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Original research article

Fossil fuel subsidy reform, distributive justice and civil unrest

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ABSTRACT

This article explores how fossil fuel subsidy reform – widely regarded as being essential for reducing carbon emissions – may contribute to societal instability by generating grievances related to fuel insecurity and perceptions of unfair costs. The article explores the role that 'distributive justice' plays as a moderating factor in the relationship between reductions in fossil fuel subsidies and social unrest, based upon a new dataset combining data on fossil fuel subsidies, incidents of energy-related civil unrest, and measures of the equitable distribution of resources within society, covering the years 2015 to 2022. The article finds that fossil fuel subsidy reform increases social unrest in countries where distributive justice is lacking. Finally, the article explores the policy implications of these findings, suggesting that fuel subsidy reform should be accompanied by progressive social measures which not only protect the most vulnerable but also reflect the principle of 'fairness'.

1. Introduction

The reduction or reform of fossil fuel subsidies – aimed at narrowing or eliminating the gap between energy production and consumption costs – is a prominent theme in international climate change diplomacy because of the role that it potentially plays in reducing emissions and encouraging renewable energy use. It is also an important fiscal agenda for many countries, given the significant value of fuel subsidies. However, subsidy reform has generated serious unrest in many countries – and sometimes upheaval – as a result of fuel price inflation, and in many cases governments have suspended or reversed reform in response to this unrest. Exploring the societal conditions in which instability related to fuel price reform may occur is therefore important in order to better understand the domestic political challenges of implementing international climate change commitments and undertaking fiscal reform in relation to energy.

This article explores how fossil fuel subsidy reform may contribute to instability by generating or exacerbating grievances related to broad social and political societal conditions. It analyzes a range of social and political factors associated with instability in the context of fossil fuel subsidy reform, focussing on the overarching question: Does distributive justice – the socially just allocation of resources, goods and opportunities – moderate the effect of fossil fuel subsidy reform on civil unrest?

The article demonstrates, through cross-national statistical analysis, that the level of distributive justice in societies is highly relevant to the occurrence of instability in relation to fuel subsidy reform. In countries where distributive justice is poor or scarce, the reduction of subsidies for fossil fuels has a heightened impact on society, leading to a rise in social unrest. This is a function of the worsening living conditions of a larger proportion of people who suffer individual and household hardship, and also potentially an expression of relative deprivation grievances related to socio-economic inequalities. The article concludes by exploring the implications of this for better anticipating and managing the conflict and opposition which can be generated by fossil fuel subsidy reform policies. This is relevant to the resilience of climate change commitments, the challenges of fiscal reform, and the importance more broadly of justice in terms of the social costs of the green transition. In broader perspective it therefore highlights the potentially destabilizing effects of the 'green transition' with implications both for justice and the resilience of international climate change commitments. The current energy crisis, which has seen unprecedented levels of fuel subsidies in parallel with increasing societal instability, highlights the politically sensitive nature of addressing this obstacle to climate change action and the timeliness of this topic. This paper addresses research gaps which exist in terms of the impact of fossil fuel subsidy changes, with reference to societal conditions. Its originality comes from its novel theoretical focus – which tests the relevance of distributive justice in relation to instability linked to fuel price reform – and the broader implications of this, as well as from the wide range of data captured by the research design.

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2. Fossil fuel subsidy reform

In this article fossil fuel subsidies are defined as financial interventions in energy markets which are provided either to producers or consumers in order to reduce or limit the cost of fossil fuels used for domestic cooking, heating and lighting, and for operating vehicles. It is widely believed that these subsidies obstruct efforts to meet climate change reduction targets, in addition to contributing to other social and economic ills [1–6]. Subsidies shield consumers from the true cost of energy since they are paying below the market value, which encourages consumption. They also represent a fiscal burden on many countries, absorbing public resources which could be used for other purposes, and obstruct the development and take-up of renewable energy sources since the financial competitiveness of renewable energy is dampened by the availability of subsidized fossil fuel products. It is generally the fiscal problems associated with large fossil fuel subsidies which lead governments to attempt to reform or reduce subsidies, rather than the ecological benefits, although the latter attract significant attention given their relevance to the political challenges of addressing climate change.

Two different methodologies are used to measure and define subsidies [7–9] and as a result of this assessments of their value vary widely. Firstly, the measurement of explicit subsidies – which is used in this article – is based on the absolute value of financial interventions and the 'price gap' that this generates between production and consumption costs. These interventions can include fixing prices or capping price increases, exemptions from taxes, assistance for specific groups of consumers, and support for energy companies [10]. Secondly, an alternative definition includes the wider impacts and costs of fossil fuel use which are exacerbated by subsidies – such as the public health consequences of pollution – which are counted as externalities and thus regarded as the 'true costs' of subsidies. The IMF [10] describes these broader costs as 'implicit subsidies', since they include the wider impacts of subsidizing fossil fuels as well as the price gap between production and retail values. Although these are presented as alternative 'definitions', they represent fundamentally different understandings of fuel subsidies and their impact. By including externalities, the IMF approach involves a far wider range of impacts and costs linked to carbon emissions, given that these are inflated by subsidies. Therefore, defining subsidies — especially the implicit approach — and their impact is not without controversy [11].

Using the wider definition, the IMF [10] finds that fossil fuel subsidies were US$7 trillion globally in 2022, which represents 7.1 % of GDP. Existing work [12–14] demonstrates the broad impact of undercharging for fossil fuels using this definition, which includes a range of externalities and side-effects. In contrast, the International Energy Agency (IEA) [15], using the narrow price-gap definition, found that global fossil fuel consumption subsidies were US$1 trillion in 2022, an all-time high and double the previous year. This was in large part due to the war in Ukraine and cuts in Russia's fuel supplies to some regions, which had a sharp inflationary impact on energy prices. Higher subsidies were a response to this on the part of many governments, and they are expected to decline in the shorter term. Nevertheless, the longer-term trajectory – to 2030 – is expected to reflect an increase beyond the 2022 peak, due to the share of fuel consumption in emerging markets continuing to increase [10]. The value of subsidies also fluctuates, depending on demand and energy production and supply costs; thus, global subsidy values declined during the Covid-19 pandemic in 2020, and increased during the energy crisis of 2022. Subsidy reform is particularly sensitive – and often stalled or reversed [16] – in times of soaring international energy prices as national authorities seek to cushion the impact of this upon consumers.

The reasons why fuel subsidies are so well-established are multiple. In most countries they reflect a tradition of securing and protecting the energy sector as a vital national interest, over which governments generally seek to maintain control. In addition, subsidies reflect the embedded political privileges which are bestowed upon the energy industry. Moreover, these subsidies allow governments to insulate consumers from true prices and rising costs – especially when prices soar – which provides a form of social protection and a device to avoid or manage the political problems which arise when energy costs rise sharply. Thus, the IEA [15] notes that some subsidies "can be defended as social or political necessities, given the hardship that full exposure to market-driven prices could have caused". Arguably, subsidies also provide access for lower-income communities to cleaner, less polluting heating and cooking energy such as liquified petroleum gas [17,18]. Thus, without subsidies to gas and electricity, in the absence of alternative support, poorer communities revert back to burning solid fuels, with negative local impacts upon health [19].

3. The impacts of subsidies and the case for reform

Fossil fuel subsidies reduce energy costs and therefore encourage consumption, and so contribute to climate change emissions. The precise environmental impact of fossil fuel subsidies is, however, debatable [14]. Subsidies also represent a fiscal burden for many countries since their funding draws upon public revenues, which in turn constrains expenditure which could be used elsewhere. In 2022, for example — a peak year in the value of subsidies — IMF data [20] indicates that the value of explicit subsidies as a proportion of GDP was 2.5 % in Argentina, 1.5 % in China, 1 % in Germany, 6.2 % in Indonesia, 4 % in Russia, 13.8 % in Saudi Arabia, 5.9 % in Turkey, 1.7 % in Vietnam, 3.6 % in Ethiopia, 10.5 % in Iran, and 1 % in Morocco, and the number of countries committing >1 % of GDP to these subsidies was far larger. Subsidies also make sustainable energy less competitive and thus less attractive as an alternative to fossil fuel use. Moreover, existing research [12,15,21–24] provides ample evidence to suggest that fuel subsidies are not an efficient mechanism to protect the most vulnerable or poorest communities, because the benefits disproportionately accrue to higher income groups. This benefit leakage represents a serious challenge to the so-called social protection rationale for subsidies; Dartanto [25], for example, finds that, in some cases, a 100 % removal of subsidies could result in a significant reduction in poverty because of the re-investment opportunities which would arise from saved public revenue. In various national settings, research demonstrates a strong economic case for fossil fuel subsidy reform [26], which is reinforced by the opportunity to invest savings in the renewable energy sector. However, fuel subsidies are arguably not entirely negative since they alleviate the impact of soaring fuel prices upon households and facilitate the shift away from the use of hazardous solid fuels for cooking and heating.

There is very wide agreement that fossil fuel subsidies obstruct progress towards reducing climate change and therefore that effective reform would bring significant climate change benefits [1–6], most obviously because consumers use less energy when it is more expensive. Reform can also promote renewable energy sources [4,27] because it would create incentives for greater investment in and uptake of renewable energy, and financial savings from fossil fuel subsidy reform could become available for subsidizing the renewable sector. Although some doubts about the knock-on effects of fossil fuel subsidy reform upon renewable energy [28] and its climate benefits [29] have been raised, the general consensus is that subsidy reform is integral to effective climate change action and that it would also bring other social and fiscal benefits. Thus, the IPCC [30: 79] observed that "Removing fossil fuel subsidies would reduce emissions, improve public revenue and macroeconomic performance, and yield other environmental and sustainable development benefits such as improved public revenue, macroeconomic and sustainability performance…Fossil fuel subsidy removal is projected by various studies to reduce global CO_2 emissions by 1–4 %, and GHG emissions by up to 10 % by 2030, varying across regions."

International development and climate change negotiations have sought to address fossil fuel subsidies for some years, given their detrimental social, fiscal and ecological impact. In 2009 the G20 agreed "to rationalize and phase out over the medium term inefficient fossil fuel

subsidies that encourage wasteful consumption". This grouping also agreed to a process of peer review and monitoring to encourage and support reform at the national level [31]. The agreement to phase out fuel subsidies was reaffirmed in 2012 by the G20 and at the UN Conference on Sustainable Development in the same year, and it is reflected in Sustainable Development Goal 12.c. At COP26 in 2021, 197 countries agreed to accelerate fuel subsidy reform efforts, and the Glasgow Climate Pact [[32]: para. 36] called for the "phase-out of inefficient fossil fuel subsidies, while providing targeted support to the poorest and most vulnerable in line with national circumstances and recognizing the need for support towards a just transition". Despite this apparent international momentum, commitments to fossil fuel subsidy reform have not been met and the political challenges inherent in reform have arguably become more acute in light of the 2022 energy crisis when many governments introduced or increased subsidies to protect consumers from spiralling costs. Moreover, the monitoring and reporting of fuel subsidy reform, despite international agreement, has not been widely implemented [33].

Although subsidy reform is often framed as a tool for addressing climate change and meeting omissions targets — especially in international settings — fossil fuel subsidy reform is generally undertaken for fiscal reasons [16]. The association between fossil fuel subsidy *reform* and climate policy should, therefore, not be overdrawn. The political challenges and consequences of reforming fossil fuel subsidies are widely debated [34–36] and decisions to undertake such reform can never be made solely on ecological grounds [6,9,23,37]. Vested interests, the political importance of the energy sector, the perceived importance of subsidies for social protection, and the risk aversion of governments have obstructed reform in many countries. As a result, progress on meeting fossil fuel subsidy reform targets has been extremely slow [15,38,39]. The global subsidy peaks of 2022 – when many governments responded to exceptionally high fuel supply prices and supply disruption – suggest that the challenge is formidable, even though dozens of countries undertook reform between 2015 and 2020 [6].

