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An exploration of the association between fuel subsidies and fuel riots

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ABSTRACT

Between 2005 and 2018, 41 countries had at least one riot directly associated with popular demand for fuel. We make use of a new international dataset on fuel riots to explore the effects of fuel prices and price regimes on fuel riots. In line with prior expectations, we find that large domestic fuel price shocks - often linked to international price shocks - are a key driver of riots. In addition, we report a novel result: fuel riots are closely associated with domestic price regimes. Countries that maintain fixed price regimes - notably net energy exporters - tend to have large fuel subsidies. When such subsidies become unsustainable, domestic price adjustments are large, often leading to riots.

1. Introduction

In 2019, there were major protests related to energy in Sudan, France, Zimbabwe, Haiti, Lebanon, Ecuador, Iraq, Chile, and Iran - many of which turned into riots. In most years between 2005 and 2018, there have been energy-related riots in at least one or two countries. It is therefore surprising that there is limited academic literature that explores the determinants of fuel riots.[1] A significant literature on energy-related conflict has established a close association between violent conflict and the discovery or abundance of fossil fuels (e.g. Ploeg, 2011; Ross, 2004; Carbonnier, Brugger, & Wagner, 2011). Of particular relevance to our study, there is also strong evidence that conflict and unrest may be related to increases in oil prices. In a seminal paper, Dube et al. (2013) show that increases in the international price of oil are associated with increases in violence in Colombia in municipalities in oil-producing regions. This result is confirmed in a recent review of 350 studies by Blair, Christensen, and Rudkin (2020), who conclude that the probability of conflict is positively associated with increases in oil prices.

However, most of the existing literature focuses on armed conflict and its relation to fossil fuels and knowledge about less violent forms of political conflict (like protests and riots) is more limited.[2] Yet, the private and social costs of riots can be as high as other forms of violent conflict due to the destruction of assets and infrastructure, disruption to markets, increases in the risk of investment and the loss of trust between social groups and between citizens and state institutions (Aghajanian, Justino, & Tranchant, 2020; Barron, Kaiser, & Pradhan, 2004; Collins & Margo, 2004; Collins & Margo, 2007; Wilkinson, 2004; Wilkinson, 2005).

Evidence on the mechanisms that may explain the association between shocks in international oil prices and conflict is also limited. This paper addresses these gaps by drawing on a unique database on fuel riots (Natalini et al., 2020) to examine in detail the association between fuel riots and fuel price shocks. We find, as expected, a positive association between international oil prices and fuel riots. We show that this effect is associated with the domestic price regime and fuel subsidies. We find that countries that are net energy exporters are much more likely to fix domestic fuel prices to protect local populations against price rises. However, countries that fix prices tend to have much larger fuel subsidies and, when these can no longer be sustained, much bigger

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[1] We use the phrase 'fuel riots' to refer to events which are, at least superficially, about the price of fuel, and which feature violence and disruption of some kind, whether instigated by protestors or as a reaction to official responses to otherwise peaceful protests. For a detailed definition of fuel riots see Natalini, Bravo, and Newman (2020).

[2] One exception is Natalini (2016) who examine the role of scarcity, prices and political fragility in driving food and fuel riots using a quantitative and agent-based modelling approach.

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domestic price adjustments are needed, often leading to riots. We report also that fuel prices do not affect other broader forms of riots, as defined in the Armed Conflict Location and Event Dataset (ACLED) (Raleigh, Linke, Hegre, & Karlsen, 2010).

These results are an important contribution because the existing literature on riots and civil unrest rarely takes into consideration how fluctuations in international prices of oil may be transmitted to local markets in ways that may drive citizens to riot. This transmission is not a given because several countries adopt subsidy policies to cushion local markets against fluctuations in the international price of oil. As long as these price regimes are sustainable, it is unlikely that changes in the international price of oil will affect local markets and, therefore, the probability of riots occurring. While some countries allow international prices to pass through fully to domestic prices, others fix domestic prices - at least temporarily - in an attempt to protect domestic consumers from such shocks. We find that this can be counter-productive as it is these very countries that are most likely to experience fuel riots. This is because fixing prices below international prices generates fuel subsidies whose size depends on the regulated domestic price and the international price of fuel. When high international fuel prices are sustained for an extended period of time these governments have to drastically reduce subsidies, therefore generating a large jump in national prices, which can trigger a riot.

The propensity to use fuel subsidies to protect domestic consumers is often linked to the structure of the economy. The literature suggests that fuel exporters are particularly likely to have the kind of consumer price subsidies that are the object of protests (Cheon, Urpelainen, & Lackner, 2013; Victor, 2009). In energy-rich countries where state capacity to distribute resources is weak, consumer fuel subsidies tend to be common and resilient to reform efforts (Inchauste & Victor, 2017). Authoritarian regimes are particularly likely to rely on such subsidy regimes as a source of popular legitimacy (Andresen, 2008; Rosser, 2006). Where other forms of social protection are limited, or natural resource wealth is highly concentrated, or where economic performance is poor, subsidies may be seen as part of the social contract (Lockwood, 2015; McCulloch, Moerenhout, & Yang, 2021). However, when such subsidies become unsustainable, governments often attempt to reduce them by raising fuel prices sharply (Rentschler & Bazilian, 2017; Lockwood, 2015). When these adjustments result in large increases in the domestic price of fuel, social discontent may rise, increasing the likelihood of protests and riots.

Our paper also contributes to the literature on fossil fuel subsidies. This literature is largely concerned with detailing the size of subsidies (Coady, Parry, Sears, & Shang, 2017), the distributional impact of subsidies (Granado, Coady, & Gillingham, 2012), the impact of subsidies on economic and environmental performance (Rentschler, Kornejew, & Bazilian, 2017; Erickson et al., 2020), and the impact of subsidy reforms on the poor, among other groups (Rentschler, 2016; Soile & Mu, 2015). There is also a growing literature on the political economy of fossil fuel subsidy reform (Inchauste & Victor, 2017; Skovgaard & van Asselt, 2018), which provides a nuanced understanding of the complexities of policy reform and why so little progress has been made on reform (Ross, Hazlett, & Mahdavi, 2017). However, this literature rarely mentions an association between price subsidies and fuel riots, other than as an explanation of why reforms stop or stall, or as a reason why reforms are not attempted in the first place.

