# Commodity Price Volatility and Civil Conflict

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**Abstract**

Recent work in political science and economics emphasizes that primary commodities are linked to civil conflict. But how? Fifteen years of research has produced a blizzard of competing answers, accompanied by contradictory and null findings. We argue that is because this literature has neglected the fundamental lesson of rationalist explanations for conflict, which is that observed advantages for one party in a bargaining process will produce more concessions but not more conflict. We develop a simple extension of the canonical bargaining model of war (Fearon 1995) to explore the connection between commodity revenues and conflict. The model reveals that export commodity price volatility – the degree of unpredictability of future price changes – causes a commitment problem that should increase the probability of armed conflict; but neither commodity dependence by itself nor observed commodity price changes should have any effect. We test and find strong support for these hypotheses with the most comprehensive and disaggregated dataset yet brought to bear on these questions, using monthly data for 71 commodities and 145 non-OECD countries from 1963-2012. The tests incorporate indicators of exogenous variability and shocks in the world prices of a country's export portfolio, along with measures of civil conflict at various levels of intensity. The results hold regardless of the type of commodity in question. The paper thus provides an integrated explanation for a wide range of seemingly contradictory empirical findings in the literature on commodities and conflict.

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# 1 Introduction

Recent work in political science and economics emphasizes that primary commodities[1] are linked to civil conflict.[2] But how? Some commodity dependent economies (i.e., those where commodities account for a large share of export revenues or of gross domestic product) experience more civil conflict; but others do not. Similarly, which commodities make a state most conflict-prone: oil, lootable resources such as timber and alluvial diamonds, extractive mineral resources more generally, or all commodities? The literature emphasizes that civil war may be more likely in oil exporting nations, but then again, oil exporting Arab states were most able to spend what was necessary to prevent sustained rebellion in the Arab Spring (Ross 2011). Other observers have focused on the impact of commodity price shocks (e.g., Dube and Vargas 2013, Brückner and Ciccone 2010). Large increases in the world prices of a state's export commodities preceded the onset of civil conflict in Sierra Leone in 1991, in Liberia in 1999-2000, and in Syria in 1979. However, large drops in prices preceded the emergence of the Liberian civil war in 1989-1990, the Algerian civil war of 1992, and the violent rebellion in Uganda in 1978-1979. Sometimes there are no net price changes in a state's top export commodity and conflict nonetheless occurs: this was true for the Republic of the Congo Civil War of 1997, though world prices of oil, Congo's top export, were little different than they had been 12 months before. Commodity dependence and commodity price changes seem connected to conflict, but as these contrasting examples illustrate, the causal connection is unclear.

This paper offers a simple, novel theory capable of explaining these related empirical puzzles, inspired by a common theme and a shared weakness in what Ross (2004*a*, 62) has called the "analytical muddle" of prevailing theories about resource dependence and conflict.

[1] A "commodity" is a non-differentiated good priced uniformly by the action of the market as a whole, often through a dominant regional or global exchange.

[2] Civil or intrastate conflict refers to the use of armed force in an interaction between a state and an organized political opposition or rebel group. The conflict may occur at a relatively low level of intensity, such as the UCDP dataset's threshold of 25 battle-related deaths per year, or at a higher level, commensurate with the concept of "civil war."

The common theme in the literature is straightforward. What do commodities do? They produce revenue, whether for the state or rebel groups. Whoever controls the commodity can use the export profits to finance their security operations and/or generate domestic support, thereby improving their fortunes in a civil conflict.

But how, if at all, does a shift in the relative capabilities of the belligerents make conflict more likely? Existing research on resource dependence and conflict has broadly assumed that developments that weaken the state or empower opposition groups make armed rebellion more likely. Yet this shared assumption violates the basic tenets of rationalist explanations of conflict, the so-called "bargaining model of war" framework (Fearon 1995, Reiter 2003). Fighting is costly; potential belligerents should thus mutually prefer a range of possible settlements over fighting. Observed shifts in the balance of capabilities among the actors do not close down this "bargaining range" but rather just push it in favor of one party or the other, getting "priced in" to a revised settlement. In this framework, bargaining does not break down in favor of violence unless (a) the parties have diverging expectations about the outcome or costs of fighting or (b) incentives to comply with a settlement may change in the future, leaving one side at a disadvantage in a future fight. While this framework has a strong tradition even in the study of intrastate conflict (e.g., Walter 2002, 2009), the literature on resource dependence and conflict has overlooked its basic lessons.