Fossil fuel subsidy reform is only one amongst many policies relevant to managing or reducing climate change — and governments do not necessarily undertake FFSR (primarily) for ecological reasons — so the political dynamics and controversies related to FFSR are not necessarily the same as those associated with other climate change policies. Yet the link between FFSR and the broader political challenges of the green transition is arguably still valid. Fossil fuel subsidy reform generally involves an increase in energy prices for consumers, which is a phenomenon shared with other climate change mitigation policies. How these increases in costs are distributed and managed can generate grievances and sometimes instability, and thus the significance of FFSR goes beyond the fiscal changes narrowly involved. Moreover, in some cases governments *have* framed FFSR as a climate change reduction policy, and thus the impact of such policies has relevance to other climate-related policies, such as carbon taxes. Finally, FFSR is explicitly linked to climate change mitigation efforts in international policy settings where states commit to emissions reductions, and thus FFSR becomes a part of the broader efforts undertaken by governments in the climate change area — even if they are more motivated by fiscal considerations — and is a feature of public debate about climate action.

4. Fuel price-related instability

Fossil fuel subsidy reform generally has an inflationary impact upon energy prices because the gap between supply and consumption costs is reduced or eliminated. This can result in unevenly distributed price shocks [[30]: 79, [40]] which have a significant negative impact upon households, depending upon the proportion of household income committed to essential fuel purchases. In the absence of social protection packages for economically disadvantaged groups of people, this has the potential to create or seriously exacerbate hardship. This generates absolute and relative social grievances which can, in conjunction with other factors, result in instability [41,42]. According to the IEA [15], "subsidies are mainly concentrated in emerging market and developing economies, and more than half were in fossil-fuel exporting countries", and it is such countries which are more likely to reflect other conflict drivers. Theoretical insights from related work on fuel and food suggest that fuel price increases can generate instability through a number of potential inter-linked mechanisms [43,44]. Fuel price increases can exacerbate grievances against governments based upon absolute deprivation, whereby significant numbers of people protest against the direct impoverishment or cost of living increases they are experiencing. Price increases can also provide a catalyst for instability linked to broader patterns of contentious politics, where fuel price increases act as a focus for grievances related to government incompetence, corruption, or absence of accountability. Moreover, fuel subsidy reform can contribute to grievances related to horizontal inequalities, where some groups feel that they are compelled to shoulder an unfairly large proportion of the price increases, especially where there is a general absence of public access to economic opportunities. However, while this existing work effectively demonstrates the link between fuel price increases and instability – whether as a part of subsidy reform or not – it does not adequately explain the socio-political conditions that exacerbate the effect of fossil fuel subsidy reforms in terms of social unrest.

The impact of fossil fuel subsidy reform – whether it receives public support or is met with opposition and instability – is shaped by social, economic, political and institutional factors. Theoretically, these factors may include household spending patterns and the proportion of household income committed to essential fuel consumption, the provision of public goods and social welfare, public perception of government competence and accountability, and the manner in which subsidy reform is managed in conjunction with efforts to mitigate rising fuel prices. However, the impact is insufficiently understood across different contexts, and so the consequences of subsidy reform cannot be readily anticipated.

In some settings subsidy reform has been highly destabilizing, triggering violent protest and evolving into broader political opposition. In Nigeria [45–50] subsidy reform has been a recurring source of major disruption, and in 2012 reform plans contributed to protests across the country, resulting in multiple fatalities and a national political crisis. More recently, President Tinubu's decision to implement economic reforms, including the reduction of fuel subsidies, resulted in widespread protests across the country in 2024 [51]. The removal of fuel subsidies in Kazakhstan in 2022 triggered deadly protests which escalated into a broader challenge to the government, resulting in the unprecedented intervention of Russian 'peacekeepers' under the auspices of the Collective Security Treaty Organization [52,53]. Plans to increase tax on fuel as a part of subsidy reform in France contributed to widespread unrest – the *gilets jaunes protests – in 2018–19* which escalated into a major political challenge for the government [54,55]. In Indonesia, in 2022, plans to cut fuel subsidies resulted in major protests in multiple cities [56], even though the country is often discussed as a case of successful fuel subsidy reform [57]. Serious unrest associated with fuel pricing reform has also been experienced in Egypt, Myanmar, Mozambique, Pakistan, Zimbabwe, Sudan, Haiti, Lebanon, Ecuador, Iraq, Chile, and Iran, amongst other countries, in recent years [41,42].

In many such cases instability played a direct role in government decisions to suspend or reverse subsidy reform policies, demonstrating that governments generally prioritise their domestic political survival over international climate commitments. Research has therefore identified a tension between international commitments to subsidy reform and the national 'social contract' which underpins the responsibility of governments to the welfare of their citizens [27,49]. Fuel-related instability can therefore constitute a serious obstacle to subsidy reform, and it is therefore important to understand in what circumstances fuel subsidy reform – or the prospect of reform – is more likely to result in societal instability, in order to anticipate challenges and manage the

consequences in a manner which helps countries to meet their fuel subsidy reform commitments and centralise justice in their climate policies.

Existing work demonstrates a strong link globally between increases in fuel prices and protests [44], and some of this specifically focuses upon the impact of fossil fuel subsidy reform in different contexts [37,42,58]. A closely-related area of research focuses upon the societal response to increases in carbon taxes [59–63]. This work identifies a strong link between fossil fuel subsidy reform and protests, based upon the social grievances that are generated amongst communities hit by higher prices. It also demonstrates that the impact of fuel subsidy reform – whether it is accepted or is met with significant resistance – is shaped by local social, economic and political factors, and the manner in which national authorities manage subsidy reform in conjunction with other policies. However, there are significant gaps in understanding about the conditions that make instability more likely and the broad implications of this for the green transition. Notably, an ongoing research problem relates to the manner in which resistance to subsidy reform – including violent protests – occurs not only in the most fuel insecure societies or those most deprived in absolute terms, but also in a broad range of social settings including countries experiencing economic growth and increasing national income levels.

In addressing this research puzzle, the theoretical framework for this paper focuses not only on the relationship between fuel protests and absolute poverty, but rather the significance of distributive justice in societies for the implementation of peaceful fossil fuel subsidy reform: the extent to which public goods and access to resources are equally distributed. This is an important theoretical focus for two reasons. Firstly, it is relevant not only to low-income societies in the Global South, but also to middle and even high-income countries where economic distribution may be skewed and pockets of relative deprivation persist. It therefore captures advanced economies such as the US and France, where resistance to fuel subsidy reform is potentially significant despite the aggregate high-income level of the countries as a whole, relative to international standards. Secondly, distributive justice raises an important theme not fully captured by absolute measures of deprivation: the possible implications this has for perceptions of justice and injustice. This is an important element of the green transition, because perceptions of the 'fairness' of the distribution of the costs of climate action are key to the response of people to policies aimed at reducing climate change, and also key to whether these policies are likely to be feasible.

We therefore propose that distributive justice moderates the effect of fossil fuel subsidy reform on social unrest. This relationship is represented graphically below (Fig. 1).

5. Research design

To explore the role that distributive justice plays as a moderating factor in the relationship between reductions in fossil fuel subsidies and social unrest, we have compiled a new dataset. This dataset combines data on fossil fuel subsidies from the International Monetary Fund [64], incidents of energy-related civil unrest [65], and assessments of the equitable distribution of resources within societies [66]. The IMF's data on fossil fuel subsidies includes empirical observations for 174 countries (a list of these countries can be found in the Appendix, Table 1) spanning the years 2015 to 2022. Our data on civil unrest are obtained from the Armed Conflict Location & Event Data Project [65,67] and we therefore exclude country-year observations for which ACLED does not cover. It is also important to note that the timeframe covered by ACLED [65], which we relied upon to code event data related to energy-related civil unrest, lacks uniformity across different regions. Consequently, our final dataset takes the form of an unbalanced panel data with 1318 country-year observations.

5.1. Dependent variable

The dependent variable, civil unrest, represents the total number of contentious political events related to energy-related issues. These events encompass all typologies of events coded in ACLED [65], including instances of violent attacks, demonstrations, riots, and other politically significant non-violent occurrences [[65]: 4]. Energy-related claims pertain to grievances stemming from limited access to various types of energy and its cost, including the energy sector's failure to fulfil promises related to pricing.

To acquire these data, we initially selected all ACLED events that featured energy-related terms in their narrative event descriptions. The keywords used for this initial selection include 'fuel,' 'gasoline,' 'diesel,' 'kerosene,' 'coal,' 'gas,' 'energy,' 'elect,' 'price increase,' and 'subsidies'. Through this process, we obtained a total of 57,211 data points, along with several false-positive observations. For instance, this procedure selected events with descriptions like "high state repression fueled protests (…)", which were subsequently excluded from the analysis.

As a second step, we manually coded a binary variable, assigning a value of 1 when the description of a given event indicated the presence of political claims related to limited access to various types of energy and grievances against the energy sector in a more general sense, and 0 otherwise. Finally, we generated a count variable, which represents the sum of the number of energy-related contentious political events per country-year. Fig. 2 below illustrates that, in the final version of our dataset, civil unrest is an over-dispersed, positively skewed count variable with a mean of approximately 19 and a median of zero energy-related contentious political events and a standard deviation of 121

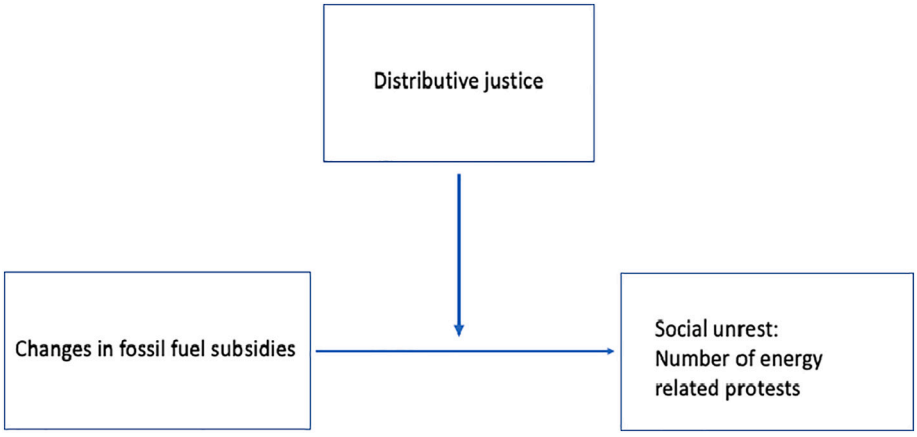

Fig. 1. The effect of fossil fuel subsidy reforms on social unrest moderated by distributive justice.

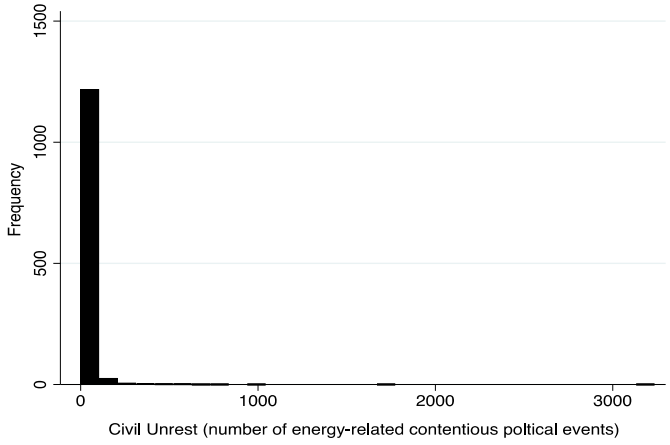

Fig. 2. Frequency distribution of the dependent variable: *Civil unrest.*

such events per country-year.

5.2. Core explanatory variables

The first independent variable, 'Change in fossil fuel subsidies,' is obtained from the International Monetary Fund Fossil Fuel Subsidies Data [64]. We chose the IMF's data on fossil fuel subsidies over the data available from the International Energy Agency due to the IMF's broader geographical coverage. The IMF dataset identifies the explicit subsidy for a fuel product in a given sector, in a given country, as the sectoral unit supply cost minus the fuel user price, multiplied by the sectoral fuel consumption in billions of US dollars [64]. The sum of all subsidies for fuel products provides the total explicit subsidy in each country-year of observation. Explicit fossil fuel subsidies are commonly discussed amongst policymakers and in the literature as they reflect fiscal costs, either directly in the government budget (e.g., rebates to households for energy purchases) or indirectly as losses/reduced profits at state-owned enterprises [[20]: 6]. This paper focuses on the effect of changes in explicit subsidies. Therefore, we use a variable that subtracts the explicit subsidies available in a given country in a specific year from the explicit subsidies available in that same country in the previous year to generate our first main independent variable: 'Change in fossil fuel subsidies'. However, we also test our expectations against an indicator that measures the relative size of the change in subsidies as a proportion of GDP. We do so to account for the variation of the size of economies across countries and report the results — consistent with the analysis below — in the Appendix (Table 7, Fig. 7). It is important to note that we are measuring changes in fossil fuel subsidies, and not fossil fuel reform, and that the value of subsidies can go up and down without government interventions based on changes in international prices and exchange rate changes. Nevertheless, subsidy values and reductions in subsidies are also a function of government fossil fuel subsidy reform policies, which can have an inflationary impact on consumer prices.

