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ARTICLE

Fiscal policy and inequality in middle- and high-income countries: redistributive effects of tax and spending shocks

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Abstract

Motivated by the sharp increases in public spending following the global financial crisis, we employ the GMM Panel VAR approach at annual frequency between 2004 and 2014 to investigate the dynamic response of alternative income distribution variables to shocks imposed on tax revenues and three key components of social expenditures: social protection, health, and education. We confirm the potential of fiscal policy to reduce income inequality in the medium to longer run, but point to the differential approaches to pursue such a goal in middle- versus high-income countries. We find that the particular expenditure component under consideration matters in terms of the dynamic effect on inequality and on different parts of the income distribution, as well as in terms of the implied time profile. In middle-income countries, positive education spending shocks are the most effective in achieving better distributional outcomes over a medium run of several years. By contrast, in high-income countries, positive health spending and tax shocks have a more pronounced favorable dynamic distributional effect.

Keywords: dynamic distributional effects; public spending component shocks; tax revenue shocks; fiscal policy; middle- vs high-income countries; income inequality

1. Introduction

The distributional implications of fiscal policy have been a long-standing topic of research, often aiming to shed light on the growth-inequality nexus. Yet, the topic has gained new impetus as a result of two recent world-wide shocks, which have both prompted substantial fiscal involvement and resulted in increased public-sector deficits and debt: the Global Financial Crisis (GFC) of 2007–2009 and the COVID-19 pandemic of 2020–2022. The former is particularly relevant here, because it led to an unprecedented increase in public debt, which has then generated hotly debated arguments about the distributional and growth implications of subsequent fiscal consolidation approaches, pursued particularly strongly by various European governments. The substantial fiscal policy intervention to counteract the impact of the COVID-19 pandemic instead has just started to be questioned for its implications on inequality as well as on growing public-sector deficits and debt (Bulow et al. 2020).

Our study examines the redistributive effects of tax and public spending *shocks* on inequality, where the shocks (i.e., the unexpected changes in taxes or public-sector spending) are considered with their longer-run dynamic effects, as opposed to the contemporaneous impact of government spending, in 56 middle-income countries (MICs), over the 2004–2014 period and in comparison with 43 high-income countries (HICs). The time period we consider is ideal to account for any possible such dynamic effects associated with the GFC. Moreover, the comparison among the

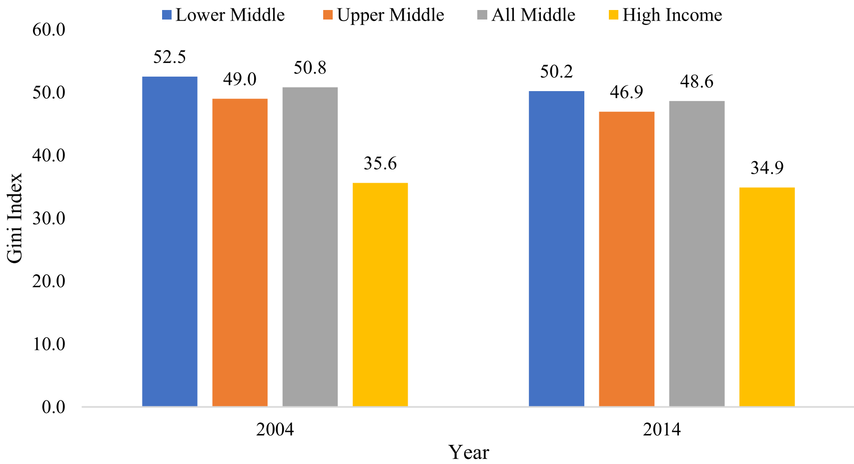

Figure 1. Income inequality within middle- and high-income countries in 2004 and 2014.
Source: Data from the Global Consumption and Income Project (GCIP) Database.

two sets of countries is relevant not just because of the relative paucity of evidence on the overall distributional incidence of fiscal policy in MICs, but also because these are characterised by higher levels of income inequality than HICs, as shown in Figure 1.

Fiscal policy has traditionally been considered an effective instrument through which to influence the distribution of income, even when the main direct target would have been economic growth, whether through impacting aggregate demand or the economy's productive capacity. The composition and combination of fiscal policies through spending and taxes is, therefore, critically important to understand the impact they may have on inequality. Middle-income countries are also characterised by relatively low levels of taxes and social spending, which limit the redistributive potential of their fiscal policies: the tax ratio for our set of MICs has been between 15% and 18% of GDP, while for advanced economies it exceeded 30% of GDP.

Most distributional studies within the fiscal policy literature tend to examine the response of inequality to the contemporaneous effect of fiscal policy variables, while giving less attention to the dynamic response of inequality to unexpected changes in these variables. However, policymakers have been confronted with unforeseen circumstances, such as the GFC, that prompted substantial fiscal policy intervention.[1] As a result of the GFC, the share of government spending in GDP for the middle-income countries in our sample increased to 29.8% in 2009, about 4 percentage points greater than the average between 1990 and 2014. It is not hazardous to claim that sudden changes in fiscal policies are likely to become a recurring phenomenon when considering that countries will have to react to the consequences of climate-related disasters and the war in Ukraine and their impact on energy and food prices worldwide.[2]

Moreover, a better understanding of the medium-run impact of unexpected fiscal policy measures, and their composition, on inequality in middle-income countries will provide evidence as to the extent to which fiscal policies may hinder or facilitate their growth path and, consequently, their transition to a higher-income status.

In this paper, therefore, we ask three related policy-informing questions: (i) How do unexpected changes in public spending components and taxes influence the income distribution in middle-income countries over the medium and long term? (ii) How do the effects of such fiscal shocks on inequality compare against high-income countries? (iii) What could fiscal policy do to reduce income inequality and is this different between high- and middle-income countries?

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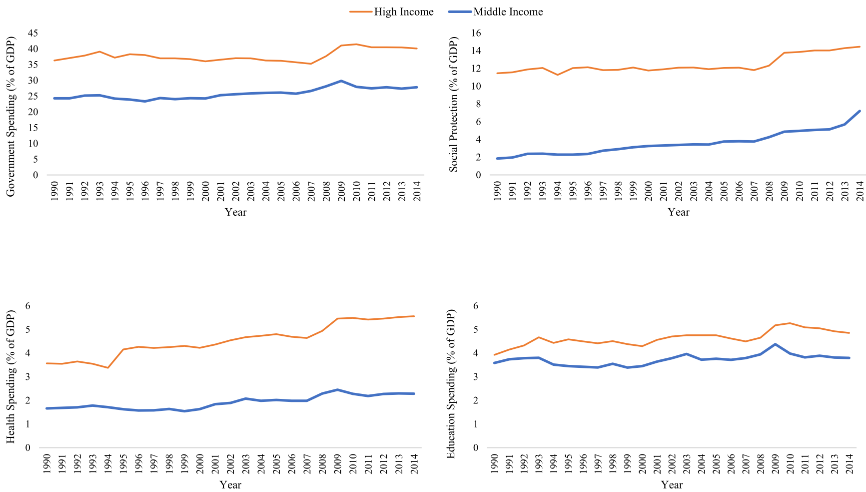

Figure 2. Public and social expenditures: MICs and HICs.
Note: Figure 2 is computed using data from the Statistics on Public Expenditures for Economic Development (SPEED) Database.

We contribute to the literature along several important dimensions. First, we examine the impact on inequality of tax and public spending shocks over the medium to long-term (up to 10 years) rather than their contemporaneous impact, as mostly done in existing literature.

Second, we investigate the impact on inequality of shocks to three social expenditure variables: social protection, health expenditures and education spending (Clements et al. 2015). Although there exists a variety of factors that determine the ultimate impact of these three categories of public-sector expenditures, Oxfam/DFI (2017) observes that they could also possess some equalizing prospects.

Third, we consider the impact of shocks on three parts of the income distribution: the low-income group (the 10th percentile), the middle-income group (the 50th percentile) and the high-income group (the 90th percentile).[3] This allows us to discuss whether the shocks are pro-rich, pro-middle class or pro-poor.

In addition, to our knowledge, the present study is the first to adopt the GMM Panel VAR approach proposed by Arellano and Bond (1991) to control for inequality persistence and reverse causality.