The paper proceeds as follows. Section 2 describes the data we use in the paper and brief descriptive statistics. Section 3 discusses the main results including an analysis of price regimes as potential mediators of the relationship between fuel prices and riots; we also present some robustness tests. Section 4 examines why countries fix prices and create subsidies. Section 5 concludes.

2. Data and descriptive statistics

The definition and data we use in this paper to measure the occurrence of fuel riots come from Natalini et al. (2020). Fuel riots have been defined by the authors as 'incidents of significant unrest - riots, demonstrations, major protests - where grievances over fuel prices, the prospective removal of subsidies, or fuel availability were specifically identified as a factor which motivated people involved in the violent event' (Natalini et al., 2020).[3] The original database spanned the period between 2005 and 2016 and was updated until 2018 for this paper using the same methodology. Specifically, we performed a manual Google search with a set of keywords to identify events that matched our definition of fuel riots. Although more sophisticated event collection methodologies exist (e.g. machine learning), these often result in a large number of duplicates (e.g. via news feed repositories such as Lexis Nexis) and encode the biases of international media coverage of protest events requiring time-consuming cross-checks to ensure that only events meeting the definition are included. A manual approach was therefore preferred.[4] Keywords included different combinations and declinations of the words fuel/energy, violence, riot/protest and for every combination we reviewed the first ten pages of Google results. The search was global in scope and included only English online newspapers (or re-published articles translated into English from the original language). The dataset may therefore suffer from different types of biases (e.g. towards larger, more important events and towards events reported in English) that are very common when performing global-level research such as in our case and difficult to avoid (Dowd, Justino, Kishi, & Marchais, 2020). In our estimation methodology we attempt to account for potential bias towards English language sources using a variable recording whether a country has an English language newspaper. Given the parameters we used, we believe the dataset is a conservative estimate of fuel riots across the world between 2005 and 2018. The full database is included in the online supplementary materials. The data were recorded on a monthly basis. When undertaking analysis with annual data, we aggregated the data by constructing a binary variable for whether the country had a fuel riot during the year or not.[5]

Fig. 1 shows the geographical distribution of fuel riots over the period. Between 2005 and 2018, we observe 59 country-years in which fuel riots occurred. In one sense, these are relatively rare events since there are 3011 country-years in our data. However, fuel riots happen in quite a few countries: 41 of the 217 countries or jurisdictions in our dataset experienced a fuel riot over the period. Some countries experienced several fuel riots in that period: India had seven; Indonesia had five; and China and Yemen both had three.

To understand the relationship between prices, subsidies and fuel riots, data was obtained on the international price of oil, the level of fuel subsidies, and the domestic price regime implemented in each country. Average international prices for crude oil were sourced from the World Bank's Commodity Price Database.[6] The data on fossil fuel subsidies comes from the IMF's calculation of subsidies for the period 2010–2017. We use estimates for 'total consumer pre-tax subsidies', which include four energy sources (oil,

[3] Our definition of fuel riots therefore does not include peaceful protests related to fuel.

[4] See Newman et al. (2020) for a comprehensive discussion on challenges with automatised event data collection with the example of food riots. For more on the biases of international media coverage see Hossain (2018), Sneyd, Legwegoh, and Fraser (2013), Hossain et al. (2017).

[5] Doing so loses very little information in the annual data because there were only two countries that had more than one fuel riot in the same year - India in 2010 and Indonesia in 2013.

[6] The Pink Sheet - see https://www.worldbank.org/en/research/commodity-markets for details.

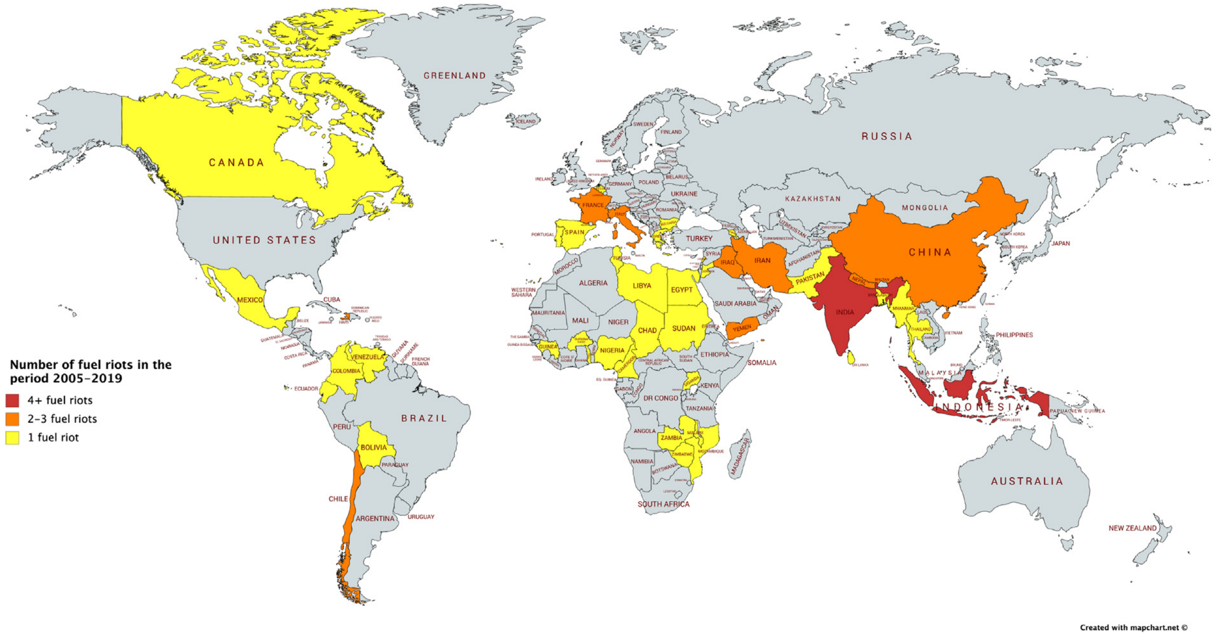

Fig. 1. Map of incidence of fuel riots 2005–2018.

natural gas, coal and electricity) as these capture the difference between retail prices and international price of the resource when this is internationally traded (i.e. fuel), and the difference between the retail price and the user cost (cost of production) for those not usually traded (i.e. electricity) (Coady et al., 2017). Our assessment of the domestic price regime is based on an analysis of monthly price changes in the dataset of international and domestic gasoline prices compiled by Ross et al. (2017) which contains information about local retail gasoline prices for 157 countries from 2003 to 2015.