Fig. 3 below reports the distribution of the frequency of changes in fossil fuel subsidies in the final version of our dataset. The vast majority of observations fall at zero, indicating that most observations report no change in fossil fuel subsidies from the previous year. On average, however, in the sample of years and states observed, fossil fuel subsidies have decreased by 0.08 billion dollars. Ninety-nine percent of observations report a change in fossil fuel subsidies ranging from minus ten billion dollars per year to around plus 9 billion dollars. In this variable, any negative value indicates a decrease in fossil fuel subsidies in a given country from the previous year, while any positive value indicates an increase in fossil fuel subsidies in a given country from the previous year.

To test our argument, we interact the variable 'Change in fossil fuel subsidies' with a measure of distributive justice. Our definition of

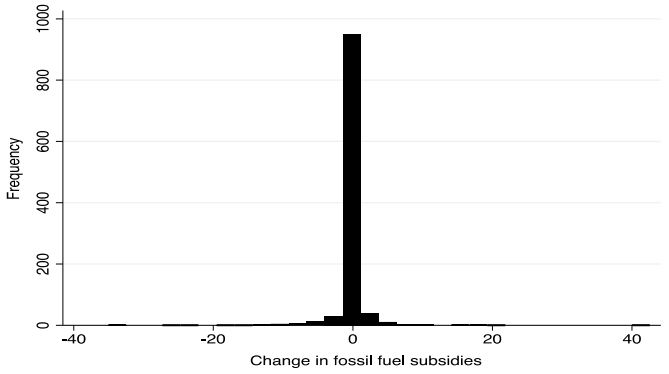

Fig. 3. Frequency distribution of the main independent variable: *Change in fossil fuel subsidies.*

distributive justice focuses on the allocation of resources, goods, and opportunities within a society [68]. To proxy this multifaceted concept, we utilize a measure of equitable resource distribution obtained from the V-Dem 'Varieties of Democracy' project data, specifically v2xeg_eqdr [66]. Consistent with our definition, this V-Dem component assesses the extent to which both tangible and intangible resources are distributed in a given society. V2xeg_eqdr takes into account measures of poverty and the degree of equality or inequality in the distribution of goods and services in a given society, and the distribution of power amongst different socio-economic groups and genders [[66]: 57]. In a society characterized by high distributive justice, basic needs are met to enable individuals to effectively exercise their rights and freedoms, and resource inequality is minimized as it undermines the ability of disadvantaged populations to participate meaningfully [69]. Fig. 4 shows that distributive justice ranges from 0.015 to 0.987, where lower values represent countries with less equal resource distribution and higher values represent countries with more equal resource distribution.

5.3. Confounders

Existing literature suggests several potential confounders that might jointly affect social unrest, distributive justice, and fossil fuel subsidies. First, we consider patterns of economic decline in the states in our sample, using a measure of economic decline from the Fragile States Index [70]. This index accounts for government debt, interest rates, inflation rates, productivity, GDP, unemployment, and public perceptions of the state of the economy [70]. Economic decline can exacerbate existing distributive inequalities within a society and motivate individuals to protest in relation to essential energy-related spending. Economic decline might also be correlated with lower fossil fuel

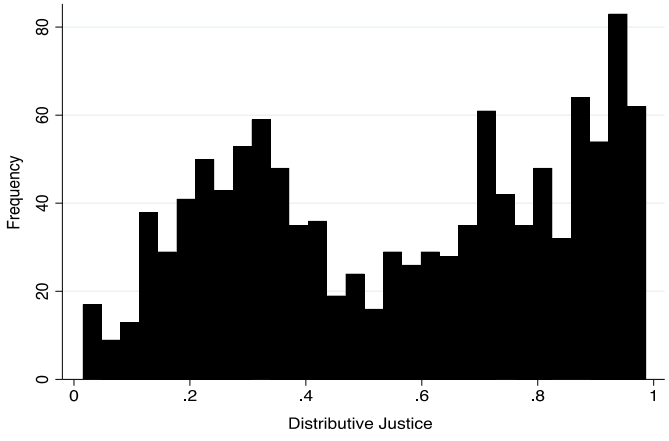

Fig. 4. Frequency distribution of the moderating variable: *Distributive Justice.*

subsidies as governments might reduce subsidies to cut budgetary expenditures [71].

We also control for the presence of group grievances, obtaining this measure from the Fragile States Index [70]. The Group Grievance indicator in this data measures divisions and schisms between different groups in a given state, particularly those based on social or political characteristics. This measure of group grievances may also have a historical component, in relation to perceived past injustices, sometimes spanning centuries, that influence and shape the group's role in society and its relationships with other groups. Group grievances are likely to be related to the capacity of significant portions of the population to access services or resources and play a meaningful role in the political process. Therefore, group grievances are likely to be correlated with distributive justice and social unrest in general. Fossil fuel subsidies might also be correlated with group grievances, particularly in cases where political divisions amongst groups are connected to environmental claims.

We then control for states' respect for human rights and fundamental freedoms using the Human Rights and Rule of Law Indicator in the Fragile States Index [70]. This indicator assesses the relationship between the state and its population in terms of protecting fundamental human rights and observing and respecting freedoms by considering state repression and abuse of legal rights [70]. States' capacity to fully respect the human rights of their citizens is likely to be connected to grievances that motivate unrest and to the extent to which these rights are equally respected across society, and thus to distributive justice. Respect for human rights and the implementation of fossil fuel reforms may also vary together depending on some unobserved state-level factors that lead states to comply with international regulations [72]. The relationship between human rights observance on the part of states and protest is not straightforward, however, and the response or anticipated response of governments can have a bearing on the willingness of people to participate in civil disturbance and thus the occurrence or frequency of protests. Protests may be less frequent in repressive states because of the fear of violent crackdown, for example. However, crackdowns can in turn provoke backlash movements, even in illiberal societies, leading to more widespread protests.

In our analysis, we also account for the proportion of the population that is undernourished. We obtain data on the prevalence of malnutrition by country-year from the Food and Agriculture Organization [73]. Higher percentages of malnutrition are likely to be indicative of states' higher fiscal constraints (and lower capacity to provide pubic goods). On the one hand, lower welfare capacity might be connected to civil unrest in general. On the other, in times of fiscal constraint governments, may reduce subsidies to cut budgetary expenditures [71].

Finally, we employ various time control strategies since civil unrest events are more likely to recur when there is a recent history of them. The time controls included in the main analysis consist of a variable measuring the years since the last energy-related civil unrest event occurred and its cubic polynomial approximation [74].

6. Empirical analysis

With the dependent variable 'civil unrest' being an over-dispersed positively skewed count variable, we estimate a negative binomial model. Negative binomial regression is a generalization of Poisson regression that relaxes the restrictive assumption that the variance is equal to the mean in the distribution of the outcome variable and is, therefore, appropriate when over-dispersion is observed in the dependent variable. Model 1 (Table 1 below), is the full model including all the controls discussed above. This model contains standard errors clustered by country, as the variance may systematically differ across states.

Table 1 displays the results of the negative binomial model that examines the conditional effect of changes in fossil fuel subsidies on civil unrest, depending on a state's level of distributive justice. It shows that the effect of changes in fossil fuel subsidies on civil unrest is contingent upon the level of distributive justice. This finding supports the hypothesis that the levels of distributive justice in a country significantly modify the impact of fossil fuel subsidy reforms on the intensity of civil unrest. Consequently, this finding suggests that states may be able to minimize civil unrest as a consequence of fossil fuel subsidy reforms if they have or put in place an effective distributive justice system that enables the population to more equitably overcome the challenges arising from the reforms.

Table 1
Negative binomial regressions examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice.

Variables	Model 1)
	Civil unrest events
Change in fossil fuel subsidies	−0.189***
	(0.029)
Distributive justice	−0.867***
	(0.584)
Change in fossil fuel subsidies * distributive justice	0.230***
	(0.061)
Economic decline	−0.074
	(0.075)
Group grievances	0.353***
	(0.074)
Respect of human rights	−0.452***
	(0.072)
Proportion of undernourished	0.002***
	(0.000)
Years since last civil unrest	−2.971***
	(0.399)
Spline 1	−0.012
	(0.012)
Spline 2	−1.113***
	(0.336)
Spline 3	0.619***
	(0.228)
Constant	4.528***
	(0.803)
Observations	863

N.B. Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

The interaction term is positive and statistically significant with $p < 0.01$. This indicates that the effect of fossil fuel subsidies on civil unrest across different levels of distributive justice is significantly different from zero for most values of changes in fossil fuel subsidies. The coefficient "Change in fossil fuel subsidies" outside of the interaction term shows the effect of changes in fossil fuel subsidies on civil unrest when distributive justice is at its minimum (at zero). This coefficient is negative and significant, supporting our expectations that a decrease in fossil fuel subsidies increases the number of civil unrest events at lower levels of distributive justice. The coefficient of "Distributive justice" outside of the interaction term shows the effect of distributive justice on civil unrest when changes in subsidies do not occur. The coefficient related to this scenario is not statistically significant, which prevents us from drawing conclusive theoretical implications regarding the effect of distributive justice on social unrest when changes in subsidies are equal to zero.

We conduct a z-test to verify whether there is a significant statistical difference between the effect of changes in fossil fuel subsidies when distributive justice equals zero versus scenarios where states are characterized by higher levels of distributive justice, as proxied in the interaction term. This z-test returns highly statistically significant results (see the Appendix, Test 1). Consistent with the findings in Table 1, the finding of the z-test indicates that a significant statistical difference exists for the effect of changes in fossil fuel subsidies on the expected number of civil unrest events across different levels of distributive justice.

The results for the interaction term reported in Table 1 can be better

interpreted by plotting the expected numbers of civil unrest events across different levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars.

At the lowest level of distributive justice (0), a decrease in fossil fuel subsidies by ten billion dollars increases the predicted number of civil unrest events by almost 200 events when compared to the scenario in which fossil fuel subsidies increase by 10 billion dollars. As distributive justice increases, a decrease of 10 billion dollars in fossil fuel subsidies is associated with smaller counts of civil unrest events until it is indistinguishable from the predicted number of civil unrest events expected where fossil fuel subsidies are actually increased up to 10 billion dollars.

Overall, Fig. 5 shows that in states with higher distributive justice the expected intensity of civil unrest as a consequence of fossil fuel subsidy reform is not higher than in cases where these reforms did not take place. In contrast, in states with lower distributive justice, cuts in fossil fuel subsidies provoke a sharp average increase in the expected number of civil unrest events when compared to a scenario where the subsidies were actually increased.

N.B. Fig. 5 plots the predicted number of civil unrest events across different levels of distributive justice and changes in fossil fuel subsidies (decrease and increase by 10 billion dollars) on the basis of the full model in Table 1 (Model 1).

The findings related to the control variables largely align with the expectations discussed in the confounder section above. Specifically, the coefficient for the proxy of group grievances is statistically significant and positively correlated with our measure of civil unrest events. This provides evidence that pre-existing group-level grievances lead to a higher level of contentious political mobilization, especially concerning energy-related claims. The coefficient for states' respect for human rights is significant and negatively correlated with civil unrest. This indicates that states that respect human rights tend to generate fewer grievances that would otherwise motivate contentious political mobilization. The coefficient for the proportion of undernourished population is positive and statistically significant. This suggests a connection between states' inability to provide basic welfare measures and the propensity of citizens to engage in contentious political behaviours. Finally, as expected, the results also demonstrate that the fewer years that have passed since the last episode of civil unrest, the higher the expected number of civil unrest events becomes.