To explore the implications of the bargaining model framework in the context of commodity dependence and possible commodity price changes, we develop a simple extension of the canonical model of Fearon (1995). In the model, commodity exports produce revenue that affects the expected outcome of armed conflict in a mutually understood way. Therefore neither commodity dependence by itself nor observed changes in export commodity prices affect the conditions under which fighting occurs in equilibrium. However, export commodity price *volatility*, defined as the degree of unpredictability (or variance) of expected price changes, means that the distribution of capabilities between the state and rebel group is less certain in the next period. Fear that the adversary may greatly benefit from a future price (and thus revenue) change creates an incentive for preventive war. Volatility, in other words, is the source of a profound commitment problem for potential belligerents. We thus hypothesize that export commodity price volatility should catalyze armed conflict while prior observed price shocks should have no effect.

In order to test these hypotheses, we assemble monthly data on intrastate armed conflict onset at various levels of intensity for 145 non-OECD countries from 1963-2012. Using monthly price series for 71 commodities tracked by the World Bank, IMF, and other sources, we calculate observed price changes and variability along with GARCH-estimated latent volatility forecasts. These indicators are weighted by the state's one-year-lagged peacetime exports of each commodity, counting only those commodities for which the state is a price taker (accounting for less than, e.g., 10 percent of world exports). This yields an application of *wholly exogenous* world price movements that is nonetheless specific to each country and month. Bivariate descriptive statistics reveal that in months with higher historical or forecasted export commodity volatility, countries experience a higher rate of armed conflict onset. Estimates using Cox survival models (of the duration of peace in between episodes of armed conflict), with and without country-specific fixed effects, controlling for a standard battery of conflict predictors, reveal the same: export commodity price volatility increases the likelihood of civil conflict onset. Also as hypothesized, observed shocks in export commodity prices and levels of commodity dependence have no effect. These results do not differ by any categorization of commodities (e.g., petroleum or fuel versus non-fuel, "lootable" versus non-lootable, or natural resource versus agricultural goods). The findings also hold at the level of full-scale civil war or at lower thresholds of violence. Together, these results lend broad support to our theory about the mechanism that connects commodities with civil conflict.

The paper thus provides explanations for some of the most pressing puzzles in the empirical record and research literature on the subject. First, why are some commodity dependent economies more prone to conflict than others? Our answer: because those countries experienced spikes in export commodity price volatility. Some commodities in practice have higher volatility than others, and exporters of such commodities are on average more prone to conflict for that reason. However, volatility also varies greatly across time for any country, so vulnerability to conflict through this mechanism is not a chronic condition, even for the most commodity dependent countries. Second, which commodities make a state more conflict prone? Our answer: any and all commodities; they work the same way. If the world prices of a country's top commodity exports become volatile, then armed conflict is more likely there. Nearly all commodities have gone through spells of lower[3] as well as higher volatility, so no commodity is unique in the mechanism by which it affects civil conflict. Third, do observed commodity price increases raise or lower the odds of conflict? Our answer: they have no effect, regardless of the type of commodity. What matters is expectations about *future* price changes and volatility, not changes that have already been observed. The paper thus provides an integrated explanation for a wide range of seemingly contradictory empirical findings in the literature on commodities and conflict.

## 2 Background and Theory

There is an extensive literature on the ties between commodity dependence and conflict, highlighting several distinct causal mechanisms with different implications for which commodities matter most. One idea is that the rents from commodity exports may act as a "prize" that rebels may fight to win (Besley and Persson 2011, Rustad and Binningsbø 2012, Sorens 2011). Dube and Vargas (2013) argue that this "rapacity effect" should apply to natural resources or minerals in particular, rather than to labor-intensive agricultural goods.[4] Another tradition highlights the possibility for rebels to gain rents and finance their operations using any kind of primary commodity (Collier and Hoeffler 2004) or specifically illicit

[3] For example, petroleum prices were relatively stable in the 1960s, 1975-1978, the early 1980s, and 1992-1998.