Globally, fuel riots are clearly related to the price of oil. Fig. 2 shows the number of fuel riots that took place globally for each year from 2005 to 2018 alongside the international oil price: as expected, fuel riots spike when international oil prices spike, since this generally has a direct impact on the domestic price of fuel.

However, there are several other factors that may influence the likelihood of a fuel riot. Since Gurr (1970), a large literature has shown how relative deprivation and drops in economic standing may give rise to social discontent and grievances.[7] Therefore, it is reasonable to expect the number of fuel riots to be associated with the economic development of the country. In addition, our fuel riots variable measures whether there has been a violent protest related to energy during that year, which makes it more likely that we will observe such riots in countries with larger populations simply because there are more people that might feel sufficiently unhappy to participate in a riot. We therefore include in our analysis country-level GDP per capita and population as controls using data compiled from the World Bank's World Development Indicators (WDI) database.

Finally, there are several different aspects of governance which might also influence fuel riots. The Varieties of Democracy (VDEM) (Coppedge et al., 2019) and the Polity IV datasets (Marshall, 2019) provide a comprehensive set of variables measuring different aspects of the political and governance makeup of countries over time. We draw on this to explore the impact of four variables. First, populations may be angered by government incompetence and/or corruption; we therefore include measures of government effectiveness and the extent of corruption. Second, the likelihood of fuel riots may be influenced by the ability to protest. Mass protests may also be more likely when there is space for civic engagement, independent media, and organizations capable of mobilizing support are present (Tilly & Tarrow, 2015). Conversely, protests may be less likely under authoritarian regimes that suppress civil society freedom; we therefore include measures of regime type and civil society freedom. Finally, riots may not be accidents; rather they be deliberated orchestrated by groups seizing the opportunity of rising prices to mobilise people against the government. We therefore include a measure that assesses the existence of 'anti-system' movements within the country.[8]

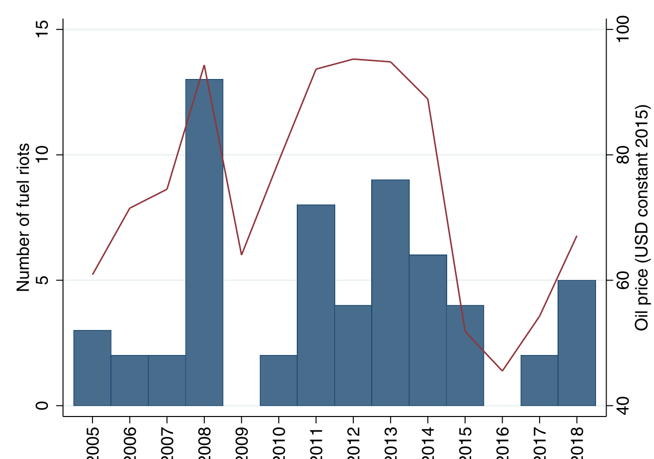

Fig. 2. Fuel riots and international oil prices.

[7] See the review of this literature in Justino and Martorano (2019).

[8] see Appendix A for a summary of all variables and descriptive statistics

3. Models

3.1. Domestic price changes and fuel riots

Our first objective is to see if there is a relationship between monthly domestic price changes and fuel riots. Given the range of other factors that could potentially influence the occurrence of fuel riots, we estimate a fixed effects logit panel regression of the log odds ratio of a fuel riot against the growth in domestic and international fuel prices. We control for the possibility of common time effects (for example, induced by changes in international oil prices) using month dummies for the entire period. By including country fixed effects, we eliminate the possibility that any observed association is due to fixed country characteristics that might affect the likelihood of a fuel riot.

As noted above, there is also a possibility that time-varying country characteristics may influence the likelihood of a fuel riot. For example, as suggested in Gurr (2011) and a large literature on economic deprivation and unrest that followed it, riots may be a reaction to worsening economic conditions in general, rather than specifically related to energy subsidy reform. Equally, people may be angry about different aspects of the governance of the country and use price changes in fuels as a pretext to protest against a wider set of issues (Hossain et al., 2018). We therefore include GDP growth, a set of governance variables (explained above) as well as the log of per capita GDP and the log of population as controls.

We choose a panel logit model, rather than panel OLS, to account for the possibility of zero inflation.[9] This could occur, for example, if our method of identifying fuel riots failed to find riots that were not reported in English language media. If this was the case, then our data is likely to have excess zeros (or missing ones) in countries with no English language media which could bias the results from an OLS regression. A logit regression is more robust to zero inflation because it omits countries where no riots took place, which are more likely to be countries where zero inflation is present. However, logit models are also subject to bias in small samples (Nemes, Jonasson, Genell, & Steineck, 2009). We therefore include panel OLS regressions in our robustness tests as described below.

The model that we estimate is:

$$Logit(Riot_{im}) = \beta_0 + \beta_1.\Delta p^{dom}_{im} + \beta_2.\Delta p^{int}_{im} + \beta_2.GDPgrowth_{it} + \beta_3.Governance_{it} + \beta_4.lnGDPpc_{it} + \beta_5.lnPop_{it} + \gamma_m + \lambda_i + \epsilon_{im} \quad (1)$$

where $Riot_{im}$ indicates that country i had a riot in month m; Δp^{dom}_{im} is the proportionate change in the domestic fuel price in the preceding month; Δp^{int}_{im} is the proportionate change in the international fuel price in the preceding month; $GDPgrowth_{it}$ is the growth in GDP between year $t-1$ and year t; $Governance_{it}$ is a vector of governance factors; $lnGDPpc_{iy}$ is log GDP per capita for country i in year y; $lnPop_{iy}$ is log of the population; γ_m is a month dummy; λ_i is the country fixed effect; and ϵ_{im} represents a random error term.

Table 1 shows that there is a statistically significant positive relationship between domestic price growth from month to month and fuel riots. The estimated coefficient suggests that an increase in the growth rate of local prices of, say 10 percentage points, would increase the (initially low) relative odds of a fuel riot by around 23 percent.[10] However, the relationship with international fuel prices is much weaker and not statistically significant, even if domestic price changes are omitted, suggesting that riots are driven more by the way in which domestic prices are determined than by international price fluctuations.

Table 1
Fuel riots and price changes - xtlogit.