6.1. Robustness checks

The supplementary material in the Appendix includes a battery of robustness checks to ensure that our results are not a statistical artifact of our modeling choice. The main findings do not change with a set of alternative model specifications. In particular, the results remain robust to an alternative time control strategy (Appendix, Table 2, Model 1 and Fig. 1) and they remain virtually unchanged when we use an alternative measure of distributive justice (Appendix, Table 3) extracted from the Fragile States Index [70]. This measure reflects the extent to which public services are equally accessible across society and it captures our concept of distributive justice as it assesses the presence of basic state functions and services that serve the people and the extent to which these services are provided across different strata of society. For example, it indicates whether the state primarily serves the ruling elites while failing to provide comparable levels of service to the general populace [70]. The results remain consistent also when substituting the absolute change in fossil fuel subsidies with a measure that allows one to account for the weight of this change relative to the GDP of a given country (Appendix, Table 7, Fig. 7).

We also test the robustness of our main finding when including controls for real GDP in 2021 USD billions and when including a dichotomous variable equal to one for oil producing countries and 0 otherwise obtained from OPEC data (Tables 8–10, Figs. 8–10). We also test the robustness of the findings against alternative sample compositions. Specifically, we examine whether our main finding holds in both the Global South and the Global North. There is reason to assume that levels of distributive justice might be systematically higher in the Global North, and our theory and the relationship identified in the main analysis of this paper could be primarily driven by less developed countries in the sample. To test this, we split our sample into two categories: a Global South sample, including Sub-Saharan Africa, South Asia, the Middle East, North Africa, Latin America, and the Caribbean, and a Global North sample, including Europe, Central Asia, East Asia and the Pacific, and North America. Table 4, Models 1 and 2, and Figs. 3 and 4 in the Appendix show that the finding in the main analysis remains valid when replicating the analysis separately for the Global South and the Global North. However, looking at the confidence intervals of Fig. 4 (in the Appendix), it appears that the effects of increases and decreases of 10 billion dollars in fossil fuel subsidies on civil unrest are largely overlapping across different levels of distributive justice for the sample of the

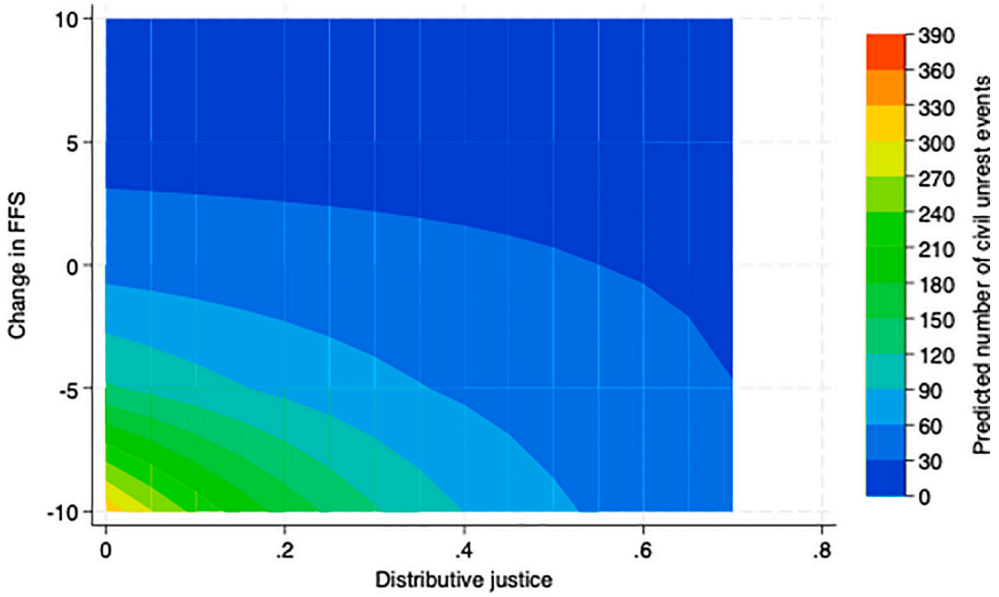

Fig. 5. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars.

Global North. This uncertainty is driven by the lower amount of data in our sample for the Global North: <200 data points than the Global South. To address the scarcity of data and test the results against the idea that our hypothesis might not be valid in more developed states, we replicate our analysis on a sample of states with percentages of the population being malnourished higher than the average percentage worldwide. Our main finding is robust to these robustness checks (Appendix, Table 5, Model 1 and Fig. 5).

We also curtail extreme leverage points and ran the analysis against a sample that excludes extreme observations of changes in fossil fuel subsidies, particularly observations related to increases and decreases in subsidies greater than ten billion dollars (Appendix, Table 6, Fig. 6). Again, this check confirms the validity of our main result. We also replicate the main analysis against a balanced panel data ranging from 2018 to 2022 and, if anything, the results are stronger (Table 12, Fig. 13). Additionally, to test the hypothesis that change in subsidies affect social unrest ultimately worsening distributive justice, we adopt a dual strategy. First, we use a Kernel-weighted local polynomial smoothing to verify whether social unrest correlates systematically with distributive justice, and this does not appear to be the case (Fig. 11). Second, we run a mediation analysis [75]. Our findings indicate that changes in subsidies not only lack a direct effect on distributive justice, but there is also no mediated effect of changes in subsidies on distributive justice through social unrest (see Table 11, Fig. 12). We also test the robustness of our main findings against an alternative model specification: a zero-inflated Poisson model. Since we suspect that the number of zeros in the outcome variable may be inflated because of specific country-level characteristics, we model the occurrence of protest events as a function of the specific country in which they take place. The results obtained are consistent with the negative binomial model in our main analysis (Table 13, Fig. 14, Appendix).

6.2. Limitations

One notable limitation of our study is the relatively short period of observation, as our panel data only covers the years from 2015 to 2022, and in some cases, even shorter periods in an unbalanced manner. This restricted timeframe limits our ability to examine longer-term trends and test the robustness of our findings across a more extensive historical context. Additionally, the presence of potential unobserved confounders poses a challenge. Given the limited time span of the data, we are unable to introduce country fixed effects to account for unobserved heterogeneity between countries, which could bias our results. Without controlling for these country-specific characteristics, it is difficult to ensure that our findings are not influenced by factors unique to each country that we cannot directly observe. Furthermore, while the inclusion of year fixed effects is a common strategy to control for unobserved heterogeneity over time, this approach is not feasible in our study. Applying year fixed effects would eliminate key variation in our primary variable of interest — distributive justice — which tends to evolve slowly over time. This slow-moving nature means that year fixed effects would effectively 'sweep away' important variation that is critical to our analysis. Notwithstanding these limitations, the findings are both clear and significant. A range of robustness tests are undertaken and described in the appendix, and the main findings do not change with a set of alternative model specifications.

7. Conclusion and policy implications

Fossil fuel subsidy reform increases social unrest in countries where distributive justice is lacking. Fuel subsidy reform – a key step in climate change politics as well as fiscal goals – cannot be achieved in isolation from broader social and political action. Moreover, as this article demonstrates, the link between instability and fuel price reform needs to be understood not only as a function of absolute levels of welfare and income, but also in terms of inequalities. This raises important implications for perceptions of fairness. Beyond fuel subsidy reform, this has wider implications for the green transition: if the costs of climate action are not shared evenly and they are imposed in the context of inequality, it may be difficult for governments to meet climate commitments and climate action will reinforce injustice.

Earlier work explores the role of international organisations in managing the pressures of fossil fuel subsidy reform within countries [76], for example by providing insights and lessons from countries which have confronted these challenges and providing technical support. International financial organisations such as the IMF have shifted from approaching this from a solely fiscal perspective to a broader view which includes the importance of social protection as a part of subsidy reform, recognizing that opposition to higher fuel prices constitutes an obstacle to reform [77]. In domestic settings, research in key cases – such as Nigeria [49,58] – indicates that opposition to reform, and thus potential for instability, is associated with a lack of confidence in government capacity to undertake reform competently, poor public service provision, a failure to pass on savings, and the perception of corruption. Thus, public understanding of 'revenue recycling' is important for gaining public acceptance of subsidy reform, for example by investing in public services [78]. However, instability related to fuel subsidy reform tends to occur in countries where government commitments to re-invest savings from subsidy reductions have weak credibility, due to perceptions of incompetence or dishonesty.

A number of implications arise from this analysis, relevant to national and international policy making. Fossil fuel subsidy reform can have a negative impact upon households, given the inflationary impact upon domestic fuel prices, but a key factor is how governments manage reform in the context of broader policy options. Research finds that reform need not have a negative impact upon low-income communities if a coherent system is in place designed to identify and address hardship [79]. Fuel subsidy reform must therefore be approached in the context of a package of compensation and social protection measures [40]. However, the findings of this article point to a nuanced understanding of instability. Fuel subsidy reform can be destabilizing not only in societies characterized as generally low-income, but also those with heightened levels of inequality of resources and opportunities across the population. This can include societies which are generally experiencing economic growth and improving income levels, but where this growth is not evenly shared and is not accompanied by investment in social protection, public goods, or accessible opportunities. As the broader conflict literature demonstrates, it is such societies which are amongst the most vulnerable to contentious politics and sometimes upheaval, and this makes climate action a potentially key trigger in instability and an obstacle to emissions reduction as risk-averse governments prioritise regime stability. In this context, mitigating instability associated with fuel subsidy reform must anticipate that fuel subsidy reform or national climate action more broadly may exacerbate contentious political behaviour – including instability – where distributive justice is scarcer.

A key policy implication is the importance of timing, careful framing, and the wider policy initiatives which accompany fuel subsidy reforms. A distinction can be made between the policy challenges associated with the initial implementation of fossil fuel subsidy reforms, and the challenges of maintaining them on a long-term basis. Subsidy reform proposals which are made in the context of adversarial election campaigns need to carefully measured since they can be particularly divisive. Reform policies – or announcements of such policies – which are sudden, or not undertaken in conjunction with compensatory or social protection measures, may be destabilizing. Moreover, although short-term initiatives – such as cash payments to economically-deprived households – have been effective in facilitating broader acceptance of reform in some cases, the findings of this article suggest that more substantive, structural political and economic measures may be necessary to make subsidy reform efforts sustainable. However, it is also necessary to recognize that for many – or most – governments, fuel subsidies are an important tool to respond to episodic price shocks in order to protect consumers and avoid

political instability. International demands to reduce them must therefore be weighed against an understanding of what is realistically possible in a national context. Finally, this article also demonstrates that perceptions and measures of justice need to be centralised within the green transition agenda.

CRediT authorship contribution statement

Margherita Belgioioso: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Edward Newman:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

Declaration of competing interest

The authors have no conflict of interests to declare.

Data availability

Data will be made available on request.

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Appendix

This supplementary material includes a list of states contained in our sample, a post-estimation test of the main analysis, and a battery of robustness checks to ensure that our results are not a statistical artifact of our modeling choice. The main findings do not change with a set of alternative model specifications; with an alternative time-control strategy; and when excluding time controls from the analysis.

Table 1. List of countries included in dataset

Afghanistan
Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Bulgaria
Burkina Faso
Burma/Myanmar
Burundi
Cambodia
Cameroon
Canada
Cape Verde
Central African Republic
Chad
Chile
China
Colombia
Comoros
Costa Rica
Croatia
Cyprus
Czechia
Democratic Republic of the Congo
Denmark
Djibouti
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Estonia
Eswatini
Ethiopia
Fiji
Finland
France
Gabon
Georgia
Germany
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland

Israel
Italy
Ivory Coast
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kosovo
Kuwait
Kyrgyzstan
Laos
Latvia
Lebanon
Lesotho
Liberia
Libya
Lithuania
Luxembourg
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
North Macedonia
Norway
Oman
Pakistan
Palestine/West Bank
Panama

Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Republic of the Congo
Romania
Russia
Rwanda
Sao Tome and Principe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
Solomon Islands
Somalia
South Africa
South Korea
South Sudan
Spain
Sri Lanka
Sudan
Suriname
Sweden
Switzerland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
The Gambia
Timor-Leste
Togo
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Arab Emirates

United Kingdom
United States of America
Uruguay
Uzbekistan
Vanuatu

Venezuela
Vietnam
Yemen
Zambia
Zimbabwe

Z Test

We conduct a z-test to verify whether there is a significant statistical difference between the effect of changes in fossil fuel subsidies when distributive justice equals zero versus scenarios where states are characterized by higher levels of distributive justice, as proxied in the interaction term. This z-test returns highly statistically significant results (see Test 1 below). Consistent with the findings in Table 1, the finding of the z-test indicates that a significant statistical difference exists for the effect of changes in fossil fuel subsidies on the expected number of civil unrest events across different levels of distributive justice

Test 1. Z test for statistical difference between the effect of changes in fossil fuel subsidies

Test Distributive justice - Change in fossil fuel subsidies = 0

[Civil unrest events] Change in fossil fuel subsidies + [Civil unrest events] Distributive justice = 0

Chi2(1) = 22.35
Prob > chi2 = 0.0000

Alternative Time control strategy

We exclude from the analysis the cubic spline and only include the count of years since the last energy-related civil unrest event as an alternative strategy to control for time dependency in our outcome variable.