Overall, we find that fiscal policy has the potential to reduce income inequality but differential approaches as to the right fiscal instrument to use are empirically supported for MICs and HICs. More specifically, in our sample of middle-income countries, positive government and education spending shocks are associated with the most pronounced effects on the income distribution. Furthermore, positive social protection shocks often exhibit a brief disequalizing effect, but unexpected increases in health spending generally have no detectable impact on inequality. Surprise increases in tax revenues neither reduce inequality nor benefit the income groups under study. Our results are robust to alternative measures of inequality and plausible variation in the econometric specifications. We also find that the same spending shocks could have different distributional effects in middle- and high-income countries. More specifically, we detect equalizing effects of positive tax and health spending shocks in high-income countries.

The rest of this paper is organized as follows: Section 2 reviews the related literature. Section 3 outlines the methodology adopted. Sections 4 and 5 present and discuss the results, for the middle- and high-income countries, respectively. Section 6 reports robustness tests. Section 7 summarizes and concludes.[4]

2. Related literature

A vast literature has looked at the distributional effects of fiscal policy, most of it examining developed countries. Studies tend to focus on the response of inequality to the contemporaneous effect of changes in taxes and public expenditures, while giving less attention to the dynamic distributional impact of fiscal shocks. These studies can be grouped into three main types, depending on the approach they adopt.

One type focuses on the distributional consequences of taxes and transfers, mostly by assessing the difference between market income and disposable income inequality determined by the progressivity of the tax system. A review of this literature for developing countries is provided in Bastagli et al. (2015). Amongst the many studies with a single country focus, some that have a comparative approach for developed countries are from Brandolini and Smeeding (2009), Paulus et al. (2010) and Joumard et al. (2012) for OECD and five EU countries, respectively. The latter assesses the impact of in-kind benefits from public housing subsidies, education, and health care.

A second and similar type of studies aims to assess the determinants of net income distributions, typically based on regressions where the Gini coefficient is explained by government actions through taxes and spending. The findings from this type of regression-based studies suggest that greater reliance on income taxes and higher spending on social benefits reduces inequality. More specifically, direct taxes are found to be more redistributive than indirect taxes, and social protection spending reduces inequality (Afonso et al. 2010; Muinelo-Gallo and Roca-Sagalés, 2011; Martinez et al. 2012). For developing countries, the distribution of in-kind social spending has been found to be regressive, due to the relatively reduced access by low-income households to education and health. More specifically, the impact of spending varies across different categories: primary health care spending, for example, is progressive, while higher-level spending is regressive. Similarly, in education, primary education spending is progressive, while secondary and tertiary education spending are regressive (Van de Walle, 1995; Demery, 2000; Gregorio and Lee, 2002). Within this line of literature, more recent studies have focused on the impact of fiscal consolidation measures, which, as mentioned earlier, have been implemented by many countries as a response to the debt sustainability crisis that emerged from the substantial fiscal expansion adopted to address the consequences of the GFC (Woo et al. 2017).

Finally, a third type of studies is based on general equilibrium approaches, whereby the effects of all taxes and expenditures are estimated simultaneously, with no assumptions made or needed on how taxes affect different income groups. Most of these papers find weak redistributive effects of taxes, particularly in developing countries (Martinez et al. 2012). Within this line of research, there are also the popular dynamic stochastic general equilibrium (DSGE) models. The standard ones, based on Smets and Wouters (2003), have a representative agent and, therefore, are not ideal to investigate distributional issues. More recent models have adopted heterogeneous agent types, mostly to assess the impact of monetary policy (Kaplan et al. 2018), while those on the impact of fiscal policy are recent (see, for example, Areosa and Areosa, 2016; Ferrara and Tirelli, 2017; Seidl and Seyrich, 2021). Meanwhile, there are other papers that investigate the effects of fiscal policy shocks on consumption (and other welfare issues aside from income inequality). However, we do not consider such papers in our brief review of the literature, as they fall outside the scope of our study.

Overall, the results of existing studies on developed countries are mixed: while some suggest that the fiscal policy instruments tend to reduce inequality, others indicate the opposite.

Table A1 in Appendix A online reports the findings of 17 empirical studies that focused on middle-income countries and the distributional impacts of a variety of fiscal policy variables, including public spending, social securities, health and education expenditures, and taxation. The studies cover a period that spans from 1950 to 2015. While some of them examine both developed and developing countries (Martinez et al. 2012; Coady and Dizioli, 2018), other concentrate on specific regions (Battistón et al. 2014; Anyanwu et al. 2016), and a few focus strictly on developing countries of varying income levels (Furceri et al. 2022). GMM and panel fixed effects methods appear to be the most commonly adopted techniques, with 8 papers using the former, and 6 employing the latter. In terms of findings, the studies examined arrive at mixed results. While some studies show that the fiscal policy variables are equalizing, others find disequalizing impacts. More importantly, the overview of the literature provided above reveals that existing studies generally give less attention to the redistributive impact and dynamics of unexpected fiscal shocks, as opposed to public sector spending and tax changes that are expected.

This review of the literature guides our research focus on the effect of tax and public expenditure shocks on a summary measure of inequality (the Gini index) as well on three sections of the income distribution over different medium-term horizons. Methodologically, we control for reverse causality by adopting a panel Vector Autoregressive (VAR) model implemented through the two-step difference GMM technique of Arellano and Bond (1991).

Perhaps, the research that is closest to ours is that of Furceri et al. (2022). However, our study differs from it in three distinct ways. First, unlike Furceri et al. (2022), our paper studies not only government spending shocks, but also tax shocks. Second, our work differs in terms of the public expenditure shocks considered, since we also examine shocks imposed on key components of social expenditures: social protection, health, and education expenditures. Third, our paper departs from that of Furceri et al. (2022) in terms of the methodology adopted towards investigating our research question. While we adopt the panel VAR approach, Furceri et al. (2022) employ the local projections estimator, which is often associated with a relatively high bias, high variance and inaccurate confidence intervals (see, for example, Kilian and Kim, 2009).

3. Method and data

The measure of income inequality we start with is the Gini index, widely used as it also satisfies most of the conditions that are desirable in an inequality measure (Foster et al. 2013). However, the Gini index is well-known for being insensitive to changes in the tails of the income distribution, while we also aim to empirically uncover how different income groups respond to tax and spending shocks. To do so, we employ three different percentile income shares; consequently, we modify our VAR framework by replacing the Gini index with each of the percentile income shares, one after the other.

3.1. Model specification

We employ a three-variable panel vector autoregressive (VAR) model following the seminal paper of Blanchard and Perotti (2002).[5] Our baseline panel VAR[6] model is provided below:

$$Y_{it} = A_0 + A_1 Y_{it-1} + \mu_i + \theta_t + e_{it} \tag{1}$$

In equation (1), Y_{it} is a vector comprising the variables $Spending_{it}$, Tax_{it} and $Gini_{it}$. $Spending_{it}$ represents public spending in country i at time t, Tax_{it} is taxation revenue, and $Gini_{it}$ represents the Gini index, our initial measure of income inequality and principal variable of interest. Further, μ_i and θ_t denote the country and time fixed effects, respectively; e_{it} represents the error term.