[4] And while it is not his chief argument, Fearon (2005, 487) similarly observes that "easy riches from oil make the state a more tempting prize relative to working in the regular economy."

or "lootable" goods such as alluvial diamonds, timber, drug crops, or petroleum (Le Billon 2001, Lujala 2010). For example, Libyan rebels and the Islamic State in Syria and Iraq (ISIS) have both made news recently for selling captured oil (Financial Times 2014, New York Times 2014). Finally, another strand of research links the state's coercive and administrative capacity to its dependence on commodity export revenues. Fearon (2005) conjectures that oil income removes the incentive to invest in strong state institutions, thereby ironically weakening state capacity, encouraging rebels, and making civil war more likely. In contrast, later work generally finds that oil revenue enables the government to improve its coercive capacity and limit effective opposition (Smith 2004, Wright, Frantz and Geddes Forthcoming). Yet Thies (2010, 330) intriguingly shows that even though oil wealth raises the risk of civil war, "it does so independently of state capacity" (see also Humphreys 2005). In an influential review of the empirical findings, Ross (2004*b*, 337) concludes that (outside of oil) "the association between primary commodities... and the onset of civil war is not robust." With mixed findings and a small set of key variables (such as oil export dependence or per capita income) bearing the burden of inferences about multiple causal mechanisms, it is no wonder Ross (2004*a*, 62) views this literature as an "analytical muddle."

Forging ahead, however, a more recent literature has examined the impact of commodity export price changes on civil conflict. Some studies find that price increases cause conflict, as Dube and Vargas (2013) argue is the case in the natural resource sector (inducing greater competition for state-controlled rents). Angrist and Kugler (2008) draw similar conclusions, but only for commodities whose revenues (like coca in Colombia) support the rebels. For Besley and Persson (2008), higher commodity export prices in general increase the prevalence of civil war. Others argue that price increases *lower* the risk of conflict. Dube and Vargas (2013) show that this is true in Colombia for labor-intensive agricultural goods, because higher farm income may increase the opportunity costs of participating in conflict. O'Trakoun (2012) finds the same for a broader set of countries. Brückner and Ciccone (2010) reveal a negative association between price rises and civil war as well, for 19 commodities in

Sub-Saharan Africa. Yet Nillesen and Verwimp (2009)'s careful study in Burundi shows that rebels had no greater recruitment success in villages where the price for the locally produced commodity had dropped. Likewise, the most comprehensive study to date likewise finds no effect of export commodity price changes on civil conflict onset (Bazzi and Blattmann 2013). Here, too, it is difficult to know what to make of these collectively mixed or null findings.

One theme, however, is clear: if commodities matter for conflict, it is because they provide revenue, for the government and sometimes for rebels. Revenues in turn help boost an actor's coercive capacity and ultimately influence the likely outcome of a fight. Many developing countries rely greatly on commodity export payments as a leading source of government revenue. Copper is reportedly the source of 16 percent of Chile's fiscal income (Frankel 2011, 8); oil and gas, over 50 percent of Russia's (US Energy Information Administration 2013); all commodities, more than 20 percent of Indonesia's (World Bank 2010, 1). According to accounting reports produced for the Extractive Industries Transparency Initiative (EITI), commodity export payments constituted 34 percent of the average government's revenues for 28 developing countries in the mid-2000s (Revenue Watch Institute 2011). The evidence is clear that an exogenous increase in the world price of a country's export commodities translates into greater tax revenues for the government (Spatafora and Samake 2012). Thies (2010) similarly demonstrates empirically that natural resource export revenues increase state capacity. Of course, rebels too may profit from commodity exports, as noted above. There is less we can say systematically about the extent of this phenomenon in proportion to government income, but it is probably the case that the state earns the lion's share of export revenues for licit commodities. One reason is that rebel-controlled commodities traded through irregular markets are commonly heavily discounted.[5]

From any perspective, however, the literature agrees that export revenues are the key to commodities' role in conflict. Yet how do increases in revenues affect the likelihood of conflict? Think of the process that produces civil conflict as a bargaining interaction between

[5] "The premium [for the broker] is considerable – if the threat is real enough ... maybe 25 percent," said one black market commodity trader (Financial Post 2012).

the government and an organized opposition group considering the use of armed force. In this context, the fundamental lesson of rationalist explanations for war (Fearon 1995, Reiter 2003) is that a mutually observed advantage for one side should translate not into more conflict but rather more concessions by the other side. That is because the costs of armed conflict for all parties create a "bargaining range" of possible settlements jointly preferred to violence. If derived from mutually observed commodity price conditions – and there is nothing more jointly observable than world commodity prices – factors that make the rebels more capable of fighting or recruiting successfully, or factors that enhance or detract from the state's coercive capacity, do nothing to close this window of peaceful possibility.[6] What causes bargaining to break down is information or commitment problems, not prior observed changes in the balance of power.[7] The broader literature on civil war has long appreciated this fundamental insight (e.g., Walter 2002, 2009), but not so the literature on resource dependence and conflict.[8] We need a model to more carefully explore how different aspects of commodity dependence and price changes affect the incentives to use armed force.