	(1) Fuel_riot	(2) Fuel_riot	(3) Fuel_riot
Fuel_riot			
Growth of domestic gasoline price	2.109**	2.057**	
	(2.55)	(2.48)	
Growth of world gasoline price	4.022		3.159
	(0.82)		(0.74)
GDP growth	−0.0545	−0.0432	−0.0437
	(-1.16)	(-0.96)	(-0.96)
Government effectiveness	−1.234	−1.144	−1.069
	(-0.82)	(-0.78)	(-0.72)
Extent of corruption	3.743	5.366	3.655
	(0.69)	(1.07)	(0.68)
Civil society freedom	0.416	0.399	0.420
	(0.84)	(0.83)	(0.86)
Anti-government movements	0.813	1.001*	0.900*
	(1.53)	(1.84)	(1.70)
Log GDP per capita	0.145	−0.287	0.0783
	(0.07)	(-0.13)	(0.04)
Log population	−0.0733	0.282	0.365
	(-0.01)	(0.05)	(0.06)
Observations	3833	3947	3833

z statistics in parentheses.
Fixed effects logit regression with month dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

3.2. The role of price regimes

We hypothesized in the introduction to the paper that the effect of fuel prices on fuel riots discussed above may be affected by price regimes. To analyze this mechanism, we proceed in three steps. First, we estimate the effect of changes in international prices on domestic prices to check how international price shocks may be transmitted to local markets. Second, we test whether fixing domestic prices - which effectively results in subsidies on fuel - may cushion domestic prices against international price changes. Finally, we estimate the effect of such subsidies on fuel riots.

Domestic fuel prices are largely driven by international price changes, but this relationship can be dampened somewhat by fixing prices domestically, at least for a while. To assess the extent to which this is true, we need a measure of the extent to which prices are fixed. Unfortunately, we are unaware of any database that indicates the policy regime followed by all countries over time. However, it is possible to infer the policy regime by looking at the extent to which prices change.[11] We therefore use the database of monthly domestic prices described above to construct a measure of price 'fixedness' which is simply the percentage of months that domestic fuel prices remained the same. If a country has a fixedness of zero, it has a completely flexible price regime in which prices change every month, while if it has a fixedness of 100 then its price regime is completely rigid with no changes in domestic prices at all between 2005 and 2018.

Of the 157 countries for which we have monthly domestic price data, 73 have regimes in which the price changes every month. By contrast, only two countries had no price changes at all over the period. All other countries kept prices fixed at least for some months. However, most let prices adjust regularly. Over three-quarters of the countries adjusted prices at least every two months, while only around a fifth of countries adjusted domestic prices infrequently. To simplify, we define a country as having a 'fixed price regime' if it keeps domestic prices the same more than 80 percent of the time across all months for which we have data. If

[9] We are grateful to a reviewer for pointing out this potential weakness.

[10] That is exp(0.1 x 2.109) = 1.23.

[11] For the moment, we have assumed that the policy regime remains fixed over the period for which we have data.

the country fixes prices less than this, we define it as having a 'flexible price regime'.

To answer our question about the pass-through of international prices to the local market in each country, we estimate the following model separately for each country:

$$\Delta p_m^{dom} = \beta_0 \Delta p_m^{int} + \beta_1 \Delta p_{m-1}^{int} + \beta_2 \Delta p_{m-2}^{int} + \beta_3 \Delta p_{m-3}^{int} + \epsilon_m$$

where Δp_m^{dom} is the change in the domestic fuel price in a country between month m and the preceding month; Δp_m^{int} is the change in the international fuel price during the same period; Δp_{m-k}^{int} are changes in international prices in the preceding months; and ϵ_m represents a random error term.

Our model reflects the fact that international prices are unlikely to pass through immediately to domestic prices, but may do so with some lag. Thus β_0 represents the short-run pass-through of international prices, while the sum $\beta_0 + \beta_1 + \beta_2 + \beta_3$ provides an estimate of the medium-run pass-through of prices.[12] Since countries have quite different approaches to regulating domestic prices, it is likely that the value of these coefficients will differ substantially by country. Because we estimate this model separately for all countries, we can examine the distribution of pass-through coefficients. We find that - for the median country, the short-run pass through is around 0.17 - that is around 17 percent of the change in the international price is passed through to domestic markets in the same month; the medium-run pass through is around 0.47.

Our hypothesis is that a policy of fixing local prices should reduce the pass through of international prices. Fig. 3 shows the range of estimates of short-run and medium-run pass through coefficients for countries with flexible and fixed price regimes. As anticipated both short-run and long-run pass through coefficients in fixed price regime countries are significantly below those in countries with a flexible price regime. The median short-run pass through for countries with flexible price regimes is 0.12 and the median long-run pass through is 0.33; however, for countries with fixed price regimes the equivalent figures are 0.005 and 0.08. As one might expect, countries which fix prices most of the time pass through international price shocks much less.

However, while fixing prices does appear to reduce domestic price volatility in the short term, it also has a major impact on the size of domestic price increases when they do occur. Fig. 4 shows the mean price change for the months in which price changes occurred for all countries plotted against the extent to which they fix prices.[13] Countries that adjusted prices frequently (low fixedness), tended to have relatively small adjustments. However, those that fixed prices and held them for longer, tended to have much larger price increases when prices did change.

Dividing countries again into flexible and fixed price regimes as above, we find that the mean price change for countries with flexible price regimes was 0.7 percent (the standard deviation of price changes was also 0.7); but for fixed price regimes (i.e. those that kept prices the same more than 80 percent of the time), the mean price change was 17.3 percent, almost 24 times larger. The standard deviation of price changes for this group of countries was 27, almost 40 times larger. Even if we include all of the months in which there is no change in price in the calculation of the mean price change and standard deviation, the mean price change for fixed price regime countries is 68 percent higher than that of flexible price regimes and the standard deviation more than double. In short, fixed price regimes may protect populations from international price changes over the relatively short term, but when price changes do happen, they are much larger.

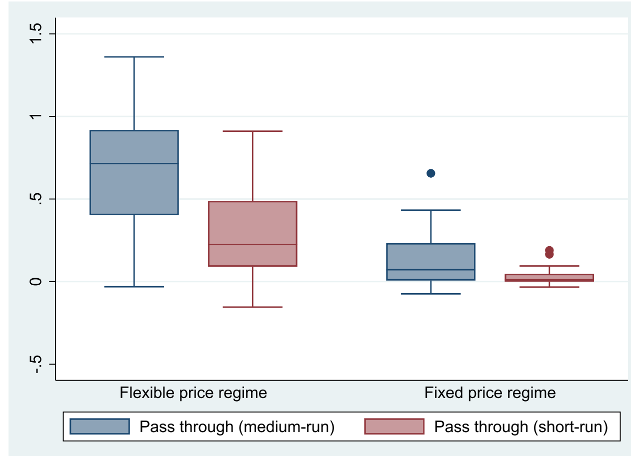

Fig. 3. Pass through of international prices under flexible and fixed price regimes.

