
BRA	2003	15.35	6.35	0.07	MEX	2004	6.24	3.65	0.05
BRA	2004	11.02	6.19	0.08	MEX	2006	6.19	3.34	0.06
BRA	2005	10.73	6.24	0.08	MEX	2008	5.72	3.61	0.04
BRA	2006	14.35	6.34	0.08	MEX	2010	3.66	1.89	0.04
BRA	2007	11.95	6.27	0.09	MEX	2012	3.57	1.88	0.04
BRA	2008	13.03	3.60	0.09	MEX	2014	3.81	1.82	0.04
BRA	2009	13.62	3.11	0.10	MEX	2016	5.66	2.69	0.04
BRA	2011	14.27	3.91	0.09	MEX	2018	5.35	2.50	0.04
BRA	2012	10.55	3.87	0.10	PER	2000	1.11	0.95	0.06
BRA	2013	13.96	3.76	0.10	PER	2001	1.11	3.16	0.04
BRA	2014	12.70	3.22	0.10	PER	2002	1.38	3.27	0.04
BRA	2015	11.77	2.88	0.10	PER	2003	1.51	1.06	0.04
BRA	2016	10.70	2.69	0.10	PER	2004	1.70	3.43	0.05
BRA	2017	10.30	2.63	0.11	PER	2005	2.19	3.44	0.05
BRA	2018	12.01	2.69	0.10	PER	2006	2.67	3.94	0.05
BRA	2019	10.69	2.69	0.12	PER	2007	2.64	3.95	0.06

Country	Year	Income taxes	Wealth taxes	Indirect taxes
CHL	2000	13.34	2.45	0.05
CHL	2003	15.10	3.43	0.06
CHL	2006	23.20	3.44	0.06
CHL	2009	19.13	1.96	0.06
CHL	2011	18.55	1.90	0.05
CHL	2013	17.42	1.94	0.05
CHL	2015	16.00	1.77	0.06
CHL	2017	19.36	2.28	0.06
COL	2002	4.49	3.78	0.09
COL	2003	5.04	3.93	0.10
COL	2004	5.23	3.17	0.10
COL	2005	5.14	3.07	0.12
COL	2008	5.13	4.27	0.11
COL	2009	5.45	3.25	0.12
COL	2010	5.08	3.20	0.13
COL	2011	5.54	4.36	0.13
COL	2012	6.01	3.96	0.15
COL	2013	7.08	3.84	0.14
COL	2014	8.14	3.73	0.14
COL	2015	8.11	3.63	0.16
COL	2016	8.08	3.43	0.15
COL	2017	7.93	2.72	0.17
COL	2018	8.12	2.02	0.15
CRI	2010	4.16	3.85	0.09
CRI	2011	4.05	4.13	0.09
CRI	2012	3.60	3.95	0.08
CRI	2013	4.04	3.74	0.08
CRI	2014	3.91	3.96	0.10
CRI	2015	3.63	3.32	0.10
CRI	2016	3.91	3.50	0.09
CRI	2017	4.79	3.74	0.09
CRI	2018	4.66	3.38	0.09
CRI	2019	5.37	3.42	0.09
PER	2008	2.53	4.18	0.07
PER	2009	2.09	3.81	0.08
PER	2010	2.36	3.57	0.06
PER	2011	2.72	2.43	0.07
PER	2012	2.75	2.21	0.09
PER	2013	2.43	2.06	0.07
PER	2014	2.38	1.92	0.08
PER	2015	2.16	1.68	0.07
PER	2016	1.97	1.50	0.08
PER	2017	1.78	1.34	0.06
PER	2018	1.83	1.46	0.07
PER	2019	2.42	1.53	0.09
SLV	2001	22.40	17.19	0.06
SLV	2002	29.12	24.65	0.05
SLV	2003	21.50	18.22	0.04
SLV	2004	25.04	21.12	0.03
SLV	2005	21.02	19.51	0.02
SLV	2006	28.19	25.47	0.02
SLV	2007	26.10	21.15	0.03
SLV	2009	25.13	21.25	0.03
SLV	2010	19.98	30.31	0.03
SLV	2012	15.97	17.41	0.04
SLV	2013	20.64	13.49	0.04
SLV	2014	11.05	17.26	0.02
SLV	2015	6.16	19.50	0.02
SLV	2016	6.05	18.61	0.01
SLV	2017	23.10	25.66	0.02
SLV	2018	21.66	27.50	0.03
SLV	2019	25.95	21.30	0.03
URY	2000	7.88	1.89	0.09
URY	2001	8.26	1.80	0.09
URY	2002	8.01	2.32	0.09
URY	2003	7.54	2.66	0.08
URY	2004	9.07	2.53	0.08
URY	2005	10.00	2.72	0.10
URY	2007	7.57	2.80	0.08
URY	2008	8.71	2.76	0.07
URY	2009	9.94	3.02	0.11
URY	2010	10.51	2.90	0.12
URY	2011	7.59	3.02	0.13
URY	2012	7.25	2.57	0.16
URY	2013	10.11	2.98	0.13
URY	2014	9.12	3.10	0.14
URY	2015	7.48	2.81	0.13
URY	2016	9.62	3.02	0.15
URY	2017	11.22	2.83	0.15
URY	2018	12.21	3.00	0.14
URY	2019	12.95	3.11	0.16

Note: Country codes as in Table 4.

Source: author's calculation using De Rosa et al. (2023) dataset.