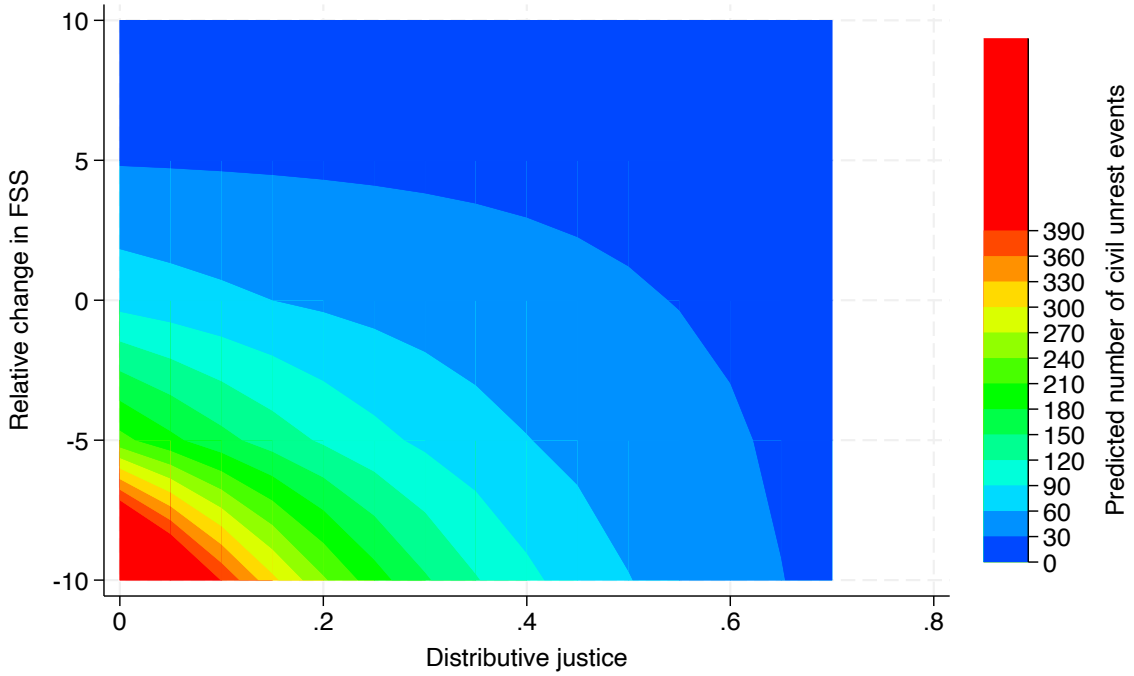
Table 2. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice (alternative time control strategy)

VARIABLES	Model 1) Civil unrest events
Change in fossil fuel subsidies	-0.206***
	(0.025)
Distributive justice	-1.785***
	(0.660)
Change in fossil fuel subsidies*distributive justice	0.284***
	(0.044)
Economic decline	-0.090
	(0.092)
Group grievances	0.365***
	(0.079)
Respect of human rights	-0.519***

	(0.080)
Proportion of undernourished	0.002***
	(0.000)
Years since last civil unrest	-0.727***
	(0.099)
Constant	5.029***
	(0.874)
Observations	863

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 1. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 2)



Alternative measure of distributive justice

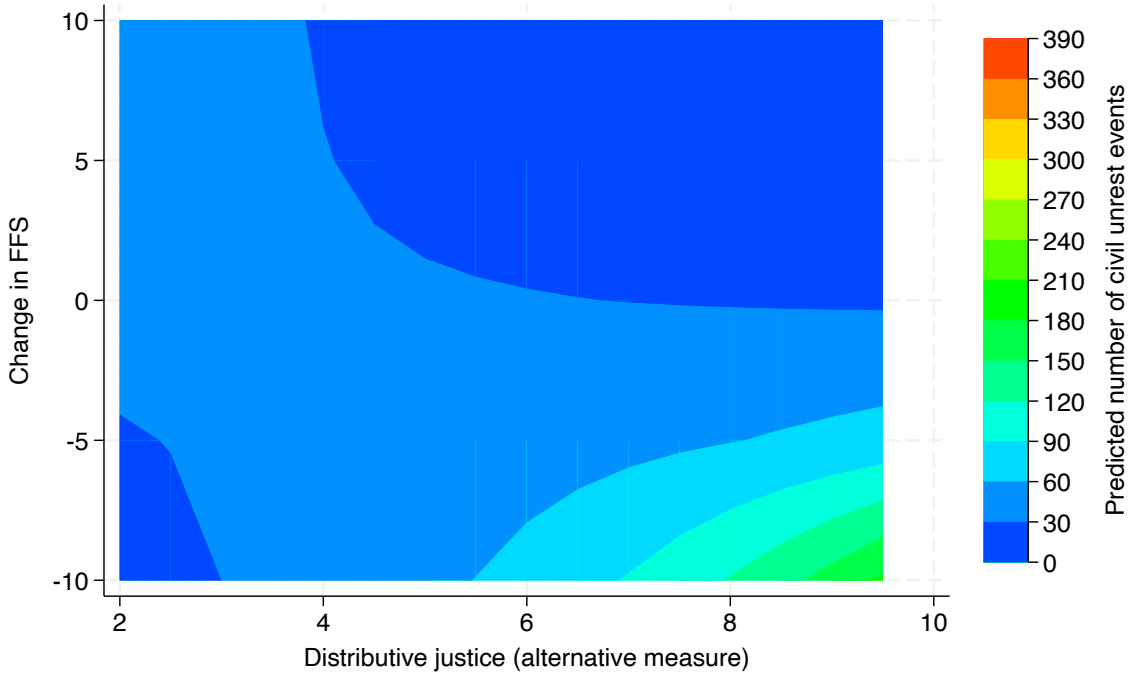
We use an alternative measure of distributive justice extracted from the Fragile States Index [70]. This measure reflects the extent to which public services are equally accessible across society and it captures our concept of distributive justice as it assesses the presence of basic state functions and services that serve the people and the extent to which these services are provided across different strata of society. For example, it indicates whether the state primarily serves the ruling elites while failing to provide comparable levels of service to the general populace [70].

Table 3. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice (alternative measure of distributive justice)

VARIABLES	Model 1) Civil unrest events
Change in fossil fuel subsidies	0.111**
	(0.051)
Distributive justice alternative 1	-0.039
	(0.084)
Change in fossil fuel subsidies*Distributive justice alternative 1	-0.032***
	(0.008)
Economic decline	-0.008
	(0.106)
Group grievances	0.340***
	(0.076)
Respect of human rights	-0.404***
	(0.074)
Proportion of undernourished	0.002***
	(0.000)
Years since last civil unrest	-3.238***
	(0.419)
Spline 1	-0.013
	(0.012)
Spline 2	-1.224***
	(0.332)
Spline 3	0.678***
	(0.225)
Constant	3.788***
	(0.420)
Observations	896

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 2. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 3)



Global South vs. Global North

We test the robustness of our main finding against alternative sample compositions. Specifically, we examine whether our main finding holds in both the Global South (Table 4, Model 1 below) and the Global North (Table 4 Model 2). There is reason to assume that levels of distributive justice might be systematically higher in the Global North, and our theory and the relationship identified in the main analysis of this paper could be primarily driven by less developed countries in the sample. To test this, we split our sample into two categories: the Global South sample, including Sub-Saharan Africa, South Asia, the Middle East, North Africa, Latin America, and the Caribbean, and the Global North sample, including Europe, Central Asia, East Asia and the Pacific, and North America.

Table 4. Negative binomial regressions examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice (Global South vs. Global North)

VARIABLES	Model 1) Civil unrest events	Model 2) Civil unrest events
Change in fossil fuel subsidies	-0.173***	-0.223***
	(0.032)	(0.084)
Distributive justice	-0.495	1.040
	(0.674)	(1.166)

Change in fossil fuel subsidies * Distributive justice	0.198**	0.302**
	(0.085)	(0.128)
Economic decline	-0.025	-0.124
	(0.102)	(0.118)
Group grievances	0.334***	0.310***
	(0.092)	(0.104)
Respect of human rights	-0.312***	-0.407***
	(0.110)	(0.106)
Proportion of undernourished	0.002***	0.003*
	(0.000)	(0.001)
Years since last civil unrest	-3.465***	-2.720***
	(0.475)	(0.655)
Spline 1	-0.009	-0.042
	(0.016)	(0.041)
Spline 2	-1.292***	-1.226**
	(0.389)	(0.611)
Spline 3	0.709***	0.768*
	(0.266)	(0.443)
Constant	3.504***	2.869**
	(0.951)	(1.201)
Observations	563	300

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 3. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 4, Model 1 Global South)

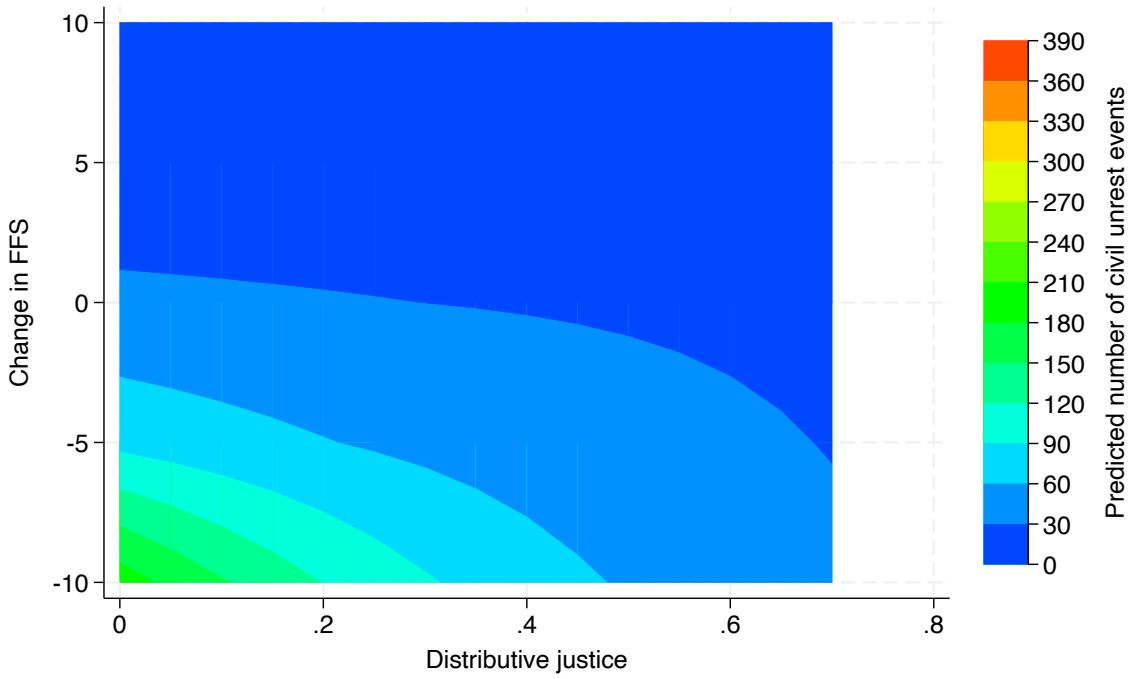
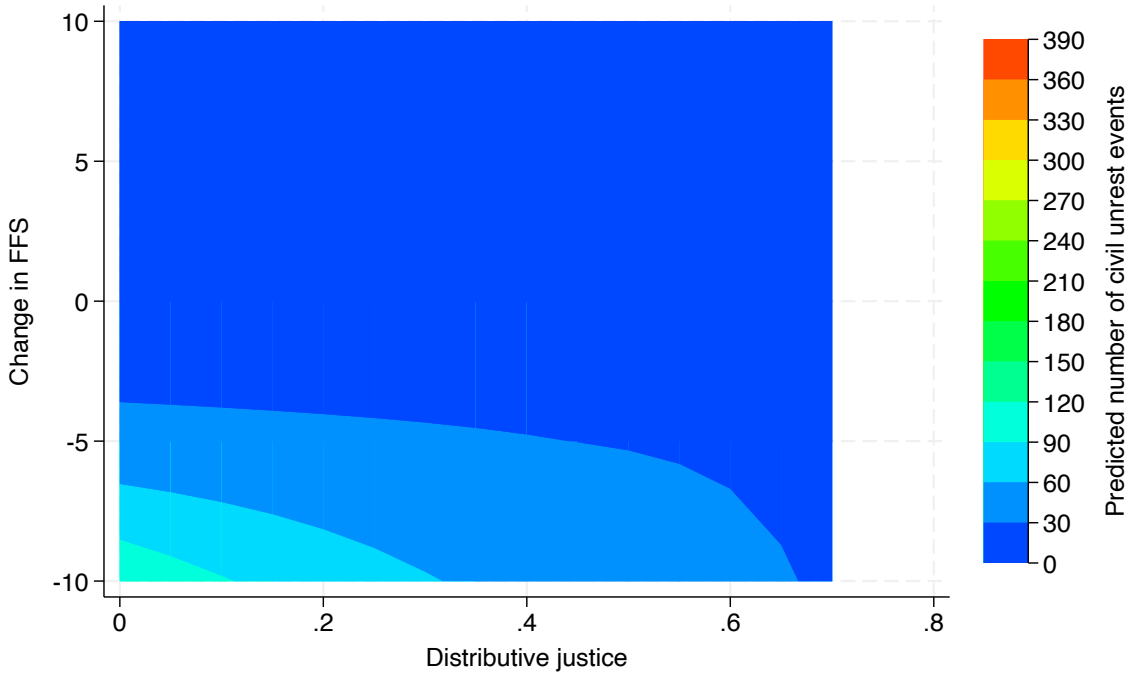