## 3 A Model of Revenue Volatility and Conflict

We develop a simple adaptation of the canonical bargaining model of war. In particular, we analyze a two-player, complete information, infinitely repeated ultimatum game with one-sided offers, following the example of Fearon (1995). The point of this exercise is to better clarify the causal mechanism that may connect commodity conditions with conflict, within a familiar theoretical framework. We thus offer the model chiefly as an explicating

[6]Similarly, the presence of valuable commodities as a prize will narrow this window, relative to fixed costs of fighting, but not eliminate it.

[7]Conflict may also hypothetically arise from indivisibility of the scarce good over which the parties are bargaining. However, this source of conflict is generally downplayed due to the possibility of side payments (Reiter 2003). Likewise, pressure for conflict from hawkish domestic groups could constitute another source of bargaining breakdown. Yet to eliminate the bargaining range, the value for conflict from hawkish domestic groups would have to exceed not just that party's costs of fighting but also the other side's as well – not generally a likely scenario. In the absence of information or commitment problems, then, hawkish domestic pressures should produce greater concessions by the other side, not conflict.

[8]For a compelling recent exception to this point, see Bell and Wolford (Forthcoming).

and clarifying device, with a simple twist, i.e., uncertainty about the future distribution of capabilities.

### 3.1 Assumptions

1. A government, $G$, is dealing with a (potentially violent) rebel group, $R$, that is organized and capable of acting strategically and collectively.

2. Both actors are risk averse.

3. The government derives a significant portion of its revenues directly or indirectly from commodity exports.[9] Revenues in turn can be translated into military capabilities in the medium term (i.e., in the next period of the game).[10]

### 3.2 Setup of the Model

A Government, $G$, and a group of Rebels, $R$, disagree about the division of a scarce good, the value of which is normalized to 1. In period $t$ of an infinitely-repeated game, the Government makes a take-it-or-leave-it offer $x_t \in [0, 1]$. The Rebels may either accept the offer or reject it, initiating armed conflict. If the Rebels accept $x_t$, then the two parties receive their payoffs from $x_t$ for that period and move on to the next period of bargaining. If the two sides fight, however, the Government and Rebels win $p_t \in [0, 1]$ and $1 - p_t$ of the scarce good,[11] respectively, for the current and all future periods, while each bearing a one-time fixed cost of conflict, $c_G$ or $c_R$, where $c_G, c_R > 0$. It is conventional to interpret $p_t$ as the product of the balance of military capabilities. (See Figure 1.)

[9] Alternatively, the rebels may derive significant income from such exports. The key is that the government and rebels do not profit in equal proportion.

[10] In this key respect, we abstract away from the strategic use of degrees of mobilization of latent resources, which has been a central concern in recent innovative formal models of conflict, such as that of Debs and Monteiro (2014), Tarar (2013), and others.

[11] This feature of the model distinguishes it from Fearon (1995). Here, war is not a probabilistic winner-take-all process but rather a deterministic one that yields a mutually anticipated interior point on the $[0, 1]$ interval. For risk-neutral utilities, the distinction makes no difference.

For ease of exposition, we will analyze quadratic loss utilities, but our key result requires only that the players be risk averse, not this particular functional form. The parties discount future payoffs by applying the shared discount factor $\delta \in (0,1)$ in each subsequent period. At period $t$, the payoffs for an infinite series of peace settlements all at $x_t$ are thus

$$U_G = \frac{1-(1-x_t)^2}{1-\delta} \qquad\qquad U_R = \frac{1-x_t^2}{1-\delta}. \tag{1}$$

The payoffs for fighting at period $t$ are

$$U_G = \frac{1-(1-p_t)^2}{1-\delta} - c_G \qquad\qquad U_R = \frac{1-p_t^2}{1-\delta} - c_R. \tag{2}$$

In our variant of this simple game, the parties have common knowledge that there may be a shift in the balance of capabilities between period $t$ and $t+1$. For this paper's purposes, the shift in capabilities arises from changes in world prices for commodities the state exports. The model assumes these changes are exogenous: i.e., the state is a price taker in the relevant commodity markets.[12] We also assume that the state derives a significant amount of revenue from commodity exports and can convert revenues into capabilities to combat the rebels. As a result, changes in commodity export prices can translate into changes in capabilities, such that $p_{t+1}$ may be different from $p_t$.