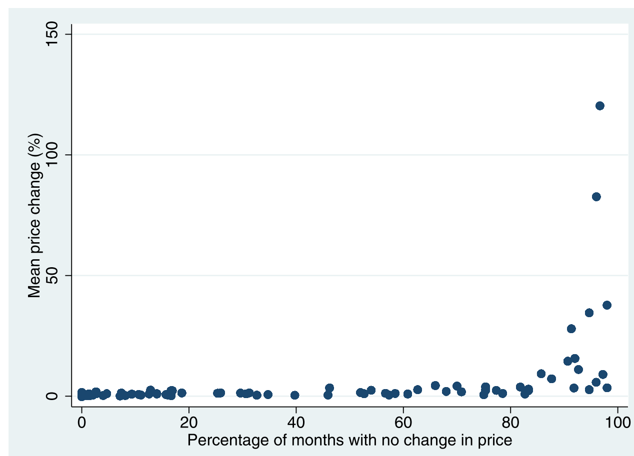

Fig. 4. The impact of fixed prices on average price changes.

Why does fixing prices result in large domestic price shocks? The discussion in the introduction to the paper suggests that this is because fixing prices tends to create large subsidies. When such subsidies become fiscally unsustainable, governments choose to raise the domestic price. If this is true, we would expect to find evidence of a strong relationship between fixing prices and subsidies. We use the data on domestic and international gasoline prices in (Ross et al., 2017) as well as their data on gasoline consumption to construct a measure of gasoline subsidies for each country and year. We then regress annual gasoline subsidies on international oil prices and our measure of price fixedness.[14] As before, there are a range of country specific reasons why gasoline subsidies might be high, and gasoline subsidies are also likely to be influenced by the international oil price in any given year. We account for these by estimating using a fixed effects panel model, including GDP per capita and population as time-varying controls.

Table 2 shows that, as expected, higher oil prices make gasoline subsidies larger - but fixing domestic gasoline prices also increases

[12] Where medium-run means four months in this instance. See Sun, Zhang, Hong, and Wang (2019) for recent evidence on the pass through of oil prices to gasoline prices.

[13] Here we are using the continuous measure of price fixedness described above i.e. the percentage of months in which prices stay the same.

[14] Because we are estimating with fixed effects, we cannot use a measure of price fixedness for the entire period since this would then be a fixed effect. We therefore calculate an annual measure of price fixedness to allow for the possibility that countries change the extent to which they fix prices.

subsidies significantly. Increasing the level of price fixedness from its mean level of 23 percent, to 75 percent (equivalent to shifting from changing prices every three months to changing prices every nine months) more than doubles gasoline subsidies.

So far, we have shown that domestic price shocks are associated with fuel riots; that domestic price changes are larger in regimes that attempt to fix prices for longer; and that fixing gasoline prices increases gasoline subsidies. But are larger subsidies associated with large domestic price changes? To assess this, we also regressed the largest fuel price rise in a year against the size of gasoline subsidies. Again, we control for country fixed effects and include dummies for each year. Table 3 shows a strong association between lagged subsidies and the maximum size of price changes in the subsequent year.[15]

Gasoline subsidies are only one part of the energy subsidies that countries have. Many countries also subsidise other fuels including diesel, kerosene, coal, natural gas and electricity. Our hypothesis is that it is the fiscal unsustainability of such subsidies that gives rise to the large energy price shocks. Reducing or removing such subsidies may abrogate a social contract which could lead to violent protest (McCulloch et al., 2021). If this is the case, we would expect that the IMF's full measure of energy subsidies should have an independent impact on the likelihood of fuel riots.

To test this, we estimate a model similar to Eq. 1 i.e. a panel logit model, but now using annual data and where our parameter of interest is the effect of our full measure of subsidies. As before we include other possible drivers of fuel riots including economic growth, and the quality of governance, as well as controlling for GDP per capita and population size. The model is:

$$Logit(Riot_{it}) = \beta_0 + \beta_1.L.lnSubsidies_{it} + \beta_2.GDPgrowth_{it} + \beta_3.Governance_{it} + \beta_4.lnGDPpc_{it} + \beta_5.lnPop_{it} + \gamma_t + \lambda_i + \epsilon_{it} \quad (3)$$

where $Riot_{it}$ indicates that country i had (at least) one riot in year t; $lnSubsidies_{it}$ is the log of pre-tax subsidies for country i in year t; $GDPgrowth_{it}$ is the growth in GDP between year $t-1$ and year t; $Governance_{it}$ is a vector of governance factors; $lnGDPpc_{it}$ and $lnPop_{it}$ are GDP per capita and population controls as before, γ_t is a time dummy; λ_i is the country fixed effect; and ϵ_{it} represents a random error term.

We use total pre-tax energy subsidies from the comprehensive database provided by the IMF.[16] We lag this variable to minimise endogeneity due to the fact that a subsidy reform early in a year could cause a riot, but also reduce the value of subsidies.

To account for the possibility of poor general economic performance leading to riots (even if they are ostensibly about energy), we include GDP growth as an independent variable. If this is important, we would expect that recessions should be associated with riots (i.e. β_2 will be negative).

Table 4 shows the results. Our first model includes only lagged subsidies and the GDP per capita and population controls. Subsidies are strongly positively associated with fuel riots. The coefficient suggests that a 10 percent increase in the size of subsidies will increase the relative odds of a fuel riot by around 22 percent.

Model 2 explores whether fuel riots are also driven by poor economic performance. As expected, we see a negative coefficient, but it is small and not statistically significant suggesting that fuel riots are not primarily driven by overall economic performance. The size and significance of the effect of subsidies is unchanged.

[15] We lag subsidies because price changes can affect the size of subsidies in the same year.

[16] By 'pre-tax subsidies' the IMF mean the financial value of subsidies before adding optimal taxation to account for the externalities caused by the consumption of energy.

Table 2
Subsidies, oil prices and price fixing - xtreg.