Figure 4. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 4, Model 2 Global North)



Alternative sample for most developed countries

Table 4, Models 1 and 2 show that the finding in the main analysis remains valid when replicating the analysis separately for the Global South and the Global North. However, looking at the confidence intervals of Figure 4 (above) it appears that the effects of increases and decreases of 10 billion dollars in fossil fuel subsidies on civil unrest are largely overlapping across different levels of distributive justice for the sample of the Global North. This uncertainty is driven by the lower amount of data in our sample for the Global North. To address the scarcity of data and test the results against the idea that our hypothesis might not be valid in more developed states, we replicate our analysis on a sample of states with percentages of the population being malnourished higher than the average percentage worldwide. Our main finding is robust for the sample of state with higher-than-average percentage of population being malnourished.

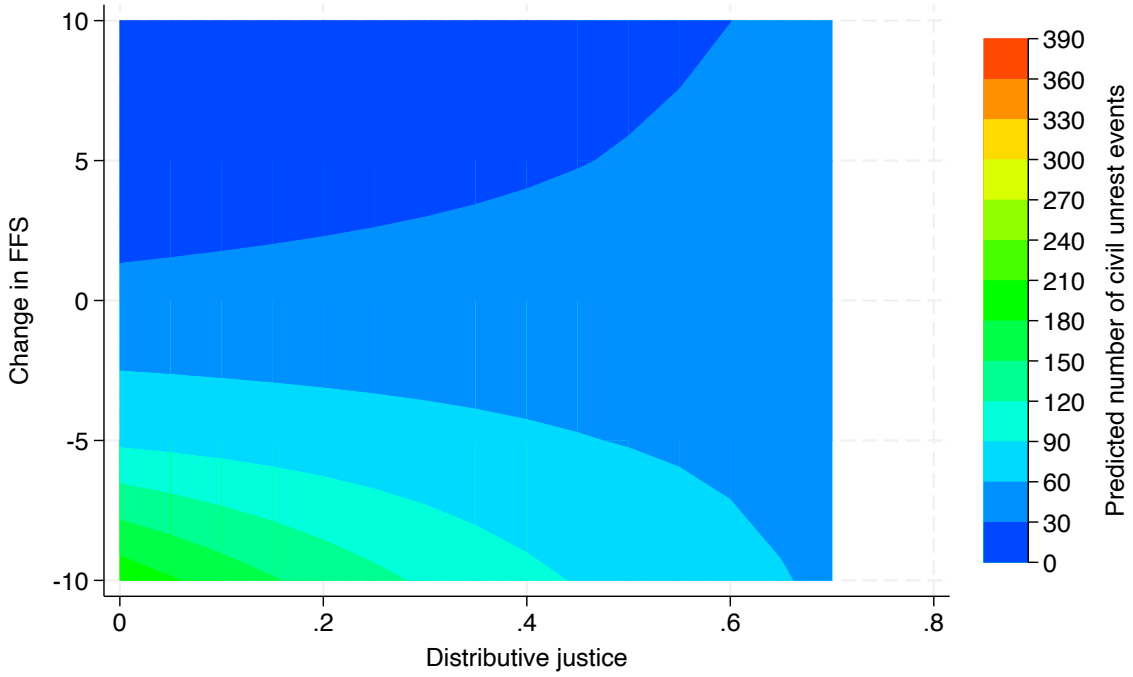
Table 5. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice in states where the population being malnourished is higher than the average percentage worldwide

VARIABLES	Model 1) Civil unrest events
Change in fossil fuel subsidies	-0.173*** (0.0260)

Distributive justice	0.385
	(0.647)
Change in fossil fuel subsidies * Distributive justice	0.221***
	(0.0568)
Economic decline	0.0520
	(0.0882)
Group grievances	0.299***
	(0.0953)
Respect of human rights	-0.463***
	(0.0874)
Proportion of undernourished	0.00236***
	(0.000254)
Years since last civil unrest	-3.102***
	(0.456)
Spline 1	-0.00512
	(0.0149)
Spline 2	-1.182***
	(0.388)
Spline 3	0.637**
	(0.265)
Constant	3.859***
	(0.835)
Observations	509

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 5. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 5)



Curtail leverage point to -10 billion to +10 billion

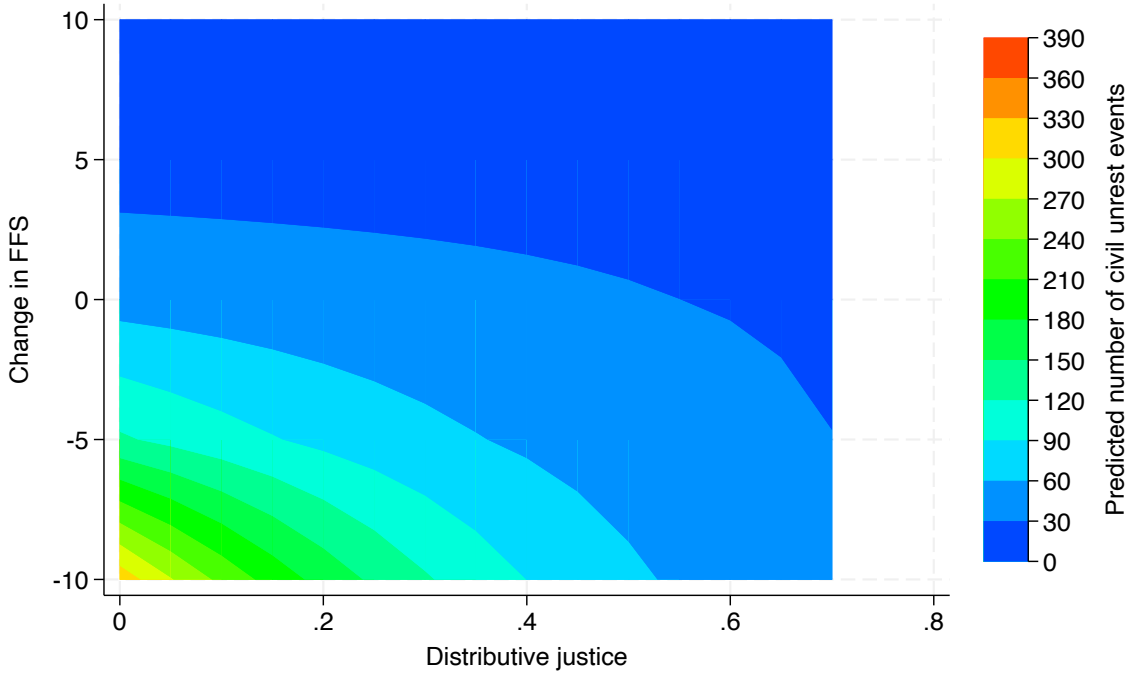
We curtail extreme leverage points and ran the main analysis against a sample that excludes extreme observations of changes in fossil fuel subsidies, particularly observations related to increases and decreases in subsidies greater than ten billion dollars.

Table 6. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice limit range of change in fossil fuel subsidies

VARIABLES	Model 1) Civil unrest events
Change in fossil fuel subsidies	-0.189***
	(0.029)
Distributive justice	-0.867
	(0.584)
Change in fossil fuel subsidies * Distributive justice	0.230***
	(0.061)
Economic decline	-0.074
	(0.075)
Group grievances	0.353***
	(0.074)
Respect of human rights	-0.452***
	(0.072)
Proportion of undernourished	0.002***
	(0.000)
Years since last civil unrest	-2.971***
	(0.399)
Spline 1	-0.012
	(0.012)
Spline 2	-1.113***
	(0.336)
Spline 3	0.619***
	(0.228)
Constant	4.528***
	(0.803)
Observations	863

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 6. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 6)



Absolute vs. Relative Change of FFS

Countries vary significantly in size - some are vast, while others are quite small. A change of $1 billion may be negligible for some nations but could represent a substantial portion of the entire economy for others. We check if the results in the main analysis are robust when accounting for the relative magnitude of the change of FFS as a percentage of the GDP rather than its absolute value. The results remain consistent when using this relative measure.

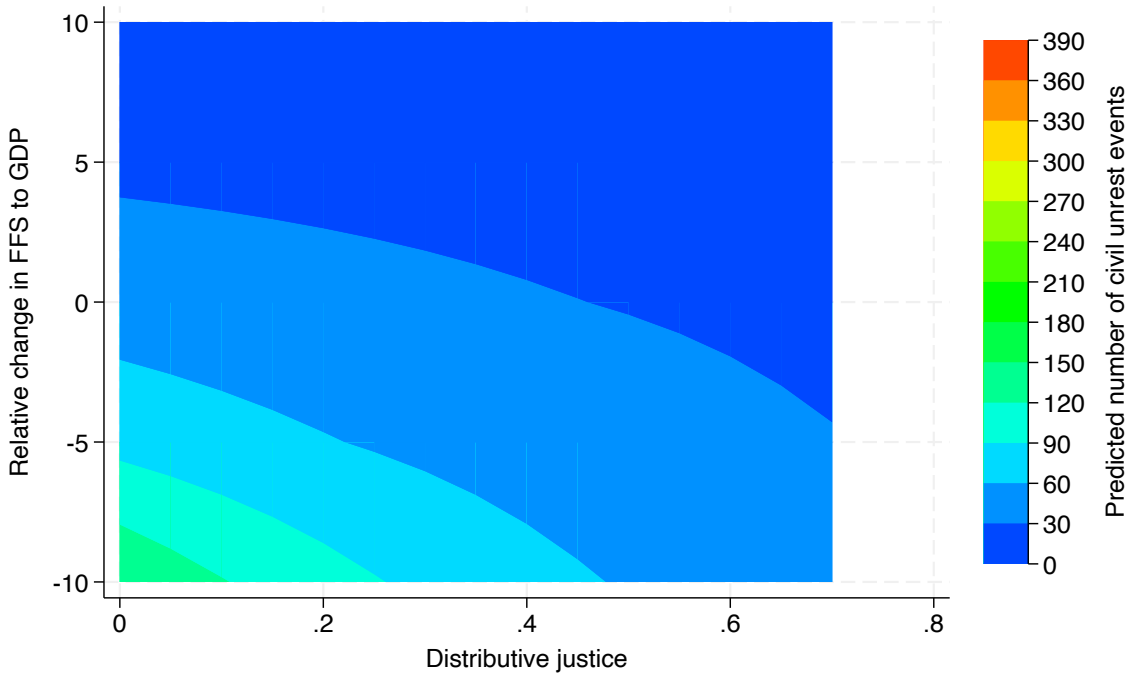
Table 7. Negative binomial regression examining the effect of changes in fossil fuel subsidies relative to GDP on civil unrest moderated by distributive justice

	Model 1)
VARIABLES	Civil unrest events
Relative change in fossil fuel subsidies	-0.188***
	(0.013)
Distributive justice	-0.884
	(0.589)
Change in fossil fuel subsidies*distributive justice	0.099
	(0.133)
Economic decline	-0.093
	(0.074)
Group grievances	0.364***
	(0.073)

Respect of human rights	-0.458***
	(0.074)
Proportion of undernourished	0.002***
	(0.000)
Years since last civil unrest	-2.999***
	(0.398)
Spline 1	-0.012
	(0.012)
Spline 2	-1.134***
	(0.340)
Spline 3	0.631***
	(0.230)
Constant	4.600***
	(0.805)
Observations	863

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 7. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 7).