As per Fearon (1995, 405), we model this scenario as a one-time permanent alteration in the repeated game's parameters that may occur before period $t+1$ if the parties reach a peaceful settlement in period $t$. Like all formal models in which power shifts may cause preventive wars (e.g., Powell 2006, 182), our model assumes that a fight in period $t$ "locks in" the current distribution of capabilities, $p_t$.[13] But there is a twist in our model regarding

[12] And our empirical tests later restrict themselves to conditions in which this assumption is satisfied, as we shall explain.

[13] In our story, the power shift is the indirect result of an exogenous shock to global commodity prices. Accordingly, it may be that an armed conflict leaves each side with an ability to profit from commodity exports proportional to $p_t$, so that changes in world prices do not subsequently alter their balance of capabilities. Or it may be that conflict limits the potential for either to participate actively in global markets, leaving the status quo balance of capabilities in place. Consistent with the latter mechanism, Mitchell and

how the power shift is implemented. The standard approach is to treat the power shift as a fixed parameter, say, $d = p_{t+1} - p_t$. In contrast, we treat the power shift as a random variable drawn by Nature: $\Delta \sim U(d, s)$, where $U$ is a uniform distribution with mean $d \in \mathbb{R}$ and standard deviation $s$ (therefore with range $2s\sqrt{3}$). On the basis of Nature's draw, the resulting balance of capabilities in period $t+1$, shown in the shaded area in Figure 1, is

$$p_{t+1} = \begin{cases} 0 & \text{if } p_t + \Delta < 0 \\ p_t + \Delta & \text{if } 0 < p_t + \Delta < 1 \\ 1 & \text{if } p_t + \Delta > 1, \end{cases} \tag{3}$$

which constrains $p_{t+1}$ to the feasible bargaining space $[0, 1]$ so that no parameters yield "out of bounds" results. All subsequent periods $t+2, t+3, ...$ will also share the same new $p_{t+1}$. Having reached period $t+1$, the players look back and observe the global commodity price "shock," $\Delta$; yet at period $t$, $\Delta$ is uncertain. They may anticipate on average that the power shift $\Delta$ will be $d$, but the greater the spread of the random variable's distribution, as measured by its standard deviation $s$, the less predictable $\Delta$ is. The ex ante unpredictability of the ex post "shock" $\Delta$, as measured by $s$, is precisely what we mean by "volatility."

### 3.3 Equilibrium Behavior

Because the model features complete information, we look for subgame perfect equilibria. In the simple repeated game with no power shift, the unique subgame perfect equilibrium calls for $G$ to offer $x^* = \sqrt{p^2 + (1-\delta)c_R}$ at every period $t$ and for $R$ to accept any $x \leq x^*$ and reject all others. $G$ has agenda control and therefore can propose the maximum $x$ that $R$ will accept, but were it otherwise, $G$ still prefers any settlement $x \geq 1 - \sqrt{(1-p)^2 + (1-\delta)c_G}$ to a fight. Because $c_R, c_G > 0$, these two constraints leave open a wide "bargaining range" of possible settlements that both parties prefer over fighting, shown in Figure 1.

By comparison, what happens in the model when we allow a power shift after period $t$?

Thies (2012) demonstrate empirically that commodity production declines during civil wars.

Equilibrium behavior in the subgame from $t+1$ on is the same as in the simple game above. The players know that, as of $t+1$, there will be no future change in relative capabilities. At that point, say that $R$'s strategy calls for it to accept any offer $x \leq x_2^*$ in all periods $t+1, t+2, ...$, while rejecting offers greater than $x_2^*$. $R$ will receive $(1-x_2^{*2})/(1-\delta)$ if it accepts $x_2^*$, whereas $R$ gets $(1-p_{t+1}^2)/(1-\delta) - c_R$ if it chooses to fight. From the Government's perspective, the best (i.e., maximum) $x_2^*$ that the Rebels will accept is therefore $x_2^* = \sqrt{p_{t+1}^2 + (1-\delta)c_R}$, similar to $x^*$ above. The Government strictly prefers making this offer over fighting because of its positive costs of conflict, $c_G$. As a result, in the subgame after the power shift has occurred, the best response for $G$ is to always make a peace offer of $x_2^*$, and the best response for $R$ is to accept any $x \leq x_2^*$ and fight otherwise.