Our choice of variables is underpinned by the theoretical proposition underlying the study published by the IMF in 2015 (Clements et al. 2015), wherein they observe that taxes, as well as spending decisions such as social security, education and health expenditures, are designed not only to directly impact on households' welfare, but also on the income distribution. Therefore,

Table 1. Variables definition and data sources

Abbreviation	Description	Data source
GS	Government spending represents the total expenditure incurred by a government in a given year. All spending variables are measured as a percentage of GDP.	Statistics on Public Expenditures for Economic Development (SPEED)
SPS	Social protection spending includes social securities such as provision of short- and long-term shelter to the poor, unemployment benefits, and parental leave benefits.	Statistics on Public Expenditures for Economic Development (SPEED)
HS	Health spending comprises healthcare related expenses such as health insurance, drugs funds, ambulance acquisition, subsidies, and grants channelled towards healthcare.	Statistics on Public Expenditures for Economic Development (SPEED)
ES	Education spending includes education expenditures such as grants, scholarships, allowances, and loans in support of pupils; as well as construction of academic institutions.	Statistics on Public Expenditures for Economic Development (SPEED)
Tax	Taxation revenue comprises the total government revenue but excludesgrants. It is, similarly, measured as % of GDP.	UNU WIDER Government Revenue Dataset for 2018
Gini	Gini index compares the average difference between pairs of incomes in a distribution with the distribution's mean.	Global Consumption and Income Project (GCIP) Database
Tenth, Fiftieth, and Ninetieth Percentiles	The Tenth, Fifitieth, and Ninetieth percentiles, respectively, reflect the income levels below which the incomes of the bottom 10%, bottom half and top 10% of the distribution fall. The 10th, 50th, and 90th percentiles, respectively, denote the low, middle, and high-income groups.	Global Consumption and Income Project (GCIP) Database

and similarly to the approach of Kabashi (2015), we also replace the public spending variable with three social expenditure variables, one at a time: social protection spending (SPS_{it}), health spending (HS_{it}), and education spending (ES_{it}). Moreover, in examining the impact of the spending shocks on different income groups, we replace the Gini index with three percentile income shares representing three different income groups: the 10th percentile represents the low-income group; the 50th percentile denotes the middle-income group and the 90th percentile the high-income group.[7] Table 1 summarises these variables and their data source.

We include both public spending and taxes within the same VAR model since both variables are not independent of each other, as noted by Blanchard and Perotti (2002). Following existing studies (see, Anyanwu et al. 2016; Guzi and Kahanec, 2019), we measure tax as well as the expenditure variables as a percentage of GDP. In Appendix A online, we provide further discussion concerning our panel VAR model and the results of the unit root and stability tests, respectively.[8]

Table 2 shows descriptive statistics for our data regarding 56 middle-income countries over the period 2004–2014.[9]

The table shows that the average Gini index for middle-income countries is about 49.7, with the maximum being 85.2. Also, the table reveals that, on average, the respective shares of taxation and government spending in GDP are 17.9% and 27.3%. Unsurprisingly considering the relatively large inequalities, the income share held increases as we move along the income distribution from bottom to top. Accordingly, the 90th percentile holds, on average, the highest income share, around fifteen times greater than that held by the bottom 10th of the income distribution.

3.2. GMM panel VAR estimation technique

We estimate the VAR equations using the two-step difference GMM estimator of Arellano and Bond (1991). The appeal of difference GMM lies in the hope they offer for solving a tough estimation problem: the combination of a short panel, a dynamic dependent variable, fixed effects and a lack of good external instruments. The difference GMM method in implementing our

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Table 2. Summary statistics

	Mean	SD	Min	Max
GS	27.339	10.355	5.000	67.000
SPS	4.559	4.991	0.000	26.476
HS	2.172	1.454	0.037	7.951
ES	3.874	2.294	0.079	14.727
Tax	17.913	7.829	4.975	60.946
Gini	49.748	7.889	32.919	85.165
Tenth	1.417	0.603	0.252	2.829
Fiftieth	5.529	1.074	2.568	8.136
Ninetieth	15.458	0.824	11.600	18.923

Source: Authors' own computation.
Note: GS denotes government spending, SPS is social protection spending, HS is health spending, ES is education spending, Tax is taxation revenue, all as percentage of GDP. Tenth, Fiftieth and Ninetieth denote the income shares held by the 10th, 50th and 90th percentiles, respectively, as percentage of the total income.

panel VAR model is suitable for short panels, such as ours (Arellano and Bond, 1991); indeed, other studies have employed the GMM Panel VAR approach in analysing short panels, such as Holtz-Eakin et al. (1988), which employs a dataset covering 7 years (1976–1982), and Love and Zicchino (2006), which spans over 11 years (1988–1998). Moreover, we do not use the one-step difference GMM estimator since it employs an arbitrary approximation of the weighting matrix in the GMM estimator (see Roodman, 2009a). Also, in addressing the downward bias in the standard errors of the two-step results, we adopt the Windmeijer (2005) finite-sample correction. Another important consideration is the possibility of weak instruments when employing the Generalized Method of Moments (GMM) estimator (Angrist and Pischke, 2009; Roodman, 2009b; Bun and Windmeijer, 2010). In constructing the instrument matrix, we employ the approach of Holtz-Eakin et al. (1988), which avoids the trade-off between instrument lag depth and sample depth by zeroing out missing observations of lags. It also includes separate instruments for each time period.

The two-step difference GMM estimator is expressed as follows:

$$\beta_{GMM} = (X'Z(Z'\widehat{\Omega}Z)^{-1}Z'X)^{-1}X'Z(Z'\widehat{\Omega}Z)^{-1}Z'Y \tag{2}$$

where β_{GMM} is a column vector of coefficients, X is a column vector of k regressors, Y is the column vector representing the left-hand side variable, Z denotes the instrument matrix and $\widehat{\Omega}$ is a weighting matrix.

4. Analysis and results for the middle-income countries

4.1. Impulse response analysis

To illustrate the dynamic behavior at an annual frequency of our panel VAR system, we present graphs of the impulse response functions at the 90% confidence interval (constructed by Monte Carlo simulations). Figure 3 reveals the orthogonalized impulse response of inequality (the Gini coefficient) to shocks imposed on the fiscal policy variables: government spending (GS), health spending (HS), social protection spending (SPS) and education spending (ES) and tax. Figure 4 shows the impulse response of different parts of the income distribution (bottom tenth, median and top tenth) to the same fiscal policy shocks.

A positive shock to government spending has a negative and almost immediate effect on inequality, with the Gini index reducing by as much as 0.243 percentage points in the first year

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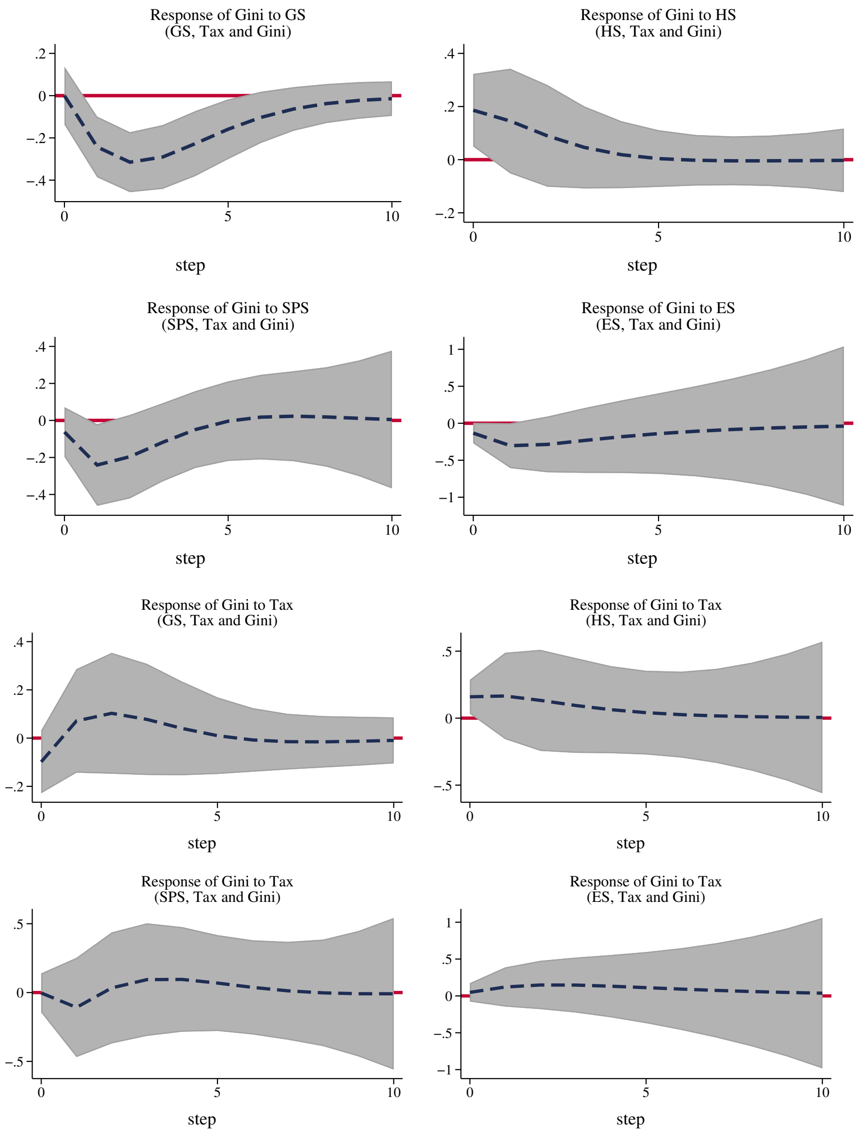

Figure 3. Impulse responses in middle-income countries: spending and tax shocks on the Gini index.
Note: The dashed blue lines denote the point estimates of the response of the relevant income distribution variable to the respective government spending or tax revenue shocks. The shaded regions represent the corresponding 90 percent confidence intervals.

after the shock. The effect peaks in the second year at 0.315 percentage points and remains statistically significant up until the fifth year. Also, a positive shock to government spending is associated with an increase in the income share held by the 10th and 50th percentiles (Figure 4), elevating both income shares one year after impact, (by 0.026 and 0.037 percentage points, respectively). In both cases, the effect reaches a maximum in the second year, and generally lasts until the fifth year. Meanwhile, a government spending shock has no significant impact on the 90th percentile.