	(1) Log fuel subsidies (Ross)
Log of real oil price	0.186**
	(2.32)
Price fixedness	0.00209**
	(2.94)
Log GDP per capita	−0.652***
	(-4.76)
Log population	0.379**
	(2.03)
Observations	873

t statistics in parentheses.
Panel regression with country level fixed effects.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Table 3
Subsidies associated with large price rises.

	(1) Max monthly growth of domestic gasoline price
L.Log fuel subsidies (Ross)	0.0547**
	(2.40)
Observations	883

t statistics in parentheses.
Panel regression with country level fixed effects.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

While the incompetence and corruption of governments is often mentioned by protesters as a reason for their actions (Hossain et al., 2018), we find no statistically significant relationship between these variables and fuel riots. However, we do obtain a particularly interesting result on the relationship between civil society freedom and fuel riots. Contrary to our expectations, we find that greater civil society freedom results in fewer, rather than more riots. The effect is statistically significant and large - an increase of one point on the five point scale measuring civil society freedom reduces the likelihood of a fuel riot by almost two-thirds. This suggests that greater openness to dialogue and the ability to complain may actually help to avert fuel riots, rather than promote them. Finally, we also obtain an interesting result regarding anti-system movements. As expected, we find that these are positively and strongly associated with the increased likelihood of a riot (with a similar size effect as that of civil society freedom).

Taken together, these results strongly suggest that fuel riots are driven by changes in domestic fuel prices but these are mediated by the price regimes in place in each country and, in particular, by the size and fiscal sustainability of subsidies. Fuel riots are more likely in countries with large energy subsidies. But they may also be influenced by aspects of country governance, notably whether civil society is free to raise complaints and the extent to which opposition groups exist that might wish to exploit price rises to discredit the government.

3.3. Robustness tests

To assess the robustness of our result that subsidies are associated with fuel riots we examine three potential weaknesses in our model.

First, we raised earlier the possibility that there may be 'missing riots' in our data because the search was only performed on English language websites. Our preferred fixed effects panel logit model already reduces any potential bias since it excludes countries where no riots occurred. However, as an additional check, we obtained a variable that indicates whether a country has English

Table 4
Riots and subsidies - xtlogit.

	(1) Fuel riot	(2) Fuel riot	(3) Fuel riot
Fuel riot			
L.Log subsidies	1.851*	1.768*	1.965*
	(1.90)	(1.83)	(1.89)
GDP growth		−0.0735	−0.0255
		(-1.29)	(-0.43)
Government effectiveness			−1.320
			(-0.67)
Extent of corruption			1.022
			(0.20)
Civil society freedom			−1.042*
			(-1.67)
Anti-government movements			1.732**
			(1.99)
Log GDP per capita	−2.845	−1.272	−1.823
	(-1.14)	(-0.42)	(-0.42)
Log population	−10.54	−10.80	−12.08
	(-1.30)	(-1.33)	(-1.37)
Observations	228	228	228

z statistics in parentheses.
Logistic panel regression with country level fixed effects and year dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

language newspapers or not. If it does not, it is more likely that any fuel riots will not have been reported in English language media. We therefore run the model again excluding these countries. The results are substantively the same (see Appendix A).

Second, we have relative few fuel riots compared to the total number of country-years in the panel. It is well known that non-linear models, such as the logit model, can be biased in small samples. OLS models are not subject to the same biases.[17] (although they may be biased downwards by zero inflation). We therefore estimate the model using a fixed effects panel OLS model. This gives similar results to the logit model. We also estimate the panel OLS model just in countries with English language newspapers and find substantively the same result. To account for the possibility that we have missed riots because of media censorship, we use a variable from VDEM to exclude countries ranking in the bottom decile for freedom of expression. In all cases, we find a strong and statistically significant relationship between subsidies and fuel riots (see Appendix A for details).

Finally, it could be argued that our results are not picking up an association between energy subsidies and fuel riots specifically, but simply the propensity for places with large subsidies to have unrest of any kind. To test this, we draw on the Armed Conflict and Event Data (ACLED) dataset, which records a variety of different types of conflict across the world and over time and has been used extensively in the analysis of the determinants of conflict (Raleigh et al., 2010). Specifically, we replace our dependent variable with the sub-event type 'Riots' from ACLED. If our results were simply capturing riots in general, rather than energy-related riots in particular, then we would expect that subsidies would also be associated with this measure. However, we find that this is not the case (see Appendix A). Subsidies are not significantly associated with riots in general; the connection only exists with riots that are linked to energy.

4. Why countries fix prices and create subsidies

Given the adverse impact of fixing domestic prices and thereby creating fuel subsidies, as well as their propensity to prompt riots, why do so many governments use this policy instrument? The literature points towards two possible motivations for adopting subsidies by fixing prices. First, people living in countries with oil may feel that they are entitled to a share of the benefits. Knowing this, states choose to subsidize fuel as a way of providing a benefit to the population that is directly linked to the resource (McCulloch et al., 2021). In a sense, this is a basic social contract, but one not based on service delivery, but rather simply sharing out, in an easy and conspicuous way, some of the proceeds of oil wealth. If this is the case, we would expect the adoption of a fixed price regime to be strongly associated with being a net energy exporter.

Second, Victor (2009) argues that some countries subsidize fuel because they lack the capacity to implement more sophisticated forms of social protection. If this is the case, we would expect to see a negative association between government effectiveness and the size of subsidies.

We therefore regress the size of subsidies against whether the country is a net energy exporter and measures of government effectiveness.[18]

Table 5 shows that the data support both of the hypotheses above. Net energy exporters are more likely to have large subsidies. Similarly, countries with more effective administration are much less likely to adopt such policies. However, we find that several of our measures of governance quality are also associated with subsidies. If we substitute our measure of government effectiveness with measures of regime type[19], we find that the more closed and autocratic the regime, the larger subsidies are likely to be. Similarly, countries with higher levels of corruption have larger subsidies. Civil society freedom is not only associated with a reduced chance of fuel riots, as shown above, but also with smaller subsidies. While we are not able to assert causality, our results are consistent with the hypothesis that such policies are often introduced in resource abundant countries with relatively weak governance.

[17] Indeed, recent work suggests that least squares estimators may be the Best Unbiased Estimators - see (Hansen, forthcoming).

[18] We cannot use a fixed effects panel regression because whether a country is a net energy exporter is almost always a fixed characteristic; we therefore estimate an OLS regression controlling for heterogeneity with year and region dummies as well as GDP per capita and population as before.