However, the players' calculations are a little different as we move backwards to period $t$. As before, if $R$ fights, it expects an outcome of $p_t$ in perpetuity, yielding $\frac{1-p_t^2}{1-\delta} - c_R$. Yet if $R$ accepts some offer $x_1$, it opens up the possibility of a random change in the balance of capabilities before the next period, which will then be the basis for an infinite series of peace settlements at the ensuing $x_2^*$. The Rebel group's expected utility for accepting $x_1$ is thus

$$EU_R(x_1) = 1 - x_1^2 + \frac{\delta}{1-\delta}\int_{p_t+d-s\sqrt{3}}^{p_t+d+s\sqrt{3}} \frac{1}{2s\sqrt{3}}(1-x_2^2)dp_{t+1}, \tag{4}$$

where

$$x_2 = \begin{cases} 0 & \text{if } x_2^* < 0 \\ 1 & \text{if } x_2^* > 1 \\ x_2^* & \text{otherwise.} \end{cases} \tag{5}$$

For a distribution $U$ with an entirely interior set of values,[14] expression (4) is

$$EU_R(x_1) = 1 - x_1^2 + \frac{\delta}{1-\delta}\left[1 - d^2 - s^2 - (1-\delta)c_R - 2dp_t - p_t^2\right]. \tag{6}$$

The offer in period $t$ that leaves $R$ indifferent between accepting and fighting is the $x_1^*$ that solves the equation setting (4) equal to $\frac{1-p_t^2}{1-\delta} - c_R$, which (in the case of interior values for

[14] That is, where $p_t + d - s\sqrt{3} \geq 0$ and $p_t + d + s\sqrt{3} \leq 1$.

$U$) is

$$x_1^* = \sqrt{p_t^2 + (1-\delta)c_R - \left(\frac{\delta}{1-\delta}\right)(2dp_t + d^2 + s^2)}. \tag{7}$$

*Peace equilibrium.* Say that the power shift is scheduled to occur between periods 1 and 2. Then, as long as $c_G$ is sufficiently large[15] and $x_1^* \geq 0$, the unique subgame perfect equilibrium is for the Government to offer $\min\{x_1^*, 1\}$ in period 1 and $\min\{x_2^*, 1\}$ in all periods thereafter, and for the Rebels to accept $x \leq x_1^*$ in period 1 and $x \leq x_2^*$ thereafter, fighting otherwise.

*Conflict equilibrium.* However, for some combinations of parameters in (7), there may be no feasible division of the scarce good in period 1 that will be sufficient for $R$ to prefer peace over conflict. This will be the case if $s$ rises above the threshold

$$s' = \sqrt{\frac{(1-\delta)}{\delta}p_t^2 + \frac{(1-\delta)^2}{\delta}c_R - 2dp_t - d^2}. \tag{8}$$

The greater the weight the players put on the future (i.e., the higher the $\delta$), the lower the amount of volatility ($s$) needed to violate the peace equilibrium's conditions. Also, because the Government is risk-averse, volatility lowers its expected utility from a peaceful settlement in period $t$ as well, raising the minimum $x_1$ it is willing to offer to avoid conflict. Depending on how high the Government's costs of war are, this constraint may become binding at lower values of $s$ than $s'$. Denote $s^*$ as the minimum of these two constraints. Then, if $s > s^*$, the unique equilibrium outcome is conflict: $G$ makes any unacceptable offer $x > \max\{0, x_1^*\}$ in period 1 (and offers an acceptable settlement $\min\{x_2^*, 1\}$ in all later periods); $R$ rejects all offers $x > \max\{0, x_1^*\}$ in period 1 (and accepts any $x \leq x_2^*$ subsequently).

Figure 2 shows how the "bargaining range," the set of potential deals mutually preferred to conflict, shrinks as volatility, $s$, increases. The horizontal axis depicts the bargaining space, just as in Figure 1. $G$'s equilibrium offer in period $t$, $x_1^*$, is labeled on the horizontal axis to the right of the initial distribution of capabilities, $p_1$.[16] The lowest offer the Government

[15] Formally, the constraint is $c_G \geq \frac{1-(1-p_t)^2}{1-\delta} - EU_G(x_1^*)$, where $EU_G(x_1^*)$ declines as a function of $s$ just as $EU_R(x_1^*)$ does in expression (6).