Similarly, after a positive shock to education expenditure, the Gini index decreases by as much as 0.303 percentage points in the first year after the shock. Notably, an education spending shock results in an increase in the income shares held by all percentiles under study, with each rising in

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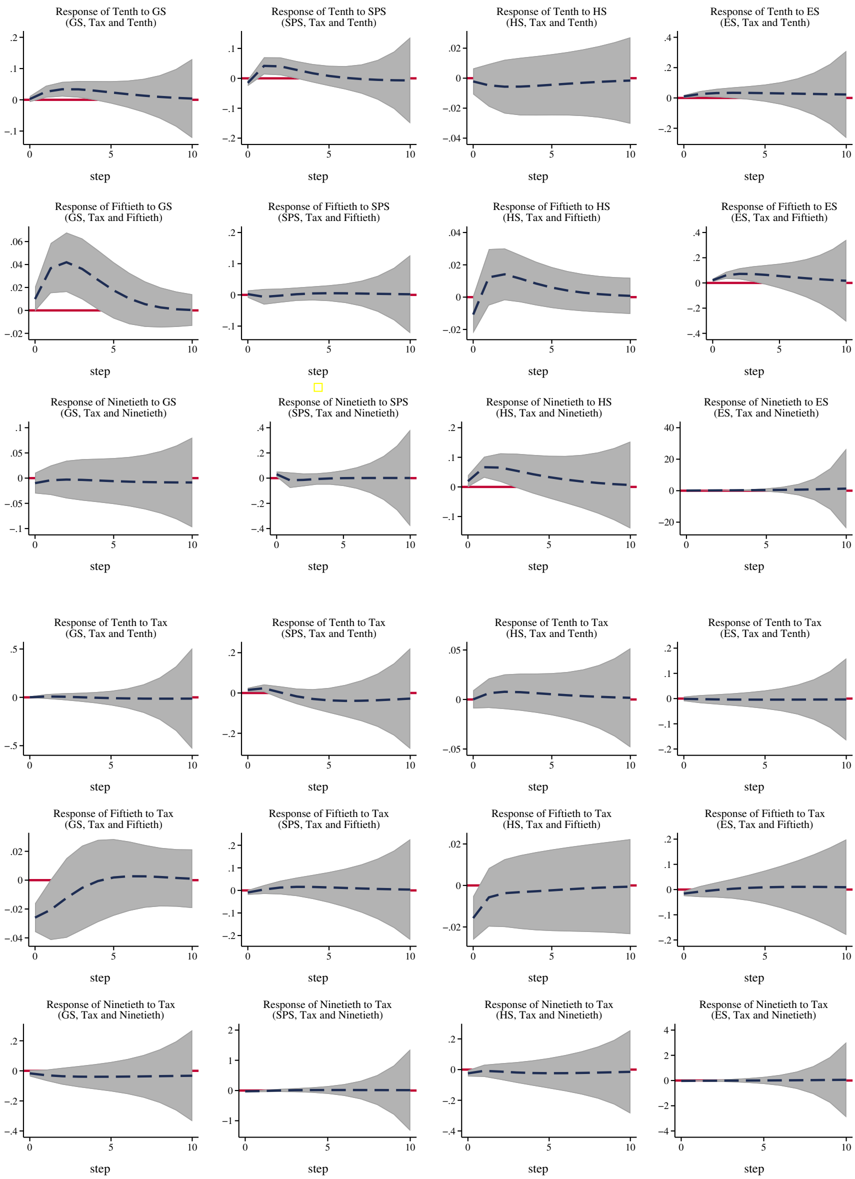

Figure 4. Impulse responses in middle-income countries: spending and tax shocks on the tenth, fiftieth and ninetieth percentiles.
Note: The dashed blue lines denote the point estimates of the response of the relevant income distribution variable to the respective government spending shocks. The shaded regions represent the corresponding 90 percent confidence intervals.

the year of impact (Figure 4). In most cases, the effect peaks in the second year, lying within a range of 0.032 and 0.194 percentage points. While the shock's impact on the 10th and 90th percentiles vanishes by the third year, the 50th percentile of the income distribution continue to benefit from the shock until the fourth year.

The first year after a shock to social protection expenditure sees a drop in inequality by 0.241 percentage points. However, this result should be interpreted with caution as the negative impact is barely significant and short-lived, i.e., detected only in the year of the shock. It is worth to

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stress that a social protection spending shock exhibits an ambiguous impact on the 10th percentile income share, initially reducing it but then increasing it a year after the shock (Figure 4). A shock to social protection spending exhibits an instantaneous positive impact on the 90th percentile but by only 0.03 percentage points, and the impulse response path becomes statistically insignificant in subsequent years. Furthermore, it has no statistically significant impact on the 50th percentile.

A health expenditure shock does not have a significant effect on income inequality nor on the percentiles representing poor- and middle-income groups, while 90th percentile income share increases after one year following a positive health spending shock (Figure 4). The effect remains positive and statistically significant for an additional year before vanishing into statistical insignificance in the third year.

Figure 3 also reveals the orthogonalized impulse response of inequality to shocks imposed on taxation. An unexpected change in the tax revenue largely exhibits no significant impact on inequality. Likewise, a positive shock to taxation generally does not benefit the percentiles representing the low-, middle-, and high-income groups (Figure 4).

4.2. Variance decomposition analysis

Table 3 provides the forecast error variance decompositions for the panel VAR model with the Gini index as the income distribution variable. From the first to the fifth year, the spending variables increase their influence on the variation in inequality, reaching up to 6.6% and 6.7% after 5 years for government and education spending shocks, respectively, which is the strongest effect. The corresponding effects at this 5-year horizon of social protection and health expenditure are about half or one-third of the reported magnitude, respectively. Taxes have the weakest influence on the variation in inequality, only 0.8% at the same 5-year horizon in the FEVDs. The inference from these empirical findings is that the fiscal variables, but mostly those on the public expenditure rather than the revenue side, are key drivers of income inequality within middle-income countries.

The variance decompositions for the income percentiles follow a similar pattern to that of inequality. Consequently, the results from the variance decompositions lend credence to those from the impulse response functions.

5. Comparison to the high-income countries

In this section, we examine how the results for middle-income countries compare with high-income countries. These are shown in Figure 5 for the Gini coefficient and Figure 6 for the three parts of the income distribution, respectively.[10]

The impulse responses for our sample of high-income countries reveal that the Gini index declines within two years of a government spending shock. Government spending shocks generally benefit the very low-income groups: the income share of the bottom 10th rises for two years after and peaks in the fifth year but remains positive until the ninth year after the shock.[11] Meanwhile, a positive shock to government spending does not exhibit a significantly positive impact on the other percentiles considered.

A shock to education spending is associated with a decrease in inequality by 0.123 percentage points on impact. The effect peaks at 0.312 percentage points in the third year, and persists until the fifth year. Furthermore, education spending shocks generally benefit the low-income group as well as the very high-income group: they are associated with an increase in the income share held by the 10th percentile in the year of impact, peaks in the fourth year but lasts until the fifth year. Differently, a positive education spending shock has no immediate impact on the 90th percentile, but marginally increases it by 0.040 percentage points in the first year after the shock. The effect subsequently becomes statistically insignificant in the third year. It does not have a significant impact on the 50th percentile.