Additional Control Variables

We perform additional robustness checks by incorporating the following control variables: real GDP (in 2021 USD billions, sourced from the IMF) and a dummy variable indicating whether the country is an oil-producing nation [80].

Table 8. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice including Real GDP as additional control

VARIABLES	Model 1) Civil unrest events
Change in fossil fuel subsidies	-0.184***
	(0.029)
Distributive justice	-0.859
	(0.584)
Change in fossil fuel subsidies*distributive justice	0.223***
	(0.062)
Real GDP in USD	0.000
	(0.000)
Economic decline	-0.045
	(0.076)
Group grievances	0.337***
	(0.082)
Respect of human rights	-0.431***
	(0.081)
Proportion of undernourished	0.001***
	(0.000)
Years since last civil unrest	-2.942***
	(0.397)
Spline 1	-0.010
	(0.012)
Spline 2	-1.062**
	(0.337)
Spline 3	0.581*
	(0.228)
Constant	4.291***
	(0.795)
Observations	863

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 8. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 8).

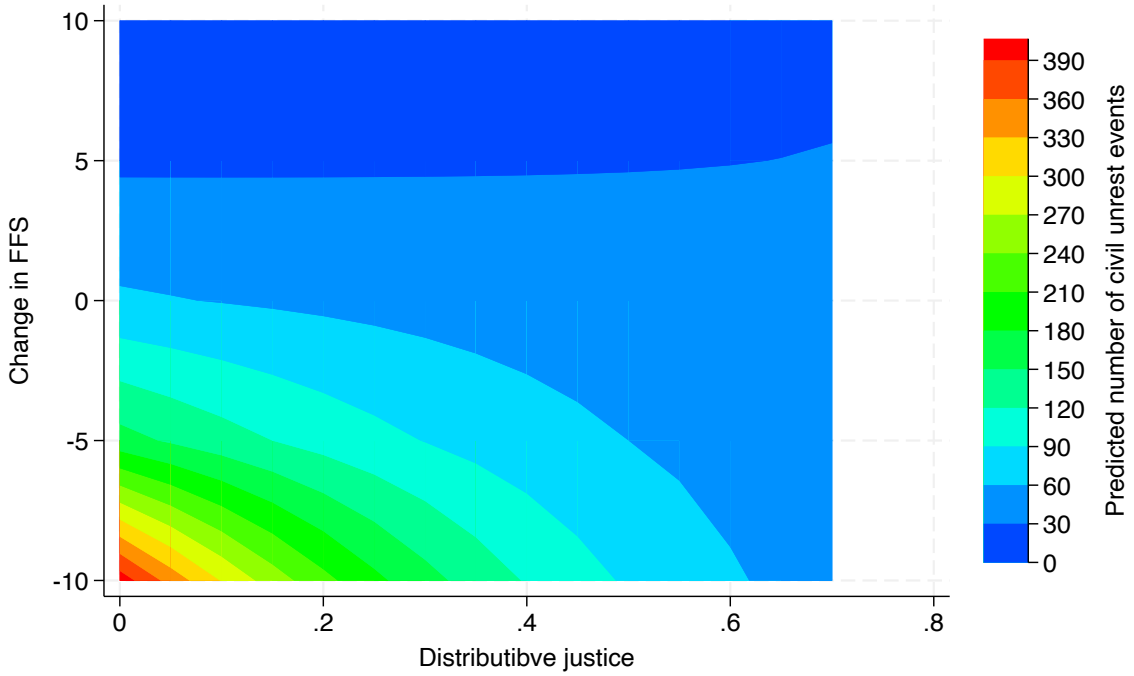


Table 9. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice including dummy equal to 1 if country is an oil producer and 0 otherwise as additional control.

	Model 1)
VARIABLES	Civil unrest events
Change in fossil fuel subsidies	-0.174***
	(0.035)
Distributive justice	-0.985
	(0.614)
Change in fossil fuel subsidies*distributive justice	0.218**
	(0.070)
Oil producer	0.717**
	(0.302)
Economic decline	-0.043
	(0.081)
Group grievances	0.376***
	(0.073)
Respect of human rights	-0.717**

	(0.302)
Proportion of undernourished	0.717**
	(0.302)
Years since last civil unrest	-2.788***
	(0.379)
Spline 1	-0.016
	(0.012)
Spline 2	-1.103***
	(0.343)
Spline 3	0.633**
	(0.232)
Constant	4.295***
	(0.848)
Observations	863

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 9. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 9).

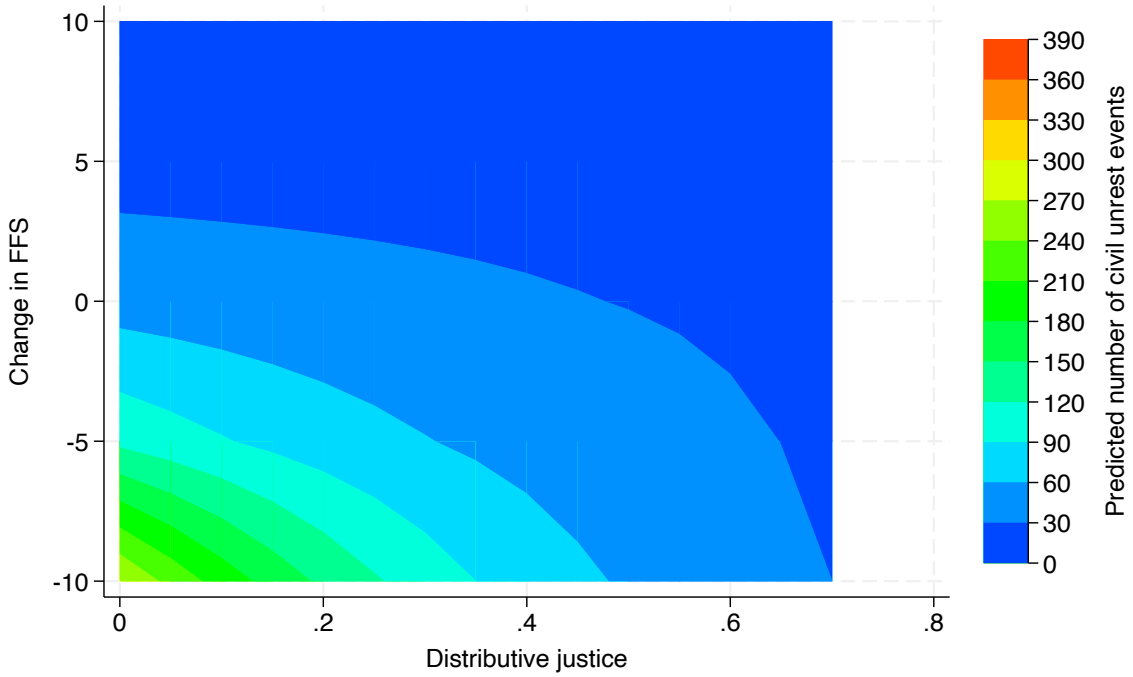


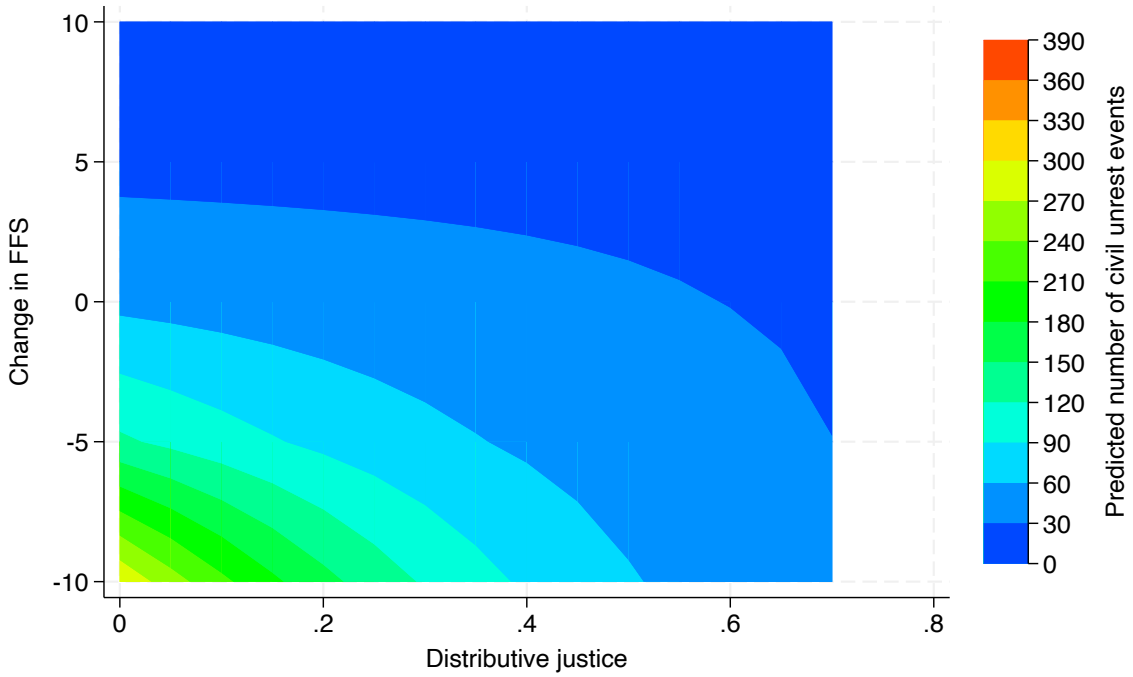
Table 10. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice including Real GDP and dummy equal to 1 if country is an oil producer and 0 otherwise as additional control.

	Model 1)
VARIABLES	Civil unrest events
Change in fossil fuel subsidies	-0.172***
	(0.034)

Distributive justice	-0.962
	(0.621)
Change in fossil fuel subsidies*distributive justice	0.214**
	(0.070)
Real GDP in USD	0.000
	(0.000)
Oil producer	0.686**
	(0.298)
Economic decline	-0.023
	(0.081)
Group grievances	0.364***
	(0.078)
Respect of human rights	-0.490***
	(0.086)
Proportion of undernourished	0.001***
	(0.000)
Years since last civil unrest	-2.768***
	(0.379)
Spline 1	-0.014
	(0.012)
Spline 2	-1.060**
	(0.346)
Spline 3	0.601**
	(0.234)
Constant	4.130***
	(0.839)
Observations	863

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 10. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 10).

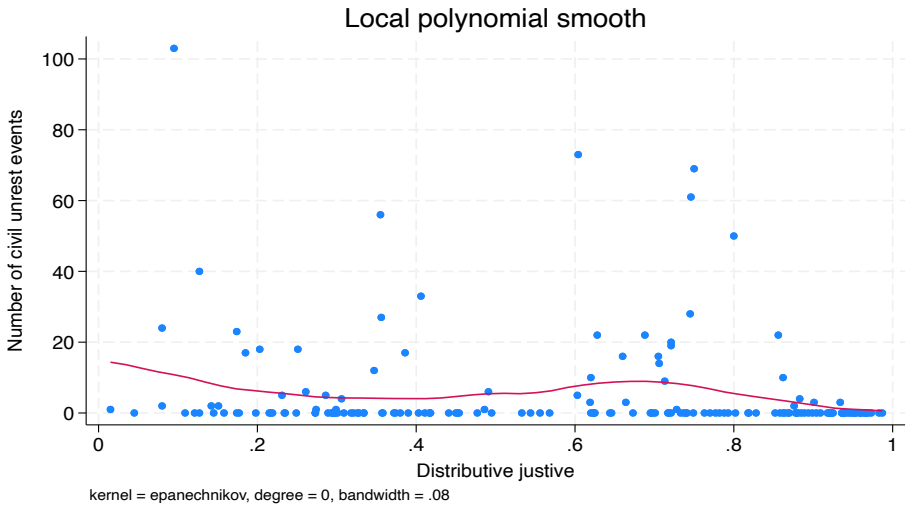


Reverse Causality

To test the hypothesis that change in subsidies affect social unrest ultimately worsening distributive justice, we adopt a dual strategy.