[16] The parameter values displayed here are: $c_R, c_G = 0.25$; $d = 0$; $p_1 = 0.5$; $\delta = 0.9$. Thus $s^* = 0.15$. The

would be willing to make to avoid conflict is to the left, where the dashed blue line intersects the horizontal axis. Moving up the vertical axis, we see what happens to these two points as volatility, or $s$, increases. The bargaining range shrinks and then disappears at $s^*$. Above $s'$ there is no possible $x_1 \in [0,1]$ that the Rebels would accept rather than fight, given the risks the Rebels expect to face in the event of peace.

## 3.4 Analysis

In this model, peace, not war, is a costly lottery. If the parties reach a peaceful settlement, they participate in a lottery determining the distribution of capabilities in the next period. One instrument of this lottery is exogenous change in the world prices of the commodities a country exports. Three distinct concepts relate to this lottery:

1. "Volatility," the *ex ante* degree of unpredictability of commodity price changes (and thus of future revenues and military capabilities), directly corresponding to $s$;
2. The "trend," or *ex ante* predicted change, in commodity prices (and future revenues and capabilities), i.e., $d$ in the model;
3. The "shock," or *ex post* observed change, in commodity prices (and revenues and capabilities), i.e., $\Delta$ as revealed by Nature's draw in the model.

How do each of these affect the likelihood of conflict in the model? We begin with volatility. To see the effect of $s$, look at its role in the equilibrium peace offer $x_1^*$ in (7). It is clear that volatility has a monotonically negative impact on the first-period settlement offer. Why? A large $s$ means that the outcome of a period $t+1$ conflict is highly uncertain in period $t$. Some possible ensuing values of $p_{t+1}$ are more favorable for the Rebels, while others are less favorable. However, the players are risk averse, so better draws produce only minor

equilibrium offer $x_1^*$ is not far from $p_1$ here because these values represent a situation in which the parties' costs of conflict are not overridingly high, and the parties are significantly concerned about the infinite series of future settlements.

gains while worse draws generate significantly lower payoffs. In this context, the parties face a variant of the classic preventive war commitment problem. Namely, the Government cannot compensate the Rebels for the risks of peace by promising *ex ante* to demand less *ex post* should the draw go the Government's way. Such a commitment is not credible (i.e., subgame perfect). Consequently, the Rebels can credibly threaten conflict unless they get a better deal (i.e., a lower $x_1^*$) up front. The Government is willing to pay this extra price for peace in period $t$ as long as its costs of conflict are sufficiently large. However, as volatility increases, if the parties weigh the future highly enough, no offer today may be large enough to compensate the Rebels for the risk that the Government will be able to demand virtually all the scarce good in the future. In that case, the Rebels would rather initiate armed conflict now.[17] For countries dependent on commodity exports and with potentially organized rebel groups, the observable implication is as follows:

**Hypothesis 1.** *The greater the expected volatility in the world prices of a country's export commodities, the higher the probability of intrastate armed conflict onset in that country.*

Next, how does a predictable trend – as distinct from unpredictable changes – affect the prospects for conflict? Consistent with existing work, our model suggests that expectations of an extreme power shift, favoring either the rebels or the government, can spark conflict. In the model's terms, the relevant parameter is $d$, and the $-(2dp_t + d^2)$ term in expression (7) shows that the impact of $d$ is non-monotonic. In our application, if the prices of the state's revenue-producing commodity exports follow a predictable trend that is too steep in either the positive or negative direction, conflict may ensue. This observable implication, however, requires that past trends are expected to continue into the future. Whether any commodity prices reliably exhibit that pattern is an empirical question. As it turns out for the sample used in the empirical tests reported below, past commodity price trends are

[17]The model's implications about volatility go beyond this basic claim as well. Interestingly, even when volatility is not high enough to induce conflict, it tends to compel the government to make more generous settlements with the rebels than the government would otherwise offer. If such concessions allow the rebels to remain organized and recruit successfully, then volatility may help sustain the preconditions for civil conflict even in the absence of armed violence at any given point.

terrible predictors of future trends,[18] so we do not attempt to test this implication of the model.