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Table 3. Variance decomposition in middle-income countries: Gini, tenth, fiftieth and ninetieth percentiles

Gini index												
Response variable and periods ahead	Impulse variable											
	GS, Tax, and Gini			SPS, Tax, and Gini			HS, Tax, and Gini			ES, Tax, and Gini		
Gini	GS	Tax	Gini	SPS	Tax	Gini	HS	Tax	Gini	ES	Tax	Gini
1	0.000	0.004	0.996	0.001	0.000	0.999	0.012	0.009	0.979	0.006	0.001	0.993
2	0.016	0.004	0.981	0.017	0.003	0.979	0.017	0.016	0.967	0.031	0.005	0.965
3	0.037	0.006	0.957	0.027	0.003	0.970	0.019	0.021	0.960	0.049	0.010	0.941
4	0.055	0.007	0.938	0.030	0.006	0.964	0.020	0.024	0.957	0.060	0.015	0.925
5	0.066	0.007	0.927	0.031	0.008	0.961	0.020	0.025	0.955	0.067	0.019	0.915
Tenth Percentile												
Response variable and periods ahead	Impulse variable											
	GS, Tax, and Tenth			SPS, Tax, and Tenth			HS, Tax, and Tenth			ES, Tax, and Tenth		
Tenth	GS	Tax	Tenth	SPS	Tax	Tenth	HS	Tax	Tenth	ES	Tax	Tenth
1	0.000	0.000	1.000	0.014	0.015	0.971	0.000	0.000	1.000	0.008	0.000	0.992
2	0.035	0.004	0.962	0.087	0.034	0.879	0.002	0.002	0.996	0.045	0.000	0.955
3	0.081	0.005	0.914	0.139	0.031	0.830	0.003	0.005	0.992	0.089	0.001	0.910
4	0.124	0.005	0.871	0.161	0.039	0.800	0.005	0.008	0.987	0.131	0.001	0.868
5	0.154	0.005	0.840	0.164	0.068	0.768	0.006	0.010	0.984	0.166	0.002	0.832

Table 3. Continued

Fiftieth Percentile												
Response variable and periods ahead	Impulse variable											
	GS, Tax, and Fiftieth			SPS, Tax, and Fiftieth			HS, Tax, and Fiftieth			ES, Tax, and Fiftieth		
Fiftieth	GS	Tax	Fiftieth	SPS	Tax	Fiftieth	HS	Tax	Fiftieth	ES	Tax	Fiftieth
1	0.006	0.038	0.956	0.000	0.005	0.995	0.007	0.014	0.979	0.025	0.013	0.962
2	0.062	0.046	0.892	0.002	0.004	0.994	0.012	0.013	0.976	0.150	0.011	0.838
3	0.123	0.048	0.830	0.002	0.010	0.988	0.019	0.012	0.969	0.271	0.009	0.719
4	0.164	0.046	0.789	0.002	0.019	0.980	0.024	0.012	0.964	0.358	0.008	0.633
5	0.185	0.045	0.770	0.003	0.027	0.971	0.026	0.012	0.962	0.415	0.008	0.577
Ninetieth Percentile												
Response variable and periods ahead	Impulse variable											
	GS, Tax, and Ninetieth			SPS, Tax, and Ninetieth			HS, Tax, and Ninetieth			ES, Tax, and Ninetieth		
Ninetieth	GS	Tax	Ninetieth	SPS	Tax	Ninetieth	HS	Tax	Ninetieth	ES	Tax	Ninetieth
1	0.002	0.005	0.994	0.016	0.012	0.973	0.006	0.010	0.984	0.082	0.013	0.904
2	0.001	0.013	0.986	0.017	0.013	0.970	0.058	0.008	0.934	0.196	0.011	0.793
3	0.001	0.024	0.975	0.019	0.013	0.968	0.097	0.009	0.895	0.323	0.008	0.669
4	0.001	0.037	0.962	0.019	0.015	0.966	0.120	0.012	0.868	0.436	0.005	0.559
5	0.001	0.051	0.948	0.019	0.018	0.963	0.133	0.016	0.850	0.524	0.003	0.473

Source: Author's own computation.

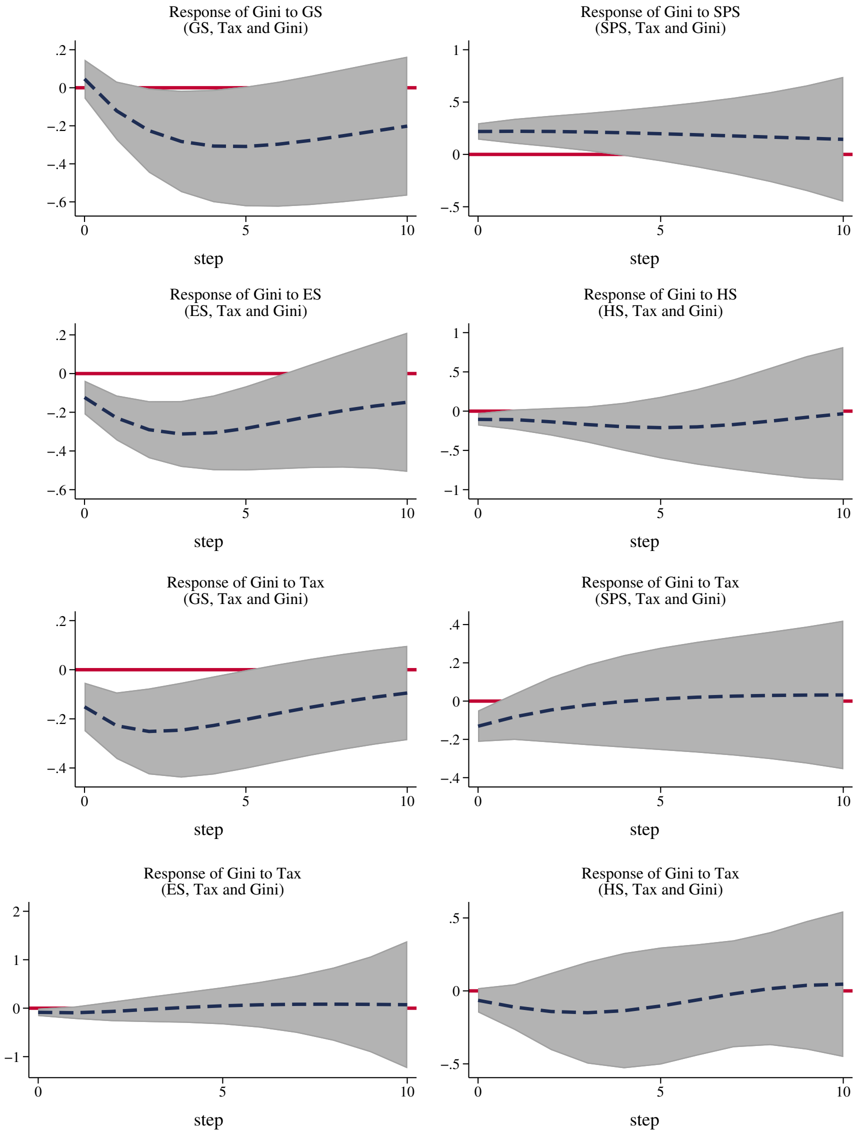

Figure 5. Impulse responses in high-income countries: spending and tax shocks on the Gini index.
Note: The dashed blue lines denote the point estimates of the response of the relevant income distribution variable to the respective government spending shocks. The shaded regions represent the corresponding 90 percent confidence intervals.

A positive shock to social protection spending neither reduces inequality nor exhibits a significantly positive impact on any of the percentiles considered.