[19] This takes the values: 0-autocracy; 1-electoral autocracy; 2-electoral democracy; 3-liberal democracy. See Coppedge et al. (2019) for details.

Table 5
Structural determinants of subsidies.

	(1) Log subsidies	(2) Log subsidies	(3) Log subsidies	(4) Log subsidies	(5) Log subsidies
Net energy exporter	0.612***	0.630***	0.604***	0.552***	0.466**
	(3.96)	(4.29)	(4.12)	(3.51)	(3.06)
Government effectiveness	−0.348**				−0.103
	(-2.71)				(-0.70)
Closed autocracy		0.830**			
		(3.08)			
Electoral autocracy		0.591**			
		(2.98)			
Electoral democracy		0.415**			
		(2.80)			
Extent of corruption			0.956***		0.659*
			(3.49)		(1.86)
Civil society freedom				−0.217***	−0.162**
				(-3.60)	(-2.65)
Log GDP per capita	0.215**	0.125*	0.175**	0.0956	0.208**
	(2.25)	(1.84)	(2.44)	(1.62)	(2.39)
Log population	0.302***	0.315***	0.301***	0.302***	0.314***
	(6.80)	(7.01)	(6.65)	(6.77)	(7.13)
Observations	703	698	698	698	698

t statistics in parentheses.
OLS regression with year and region dummies. Omitted regime is Liberal Democracy.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

5. Conclusions

Fuel riots can have major implications for ordinary people and for entire countries. They are violent - sometimes leading to deaths - and are highly disruptive. Moreover, fuel riots often pre-empt or prevent further attempts at policy dialogue and reform - at least for a while (Hossain et al., 2021).

Our findings suggest that fuel riots are primarily driven by domestic price increases. To some extent, these reflect changes in the international oil price, but these effects are mediated by how countries attempt to protect their populations by fixing domestic prices for periods of time. However, fixed price policies (both for fuel and electricity) tend to result in large subsidies which can create fiscal strains. Our results show that large subsidies may make fuel riots more likely. This is because when these subsidies are no longer sustainable, the price increases resulting from a reduction of the subsidies are much larger than those that typically occur in countries with more flexible price regimes, potentially triggering riots.

We also find that countries which are net energy exporters are much more likely to have large subsidies. Countries with low levels of government capability and effectiveness are also more likely to have large subsidies, supporting the idea that subsidies are used as an administratively easy way of providing a social transfer. Ironically, we find that the large subsidies that such policies produce do not protect populations from price shocks and make fuel riots more likely.

Our findings further emphasize the value of removing fuel subsidies and shifting to flexible price regimes (although this should be done with steps to mitigate the social impact of doing so - see Rentschler & Bazilian (2017) for good practice in implementing reforms). However, this naturally begs the question of why countries have not already done so. The answer is likely to lie in the complex politics of social contracts in countries that are net exporters of energy. Nonetheless, our results should give policymakers further pause for thought about the wisdom of policies that perpetuate large subsidies. Subsidies may provide short-term political gains but, by making riots more likely, they may have large long-term political costs. Going forward, researchers may wish to focus more on building a better understanding of the political, and not just the economic, dimensions of subsidy reform.

Data availability statement

The authors declare that the data supporting the findings of this study are available within the paper and its supplementary information files.

Code availability statement

The authors declare that the Stata do files used to undertake the analysis are included in the supplementary information files.

CRediT authorship contribution statement

Neil McCulloch: Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration. **Davide Natalini:** Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration. **Naomi Hossain:** Writing - review & editing, Supervision, Project administration, Funding acquisition. **Patricia Justino:** Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

A.1. Summary statistics

Table 6
Summary statistics.

	Mean	SD	Min	Max	N
Fuel riot	0.02	0.14	0.00	1.00	3,011
GCMP_fuel	0.01	0.09	0.00	1.00	3,011
ACLED riot	0.27	0.44	0.00	1.00	2,452
Log subsidies	0.47	0.86	0.00	4.35	1,534
Log fuel subsidies (Ross)	−0.08	0.79	−5.15	3.08	886
Max monthly growth of domestic gasoline price	0.08	0.17	−0.12	4.00	1,696
Log of real oil price	4.28	0.24	3.82	4.56	3,011
Price fixedness	23.24	37.19	0.00	100.00	1,696
Net energy exporter	0.34	0.47	0.00	1.00	1,419
Government effectiveness	−0.02	1.00	−2.48	2.44	2,822
Regime type	1.65	0.99	0.00	3.00	2,479
Extent of corruption	0.53	0.30	0.01	0.98	2,479
Civil society freedom	0.98	1.40	−3.73	3.38	2,479
Anti-government movements	−0.69	1.12	−2.97	3.01	2,479
Log GDP per capita	8.67	1.50	5.35	12.19	2,780
GDP growth	3.45	5.35	−62.08	123.14	2,575
Log population	15.21	2.36	9.21	21.05	2,962
English newspaper	0.83	0.37	0.00	1.00	2,983
Freedom of expression	0.89	0.31	0.00	1.00	2,479

A.2. Robustness tests for Table 1

Table 7
Fuel riots and price changes - xtlogit - only English.

	(1)	(2)	(3)
Fuel_riot			
Growth of domestic gasoline price	2.221**	2.140**	
	(2.62)	(2.52)	
Growth of world gasoline price	4.763		3.607
	(1.00)		(0.88)
GDP growth	−0.0641	−0.0497	−0.0511
	(-1.27)	(-1.05)	(-1.07)
Government effectiveness	−1.439	−1.371	−1.241
	(-0.93)	(-0.90)	(-0.81)
Extent of corruption	2.782	4.992	2.815
	(0.48)	(0.95)	(0.49)
Civil society freedom	0.554	0.523	0.559
	(1.07)	(1.05)	(1.09)
Anti-government movements	0.830	1.082*	0.950
	(1.36)	(1.77)	(1.58)
Log GDP per capita	−0.0146	−0.467	−0.0583
	(-0.01)	(-0.21)	(-0.03)
Log population	−0.520	−0.0884	0.139
	(-0.08)	(-0.01)	(0.02)
Observations	3493	3605	3493

z statistics in parentheses.
Fixed effects logit regression with month dummies - English.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Table 8
Fuel riots and price changes - xtreg.