First, we use a Kernel-weighted local polynomial smoothing to verify whether social unrest correlates systematically with distributive justice, and this does not appear to be the case as shown in the figure below.

Figure 11. Kernel-weighted local polynomial smoothing for the relation of distributive justice on social unrest



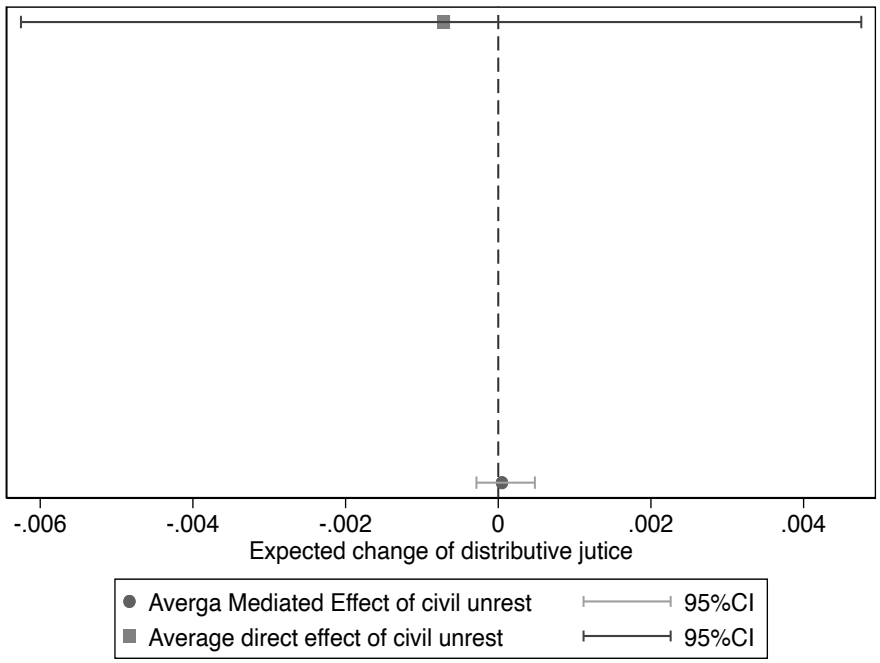
Second, we conducted a mediation analysis to test the validity of the claim that changes in subsidies affect social unrest, which in turn influences distributive justice [75]. Our findings indicate that changes in subsidies not only lack a direct effect on distributive justice, but there is also no mediated effect of changes in subsidies on distributive justice through social unrest. This analysis has been discussed in the robustness checks section and included in our robustness checks in the Appendix (Table 11, Figure 12).

Table 11. Testing a mediation effect of changes of fossil fuel subsidies on distributive justice through social unrest to verify possible evidence of reverse causality

VARIABLES	MODEL 1(a) Exposure-Mediator OLS Number of civil unrest events	MODEL 1(b) Mediator-Outcome OLS Distributive justice
Explanatory Variable		
Change in FFS	-0.314 (0.890)	-0.000 (0.002)
Mediator Variable		
Number of civil unrest events		-0.000* (0.000)
Constant	20.672*** (2.900)	0.562*** (0.009)
Observations	984	984

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 12. Estimated average mediation and direct effects of fossil fuel subsidies on distributive justice through social unrest



Balance Panel Data

We have replicated the main analysis against a balanced panel data ranging from 2018 to 2022.

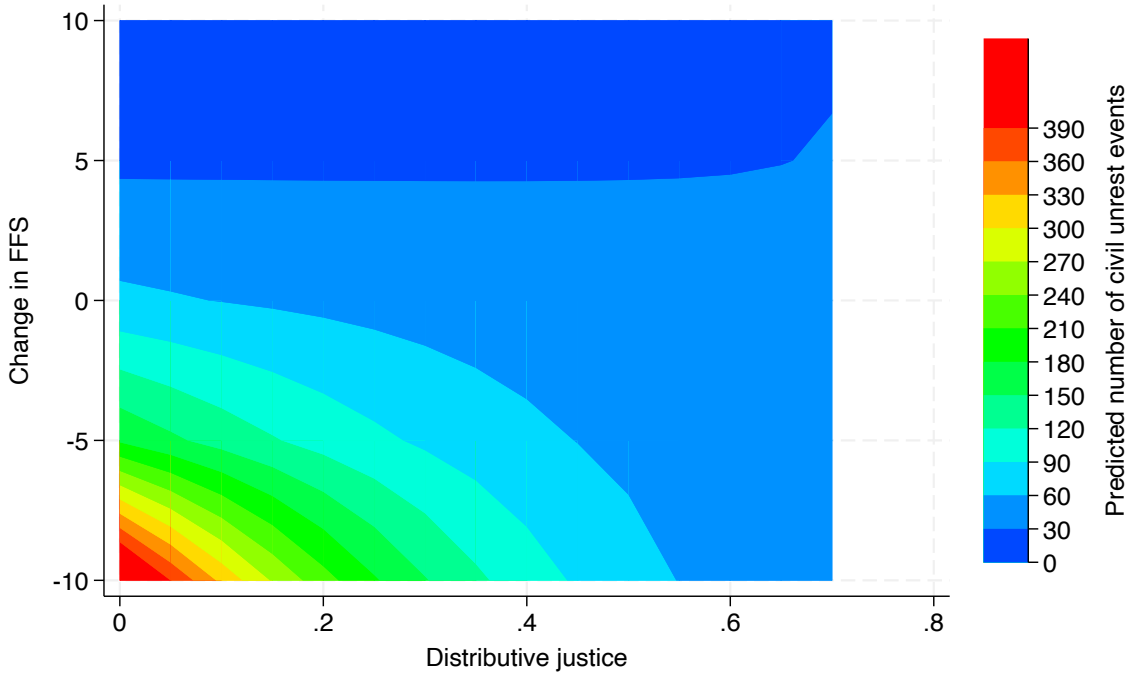
Table 12. Negative binomial regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice balanced panel 2018-2022

VARIABLES	Model 1) Civil unrest events
Change in fossil fuel subsidies	-0.196***
	(0.025)
Distributive justice	-1.055*
	(0.586)
Change in fossil fuel subsidies*distributive justice	0.271***
	(0.047)
Economic decline	-0.070
	(0.079)
Group grievances	0.346***
	(0.073)
Respect of human rights	-0.439***
	(0.074)
Proportion of undernourished	0.002***

	(0.000)
Years since last civil unrest	-2.415***
	(0.454)
Spline 1	-0.016
	(0.013)
Spline 2	-0.831**
	(0.389)
Spline 3	0.477**
	(0.263)
Constant	4.617***
	(0.828)
Observations	693

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 13. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 12).



Alternative functional form: Zero Inflated Poisson Regression

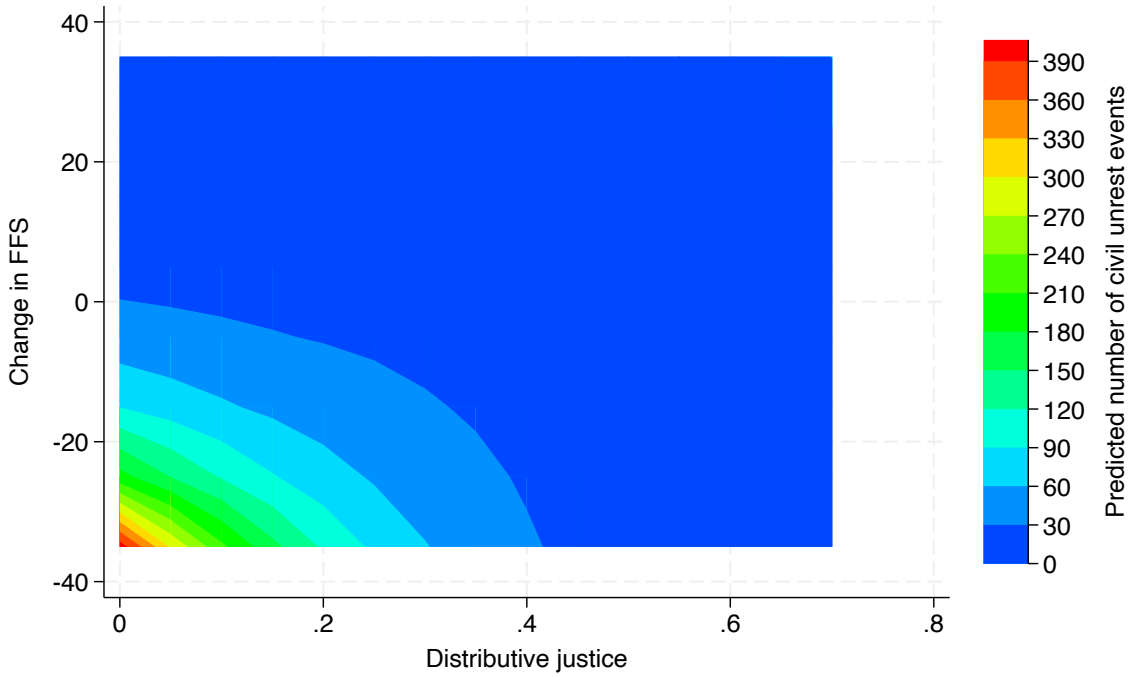
Since it might be plausible that the number of zeros in the outcome variable may be inflated because of specific country-level characteristics, we model the occurrence of protest events as a function of the specific country they take place and use a Zero inflated Poisson regression model to test the robustness of our main findings. The results obtained are consistent with the negative binomial model in our main analysis.

Table 13. Zero inflated Poisson regression examining the effect of changes in fossil fuel subsidies on civil unrest moderated by distributive justice

	Model 1)
VARIABLES	Civil unrest events
Change in fossil fuel subsidies	-0.075***
	(0.004)
Distributive justice	-1.215***
	(0.046)
Change in fossil fuel subsidies*distributive justice	0.144***
	(0.009)
Economic decline	0.115***
	(0.005)
Group grievances	0.165***
	(0.005)
Respect of human rights	-0.368***
	(0.005)
Proportion of undernourished	0.001***
	(0.000)
Years since last civil unrest	-2.439***
	(0.078)
Spline 1	-0.058***
	(0.006)
Spline 2	-1.443***
	(0.077)
Spline 3	0.969***
	(0.059)
Constant	4.618***
	(0.060)
Observations	862
INFLATE	
Country	0.008***
	(0.001)
Constant	-0.911***
	(0.145)

N.B. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Figure 14. Predicted number of civil unrest events by levels of distributive justice and changes in fossil fuel subsidies, increasing or decreasing by ±10 billion dollars (Table 13).



Summary Statistics and Multicollinearity

Table 14. Summary Stats

Variable	Obs.	Mean	St. dev	Min.	Max.
Civil unrest events	1,269	19.362	121.057	0	3236
Change in fossil fuel subsidies	1,077	-0.081	3.113	-35.070	42.556
Distributive justice	1,158	0.563	0.284	0.015	.987
Economic decline	1,062	5.737	1.990	1.1	10
Group grievances	1,062	6.072	2.210	.3	10
Respect of human rights	1,062	5.828	2.5023	.3	10
Proportion of undernourished	1,264	42.571	157.581	0.005	1411.338

Table 15. Collinearity

Variable	VIF	SQRT VIF
Civil unrest events	1.23	1.11
Change in fossil fuel subsidies	1.01	1.00
Distributive justice	2.33	1.52
Economic decline	2.13	1.46
Group grievances	1.90	1.38
Respect of human rights	2.34	1.53
Proportion of undernourished	1.31	1.14