In contrast to the results obtained for the middle-income countries, for the high-income countries we find that a positive shock to health spending has an immediate inequality-reducing effect, with the Gini index declining by 0.105 percentage points in the year of the shock. The share of income held by the 90th percentile also sees an increase after the unexpected increase in health spending.[12]

Contrary to the results obtained for middle-income countries, an unexpected rise in taxation revenue now largely reduces income inequality in the high-income countries sample. The reduction often occurs in the year of impact and persists for at least one additional year. Interestingly,

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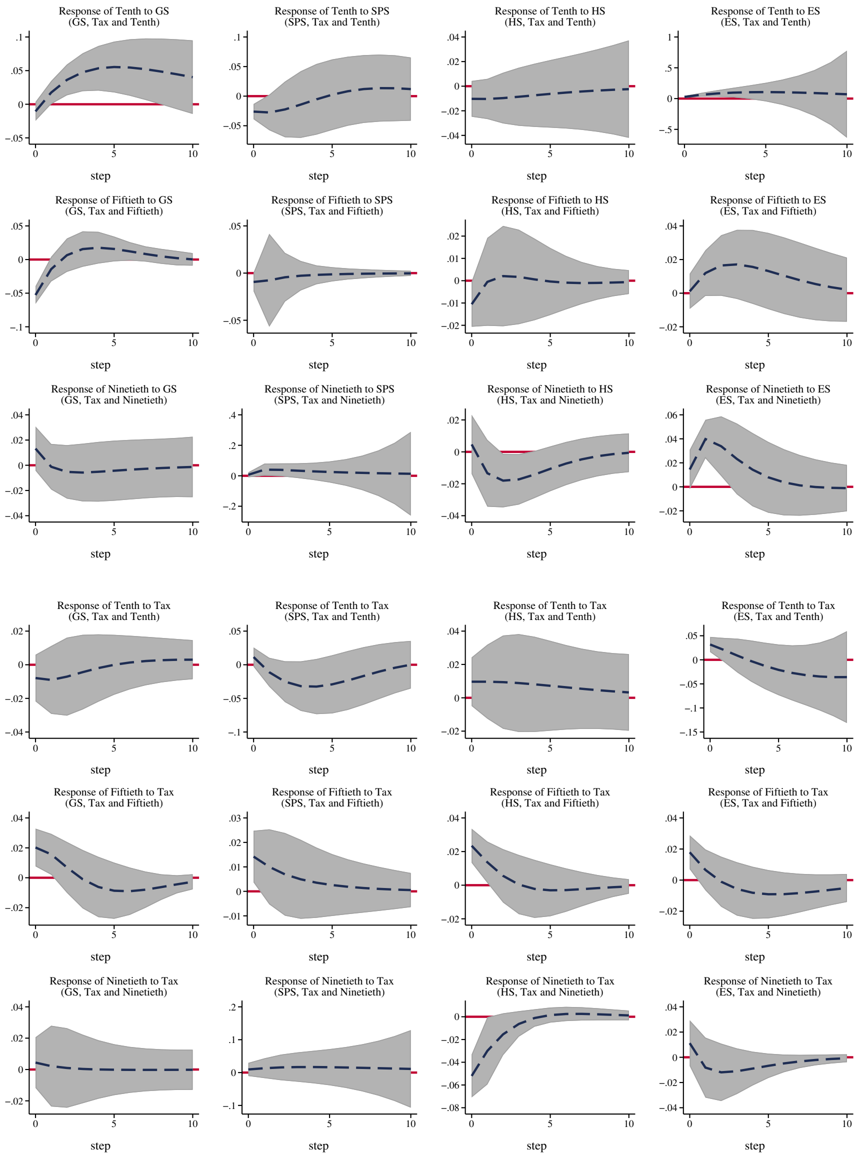

Figure 6. Impulse responses in high-income countries: spending and tax shocks on the tenth, fiftieth and ninetieth percentiles.
Note: The dashed blue lines denote the point estimates of the response of the relevant income distribution variable to the respective government spending shocks. The shaded regions represent the corresponding 90 percent confidence intervals.

in the model in which our spending variable is represented by total government expenditure, the effect persists till the fifth year. Furthermore, a positive shock to taxation revenue benefits the 50th percentile, with the beneficial effect being often immediate and then fading away by the second year.

The results from the variance decomposition validate those from the impulse responses, showing that the fiscal policy variables we examined contribute significantly to the variations in all the income percentiles considered (see Table 4).

Table 4. Variance decomposition in high-income countries: Gini, tenth, fiftieth and ninetieth percentiles

Gini Index												
Response variable and periods ahead	Impulse variable											
	GS, Tax and Gini			SPS, Tax and Gini			HS, Tax and Gini			ES, Tax and Gini		
Gini	GS	Tax	Gini	SPS	Tax	Gini	HS	Tax	Gini	ES	Tax	Gini
1	0.002	0.017	0.982	0.050	0.018	0.932	0.012	0.005	0.983	0.017	0.008	0.975
2	0.007	0.032	0.961	0.054	0.013	0.932	0.015	0.011	0.974	0.045	0.011	0.945
3	0.021	0.043	0.935	0.058	0.010	0.931	0.022	0.019	0.959	0.076	0.010	0.913
4	0.039	0.052	0.910	0.062	0.009	0.930	0.032	0.027	0.941	0.104	0.009	0.887
5	0.056	0.058	0.887	0.065	0.007	0.928	0.046	0.032	0.922	0.125	0.008	0.868
Tenth Percentile												
Response variable and periods ahead	Impulse variable											
	GS, Tax and Tenth			SPS, Tax and Tenth			HS, Tax and Tenth			ES, Tax and Tenth		
Tenth	GS	Tax	Tenth	SPS	Tax	Tenth	HS	Tax	Tenth	ES	Tax	Tenth
1	0.004	0.002	0.994	0.025	0.005	0.970	0.004	0.003	0.993	0.025	0.034	0.941
2	0.009	0.003	0.988	0.035	0.006	0.959	0.004	0.004	0.992	0.084	0.027	0.889
3	0.029	0.003	0.968	0.040	0.018	0.942	0.005	0.005	0.990	0.154	0.021	0.826
4	0.058	0.003	0.939	0.041	0.036	0.923	0.005	0.005	0.989	0.222	0.016	0.762
5	0.090	0.003	0.907	0.040	0.054	0.906	0.006	0.006	0.989	0.280	0.015	0.705

Table 4. Continued

Fiftieth Percentile												
Response variable and periods ahead	Impulse variable											
	GS, Tax and Fiftieth			SPS, Tax and Fiftieth			HS, Tax and Fiftieth			ES, Tax and Fiftieth		
Fiftieth	GS	Tax	Fiftieth	SPS	Tax	Fiftieth	HS	Tax	Fiftieth	ES	Tax	Fiftieth
1	0.113	0.017	0.870	0.006	0.015	0.979	0.007	0.037	0.956	0.000	0.021	0.979
2	0.077	0.017	0.906	0.009	0.019	0.972	0.005	0.032	0.963	0.006	0.015	0.979
3	0.067	0.016	0.917	0.010	0.021	0.969	0.004	0.029	0.967	0.014	0.012	0.974
4	0.070	0.015	0.916	0.010	0.023	0.967	0.004	0.027	0.968	0.021	0.012	0.967
5	0.075	0.016	0.909	0.011	0.023	0.966	0.004	0.027	0.969	0.027	0.013	0.961
Ninetieth Percentile												
Response variable and periods ahead	Impulse variable											
	GS, Tax and Ninetieth			SPS, Tax and Ninetieth			HS, Tax and Ninetieth			ES, Tax and Ninetieth		
Ninetieth	GS	Tax	Ninetieth	SPS	Tax	Ninetieth	HS	Tax	Ninetieth	ES	Tax	Ninetieth
1	0.004	0.000	0.995	0.001	0.002	0.997	0.000	0.056	0.944	0.005	0.003	0.992
2	0.004	0.001	0.996	0.031	0.005	0.964	0.004	0.072	0.923	0.036	0.004	0.960
3	0.004	0.001	0.995	0.053	0.008	0.939	0.010	0.076	0.914	0.057	0.007	0.936
4	0.005	0.001	0.995	0.067	0.012	0.921	0.016	0.076	0.908	0.067	0.009	0.925
5	0.006	0.001	0.994	0.076	0.016	0.908	0.020	0.076	0.904	0.070	0.010	0.920

Source: Author's own computation.