	(1)	(2)	(3)
Growth of domestic gasoline price	0.0397***	0.0392***	
	(5.63)	(5.58)	
Growth of world gasoline price	0.0144		0.0173
	(0.76)		(0.91)
GDP growth	−0.000182**	−0.000169**	−0.000179**
	(-2.12)	(-1.99)	(-2.09)
Government effectiveness	−0.00275	−0.00225	−0.00322
	(-0.70)	(-0.58)	(-0.82)
Extent of corruption	0.00908	0.0114	0.00910
	(0.82)	(1.04)	(0.82)
Civil society freedom	0.00176	0.00163	0.00173
	(1.33)	(1.24)	(1.31)
Anti-government movements	0.00317**	0.00351**	0.00325**
	(2.32)	(2.59)	(2.38)
Log GDP per capita	0.00281	0.000719	0.00226
	(0.44)	(0.11)	(0.35)
Log population	0.00157	0.00178	0.00141
	(0.16)	(0.18)	(0.14)
Observations	16673	16931	16673

t statistics in parentheses
Fixed effects regression with month dummies
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$

Table 9
Fuel riots and price changes - xtreg - only English.

	(1)	(2)	(3)
Growth of domestic gasoline price	0.0452***	0.0446***	
	(5.82)	(5.76)	
Growth of world gasoline price	0.0196		0.0225
	(0.93)		(1.06)
GDP growth	−0.000234**	−0.000219**	−0.000233**
	(-2.37)	(-2.23)	(-2.36)
Government effectiveness	−0.00447	−0.00393	−0.00516
	(-1.00)	(-0.88)	(-1.15)
Extent of corruption	0.0108	0.0137	0.0109
	(0.84)	(1.08)	(0.85)
Civil society freedom	0.00227	0.00211	0.00221
	(1.50)	(1.41)	(1.47)
Anti-government movements	0.00382**	0.00433**	0.00394**
	(2.23)	(2.54)	(2.30)
Log GDP per capita	0.00425	0.00188	0.00354
	(0.59)	(0.27)	(0.49)
Log population	0.00306	0.00296	0.00274
	(0.28)	(0.27)	(0.25)
Observations	14147	14313	14147

t statistics in parentheses.
Fixed effects regression with month dummies - English.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

A.3. Robustness tests for Table 3

Table 10
Riots and subsidies - xtlogit - English only.

	(1) Fuel riot	(2) Fuel riot	(3) Fuel riot
Fuel riot			
L.Log subsidies	1.952*	1.875*	2.063*
	(1.95)	(1.89)	(1.94)
GDP growth		−0.0858	−0.0261
		(-1.31)	(-0.41)
Government effectiveness			−0.971
			(-0.49)
Extent of corruption			0.666
			(0.13)
Civil society freedom			−0.996
			(-1.60)
Anti-government movements			1.751*
			(1.95)
Log GDP per capita	−3.302	−1.812	−2.866
	(-1.30)	(-0.59)	(-0.63)
Log population	−11.87	−12.55	−12.96
	(-1.39)	(-1.46)	(-1.43)
Observations	220	220	220

z statistics in parentheses.
Logistic panel regression with country level fixed effects and year dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Table 11
Riots and subsidies - xtreg.

	(1) Fuel riot	(2) Fuel riot	(3) Fuel riot
L.Log subsidies	0.102***	0.102***	0.100***
	(4.50)	(4.50)	(4.15)
GDP growth		−0.00215**	−0.00209**
		(-2.53)	(-2.23)
Government effectiveness			0.0310
			(0.86)
Extent of corruption			0.000322
			(0.00)
Civil society freedom			−0.0221*
			(-1.73)
Anti-government movements			0.0265**
			(2.06)
Log GDP per capita	−0.0786	−0.0229	−0.0419
	(-1.22)	(-0.34)	(-0.54)
Log population	−0.182	−0.193	−0.129
	(-1.31)	(-1.39)	(-0.82)
Observations	1493	1493	1335

t statistics in parentheses.
Panel regression with country level fixed effects and year dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Table 12
Riots and subsidies - xtreg - English only.

	(1) Fuel riot	(2) Fuel riot	(3) Fuel riot
L.Log subsidies	0.109***	0.108***	0.109***
	(4.35)	(4.33)	(4.01)
GDP growth		−0.00243**	−0.00228**
		(-2.57)	(-2.17)
Government effectiveness			0.0370
			(0.86)
Extent of corruption			0.00949
			(0.07)
Civil society freedom			−0.0261*
			(-1.78)
Anti-government movements			0.0292**
			(1.98)
Log GDP per capita	−0.101	−0.0348	−0.0760
	(-1.32)	(-0.43)	(-0.79)
Log population	−0.234	−0.250	−0.190
	(-1.45)	(-1.55)	(-1.04)
Observations	1278	1278	1127

t statistics in parentheses.
Panel regression with country level fixed effects and year dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Table 13
Riots and subsidies - xtreg - Freedom of Expression.

	(1) Fuel riot	(2) Fuel riot	(3) Fuel riot
L.Log subsidies	0.125***	0.124***	0.123***
	(4.34)	(4.34)	(4.26)
GDP growth		−0.000368	−0.000425
		(-0.35)	(-0.40)
Government effectiveness			0.00665
			(0.16)
Extent of corruption			−0.0304
			(-0.25)
Civil society freedom			−0.0290**
			(-2.00)
Anti-government movements			0.0194
			(1.31)
Log GDP per capita	−0.0685	−0.0584	−0.0677
	(-0.80)	(-0.65)	(-0.73)
Log population	−0.222	−0.224	−0.186
	(-1.32)	(-1.33)	(-1.09)
Observations	1213	1213	1213

t statistics in parentheses.
Panel regression with country level fixed effects and year dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

A.4. Robustness to use of ACLED dependent variable Table 14

Table 14
Robustness to use of ACLED dependent variable.

	(1) ACLED riot	(2) ACLED riot	(3) ACLED riot
ACLED riot			
L.Log subsidies	−1.736	−2.066	−1.322
	(-0.61)	(-0.75)	(-0.43)
GDP growth		0.141	0.143
		(0.95)	(0.90)
Government effectiveness			5.881*
			(1.66)
Extent of corruption			−5.567
			(-0.52)
Civil society freedom			0.973
			(0.73)
Anti-government movements			−0.328
			(-0.26)
Log GDP per capita	2.401	0.781	−2.631
	(0.33)	(0.10)	(-0.25)
Log population	34.10*	30.17	23.73
	(1.87)	(1.61)	(1.06)
Observations	140	140	140

z statistics in parentheses.
Logistic panel regression with country level fixed effects and year dummies.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

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