This set of findings reveals some interesting similarities and differences between the HICs and the MICs. The similarities are in the inequality-reducing impact of unexpected total government spending and education spending in both sets of countries. The differences, instead, are in the inequality-reducing impact of health spending and tax revenue shocks in HICs but not in MICs. Social protection spending shocks have also a different impact on inequality in the two sets of countries, but this is not pronounced.

In the concluding section, we discuss these findings and their potential implications further.

6. Sensitivity analysis

6.1. Employing different measures of inequality in the panel VAR

We test the robustness of our results to alternative measures of inequality and to three additional income percentiles.[13] Specifically, we replace the Gini index with the Atkinson inequality measure and the Theil index and also use the 20th, 40th, and 80th percentiles, which are alternative proxies for the bottom, middle, and top income percentiles previously discussed. This allows us to examine the degree to which our findings potentially depend on the measure of inequality used.[14]

Replacing the Gini coefficient and the income percentiles with these other measures does not change the essence of the results we analyzed as a benchmark specification. Shocks to government expenditure retain their negative impact on inequality: both the Theil index and the Atkinson inequality measure exhibit negative responses. A positive shock to education spending has a negative and immediate effect on the Theil index and the Atkinson measure of inequality, while a health spending shock, and a positive tax shock, have no statistically significant impact on the Theil index and the Atkinson measure of inequality.

The findings obtained for the 20th, 40th, and 80th percentiles generally corroborate the baseline results. Similar to our previous findings, government and education spending shocks tend to benefit the 20th and 40th percentiles, with the 80th percentile benefiting from education spending shocks as well. Also, social protection and health spending shocks exhibit a positive impact on the 80th percentile. Meanwhile, tax shocks generally do not benefit any of the income shares.[15]

6.2. Re-ordering the variables in the panel VAR

6.2.1. Inclusion of taxation before government spending

We re-order our panel VAR by including taxation before the public spending variables. This ordering is based on Wagner's law of government expenditure, which suggests that an increase in tax receipts enhances the government's capacity to spend on public goods (Wagner, 1890). Moreover, there exist some middle-income countries which, on average, have recorded budget surpluses over time.[16] For some countries, a budget surplus may be necessary to realize some savings to pay off debts or foot the bills of a capital project; as such, taxation revenue is seen as a benchmark, determining how much the government spends annually (ECLAC/UNESCO, 2005).

We find that the ordering of variables affects somewhat the impulse responses and the variance decompositions.[17] More specifically, the results show that income inequality declines in response to a positive shock to government spending as well as education expenditure. While a government expenditure shock has a positive effect on the percentiles representing the low- and middle-income groups, a shock to education expenditure exhibits a positive effect on all percentiles under study. In most cases, the impact persists for at least two years.

Furthermore, a positive shock to social protection expenditure elevates the income share of the 90th percentile when considering the impulse responses. Likewise, a social protection expenditure shock initially has a negative effect on the 10th percentile, but eventually has a positive influence on the percentile's share of income in the years following the shock. Consistent with our earlier results, a positive health spending shock has no significant impact on inequality, but it exhibits a positive effect on the 90th percentile. In general, a positive tax shock does not contribute towards closing the income gap. Also, the income shares generally do not benefit from a tax shock, as shown previously.

Finally, regarding the variance decomposition, the analysis reveals that the fiscal policy variables still contribute to the variations in inequality as well as the income percentiles in a range similar to the benchmark case with the Gini index.

6.2.2. Employing the reverse of the baseline ordering

As is well-known, the results obtained for the impulse responses and variance decompositions in (panel) VARs depend on the ordering of the VAR. For instance, Brooks (2014) recommends the very extreme case of an ordering, which, in our analysis, would correspond to the exact opposite of the one we have used for the baseline. Specifically, the Gini index and government spending are, respectively, entered as the first and last variables in the panel VAR.[18]

In terms of impulse responses, we find that the inequality impact of government spending and education expenditure is comparable to the baseline results.[19] A shock to social protection spending exhibits a weak and brief negative impact on inequality. As before, a government expenditure shock has a positive effect on the bottom half of the income distribution while a shock to education expenditure exhibits a positive effect on all percentiles considered, with the impact often persisting beyond the second year. Similar to previous findings, a positive health spending shock benefits the top percentiles but has no significant impact on inequality as well as the low- and middle-income groups.

Moving on to the distributive effect of tax shocks, we find that an unexpected rise in tax revenues often exhibits a statistically insignificant effect on inequality and, also, across the income distribution. Consistent with the baseline findings, the spending variables, along with taxation, still contribute to the variations in the income distribution variables.[20]

6.3. Inclusion of inflation in the VAR model

In this section we include inflation in our VAR model based on the insider-outsider theory which predicts that inflation may exhibit a contemporaneous impact on the Gini index. Specifically, the theory suggests that some workers are granted a pay rise (insiders) during periods of high inflation, while many others are not (outsiders); and this increases income inequality (see, e.g., Fischer, 1993; Braun, 1994; Davtyan, 2017). Similar to Gunasinghe et al. (2020), we assume that inflation is conditioned on the fiscal policy variables and any feedback impact will likely be with a time-lag. While the precise impact of taxation on inflation may be unclear, the literature generally indicates that inflation is conditioned on taxation. For example, Pitchford and Turnovsky (1976) observe that conventional macroeconomic theory predicts that a tax increase could decrease demand thereby lowering inflation. Nonetheless, Smith (1952) suggests a less straightforward outcome, since inflation could also rise as a consequence of tax hikes.

When looking at the impulse responses, we find that the total government spending shock still reduces the income gap between the rich and the poor, and also impacts positively on the percentiles representing the low- and middle-income groups. Similarly, an education spending shock continues to benefit all income groups while shocks to social protection and to health spending generally benefit the wealthy, with no detectable effect on the low- and middle-income groups. A tax shock mostly has no significant effect on inequality nor exhibits any positive impact on the percentiles under study. Finally, the results for the variance decomposition are comparable to our baseline findings.[21]

Table 5. Summary comparison of findings between MICs and HICs

	Gini		10th		50th		90th	
	MICs	HICs	MICs	HICs	MICs	HICs	MICs	HICs
Government Spending	–	–	+	+	+	. . .	. . .	. . .
Education	–	–	+	+	+	+	+	+
Social Protection	–	. . .	. . .	. . .		. . .	+	. . .
Health	. . .	–	. . .	. . .	. . .	. . .	+	–
Tax Revenue	. . .	–	. . .	. . .	. . .	. . .	. . .	. . .

Note: a minus (–) sign in the Gini columns means decrease in inequality following the shock; a plus (+) sign in the 10th, 50th and 90th columns means an increase in the income share held by the respective percentile; a dots (. . .) sign means no significant effect.

7. Discussion and conclusions

We employed a panel VAR framework at annual frequency estimated by the GMM to assess the dynamic distributional effects of government spending and tax shocks over a medium to long run within samples of 56 middle-income countries and 43 high-income countries for the period ranging from 2004 to 2014. In particular, we investigated the response of three alternative income distribution variables, namely the Gini index, the Theil index and the Atkinson measure of income inequality, to shocks imposed on social protection, health and education expenditures, as well as on government expenditure as a whole and on tax revenues.

In the Introduction, we set three specific questions: (i) how do unexpected changes in public spending components and taxes influence the income distribution in middle-income countries over the medium and long term? (ii) How do the effects of such fiscal shocks on inequality compare against high-income countries? (iii) What could fiscal policy do to reduce income inequality and is this different between high- and middle-income countries?

Regarding the first question, we found that positive shocks to total government and education spending tend to reveal the most pronounced distributional effects, while positive social protection shocks often exhibit brief equalizing impacts, and health spending shocks generally have no statistically significant effects on inequality. Moreover, surprise increases in total government and education expenditures impact favorably the low- and middle-income groups, but high-income groups benefit from unexpected changes in education spending as well. Generally, the effect of the shock on the various income groups remains statistically significant in a medium run for at least 3 years. Further, positive social protection and health spending shocks often increase the income share of those already in the top of the income distribution. Meanwhile, an unexpected rise in taxes largely exhibits no significant influence on inequality, and fails to benefit any particular income group.

It may be puzzling that health spending shocks increase the share of the relatively rich while still not having an impact on the overall measure of inequality. This could be due to the fact that the Gini coefficient is relatively more sensitive to changes in income in the middle of the distribution, which is 'more populated' and, therefore, does not capture fully the changes in income that health spending may have on the right tail of the income distribution. It is, therefore, an important message overall, for assessing the policy implications of fiscal policy, to look not just at a summary measure of the spread of the distribution, because any of them is more or less sensitive to changes in income at specific parts of the distribution. Looking at different parts of the distribution can shed important light on distributional effects that a summary index of the overall spread of the distribution is not able to capture.

As for the second question, Table 5 summarises the key findings for the two set of countries, showing the effect that the respective shock to each of the spending variable and tax revenue has to the Gini coefficient and the three parts of the income distribution.

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We found that shocks to total government and education spending continue to exhibit the most pronounced distributional effects also in the sample of high-income countries. In contrast to the findings for middle-income countries, however, in high-income countries, positive tax revenue and health spending shocks tend to exhibit a negative, albeit less evident, medium-run impact on inequality. Social protection spending shocks have no noticeable inequality-reducing effects in high-income countries, while they have some in middle-income countries. Total government and education spending shocks appear to increase the income share across the whole of the income distribution in both sets of countries. Contrary to the results for MICs, we find that in HICs health spending shocks tend to reduce the income share of the relatively rich group.

Regarding the third question, some considerations emerge. First, taking the empirical results as a guide for fiscal policies, the most direct implication of this study for middle-income countries is that unexpected increases in government spending may contribute towards making a dent in income inequality. As established by existing evidence, fiscal policy can be a potent tool for achieving government's redistributive goals. However, the income distribution does not respond homogenously to shocks in the various social expenditure components under study. Hence, the specific expenditure channel under consideration matters in terms of the impact on inequality overall and on different parts of the income distribution, as well as in terms of the implied time profile. Surprise increases in education spending appear to be most effective over a medium to longer run in achieving better distributional outcomes, while positive social protection shocks often exhibit short-lived inequality-reducing effects. Interestingly, the equalizing effects of positive health spending shocks are witnessed only in high-income countries.

Education spending, in addition to being relatively more strongly associated with reduction in inequality, appears to also be associated with increase in incomes across the whole distribution: even the income share held by the 90th percentile records increases as result of an education spending shock. This may reflect the prevalence, across HICs and MICs, of publicly provided education, and the expansion of government spending on education over the past decades in MICs. Education spending may, therefore, soften the potential opposition to the distributional impact of fiscal policy by certain sections of the population, as it is seen as reaching beyond the bottom and middle of the income distribution.

Somewhat the opposite argument could be made for health and social protection spending, which, if any, is associated with disequalizing effects, increasing the income share of the relatively rich in MICs. This may well be associated with some structural aspects of the health sectors in MICs or the type of expenditures within the overall health envelope, which are beyond the scope of this analysis. For instance, it could be the case that health expenditures go to pay for salaries in the health sector, which may employ relatively well-off individuals.

It is established that in developing economies, fiscal redistribution is weaker than in developed economies, given lower and less progressive taxes and spending. On the expenditure side, the share of social insurance spending (mainly pensions) that benefits higher-income groups is high (Bastagli et al. 2015). That may be the reason why we found that social protection spending shocks also benefit the relatively rich in MICs. On the tax side, revenue relies heavily on indirect taxation (which has limited redistributive impact) in developing countries.

In conclusion, it is also obvious that data availability issues posed a constraint to the time-span covered in this paper. Hence, the redistributive dynamics of the public spending shocks, as a total or by main components, and tax revenue shocks over a longer time-frame, need to be examined in future research as the required data become available. In addition, this paper focused on the social spending sectors, and hence, future extensions could examine the distributional impacts of shocks imposed on other sectoral expenditures. Finally, further theoretical research may aid in better disentangling and interpreting the patterns presented in the data.

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previous version under a slightly different title, Isiaka et al. (2022), was circulated in August 2022 as a discussion paper of the Department of Economics at the University of Reading and presented at a few seminars and conferences.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/S1365100524000142

Notes

1 Bielecki et al. (2021), among others, have recently highlighted the redistributive effects of monetary policy too. Studies on fiscal policy and wealth-inequality, such as Garbinti et al. (2020), have adopted a longer-run intergenerational perspective. Here we focus on fiscal policy and do not expand the analysis to either monetary policy or intergenerational inequality.
2 Moreover, the public might have changed their view on what is expected from government intervention, after the role that governments have assumed in dealing with the COVID-19 pandemic, which might have changed the way fiscal policy responses can be utilised.
3 We have also carried out analysis for further parts of the distribution, including the 20th, 40th and 80th percentiles. These results are reported in the online Appendix, section B.
4 Further methodological details and explorations are relegated to the online Appendix. Alternatively, one could check the discussion paper version of this article, Isiaka et al. (2022), and its more detailed Appendix.
5 Blanchard and Perotti (2002) focused on the dynamic effects of fiscal shocks on output, by specifying a three-variable VAR comprising government spending, a level of taxation measure and GDP. As is well-known, and as they note, the use of a small-dimensional VAR is justified for parsimony reasons and the degrees of freedom problem. Three-variable VARs are also employed by Love and Zicchino (2006), Saxegaard (2014) and IMF (2014).
6 In online Appendix A, further details are provided regarding the panel VAR identification as well as the transformation of the baseline model through forward orthogonal deviations.
7 Online Appendix B contains further results for the 20th, 40th, and 80th percentiles.
8 We employ panel data analysis due to the fact that the middle-income countries are relatively comparable vis-à-vis their public spending patterns (see IMF, 1995).
9 The countries are: Albania, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Bhutan, Botswana, Brazil, Bulgaria, Cabo Verde, Congo, Rep., Costa Rica, Ecuador, Egypt, El-Salvador, Eswatini, Fiji, Georgia, Ghana, Guatemala, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz, Lesotho, Malaysia, Maldives, Mexico, Moldova, Mongolia, Morocco, Namibia, Nepal, Nigeria, Pakistan, Papua New Guinea, Peru, Philippines, Russia, Serbia, South Africa, Sri Lanka, Tanzania, Thailand, Tunisia, Turkey, Ukraine, Venezuela, Vietnam, and Zambia. These are countries that the World Bank categorises as middle-income countries. However, not all middle-income countries in the World Bank category are included here due to lack of data on public sector spending and/or lack of data on inequality and the income distribution in the datasets employed for our analysis.
10 Here, we consider a panel of 43 high-income countries, as classified by the World Bank, over the same annual-frequency period of 2004–2014, and for which data on public sector spending and inequality are available. The World Bank classification is based on estimates of gross national income (GNI) per capita in 2021. Countries classified as high-income have a minimum GNI per capita of $13,205. Specifically, the high countries we considered are: Australia, Austria, Bahamas, Barbados, Belgium, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Seychelles, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States, and Uruguay.
11 Results presented in the online Appendix show that government spending shock also benefit the 80th percentile.
12 As shown in online Appendix Figure D4, the health spending shock is further associated with a sharp increase in the share of income held by the 80th percentile, by 0.033 percentage points. The effect reaches a peak in the immediate year after the shock at 0.054 percentage points and persists for four additional years. However, health spending shocks do not exhibit a significantly positive effects on the remaining percentiles considered.
13 The related tables and figures with full results are available in online Appendix C.
14 For a detailed discussion of the properties of these inequality measures, amongst others, see Cowell (2000). Data on both the Atkinson index and the Theil index are sourced from the Global Consumption and Income Project Database.
15 As mentioned, we provide in online Appendix B further details regarding the results obtained for the 20th, 40th, and 80th percentiles.
16 For example, the IMF World Economic Outlook Database (October 2020 Vintage) reveals that between 2004 and 2014, Azerbaijan recorded, on average, a budget surplus of 5.76%.
17 See detailed results in the extended Appendix to the discussion paper version of this article, Isiaka et al. (2022), section D there.

18 As a fallout of the new ordering, the response of inequality to government spending becomes constrained to zero in the first period.
19 See detailed results in the extended Appendix to the discussion paper version of this article, Isiaka et al. (2022), section D there.
20 See detailed results in the extended Appendix to the discussion paper version of this article, Isiaka et al. (2022), section D there.
21 See detailed results in the extended Appendix to the discussion paper version of this article, Isiaka et al. (2022), section E there.

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