Finally, how should commodity price shocks as observed *ex post* affect the likelihood of conflict? We are now talking about $\Delta$ in the model. Existing research on the impact of commodity prices on conflict has almost exclusively focused on the empirical analogue of this parameter, often measured as the change in the log index price of a key export commodity from period $t-1$ to $t$. Here is the essential point: the value of $\Delta$ does not enter into $x_1^*$ in (7) or any condition shaping the possibility of the peace equilibrium. In all parameter conditions, the parties reach peaceful settlement in equilibrium from period $t+1$ on. So no matter what value $\Delta$ takes, it should not affect the prospects for peace once it is observed. In broader economic or game theoretic terms, this simple point should not be surprising: the parties merely "price in" the observed commodity revenue shock into their peace settlement, but no "shock" in this sense can make conflict a best response. The observable implication is that *ex post* observed price changes should have zero impact on the likelihood of armed conflict. This insight helps explain why existing empirical findings about the impact of price shocks have been so weak or contradictory, and it highlights how "shocks" can have very different effects from "volatility."

**Hypothesis 2.** *A prior observed increase in the world prices of a country's export commodities will not affect the likelihood of intrastate armed conflict.*

What role do the level of commodity dependence or the nature of a country's key commodities play? To be sure, the model includes no parameters speaking to those concerns. Rather, we have assumed that the country is sufficiently commodity dependent for that source of revenue to play a material role in the parties' expectations. That is, some degree of commodity dependence is a necessary but not sufficient condition for this dynamic to apply. Also, because commodities only matter in this theory to the extent that they provide rev-

[18] Some sources of change in the balance of military capabilities, such as long-run disparities in economic growth rates, offer much more potent predictors of future trends. Future trends in commodity export revenues, however, are much harder to predict (even though *volatility* in future price changes is predictable).

enue for the parties, the type of commodity is irrelevant, as long as it is a source of sufficient income.

# 4 Research Design

To test these hypotheses, we construct a dataset of 145 developing countries, $i$, observed monthly, $t$, from January 1963 through December 2012.[19] We restrict our analysis to developing countries because (1) they exhibit a higher risk of civil conflict, (2) their economies are more commodity dependent, (3) they derive a greater share of government revenue from commodity exports, and (4) they are less diversified and thus more vulnerable to volatility in any given commodity price. Developed states as a rule are more insulated from the theoretical dynamic posited by this paper.

## 4.1 Dependent Variable: Civil Conflict

The phenomenon to be explained is the onset of civil conflict. Our primary measure of this, used for Models 1, 2, and 3, is the UCDP/PRIO Armed Conflict Dataset's (Gleditsch et al. 2002) version 2014-4 list of "internal" or "internationalized internal" political or territorial conflicts pitting the government of a state against a formally organized opposition group, producing at least 25 battle-related deaths per year.[20] The variable $\textit{Civil Conflict}_{i,t}$ is 1 for the first recorded month of such a conflict and 0 otherwise. Because we are testing hypotheses about the onset of conflict, our analysis excludes country-months in which civil conflicts were already ongoing, leaving 59,829 country-months in the sample. There are a total of 186 new conflict onsets in the sample, experienced by 81 of the 145 countries.

[19] The dataset includes all independent states not in the OECD by 1990, plus Turkey (Gleditsch and Ward 1999).

[20] From this list, we exclude 22 conflict episodes solely consisting of coups, i.e., "illegal and overt attempts by the military or other elites within the state apparatus to unseat the sitting executive" (Powell and Thyne 2011, 252). These coups did not involve an organized rebel group outside of the state apparatus. Our argument, which revolves around differential growth of state versus rebel capabilities, does not apply to coups, the dynamics of which are likely to be quite different (Singh 2014).

The UCDP/PRIO's record of the start month of each conflict appears quite accurate, but the source's precision flag indicates that the start month is not known precisely for 22 (11 percent) of these conflicts; for these, following UCDP/PRIO, we assign December of the start year as the start month.

For robustness purposes, we include three additional measures of civil conflict at different levels of intensity. The first, $Civil\ War_{i,t}$, also measured monthly, is examined in Model 4. It takes on a value of one for the onset of conflicts that ultimately reach the UCDP/PRIO's threshold of 1000 annual battle-related deaths in *at least one year* of the conflict episode. There are 61 new-onset civil wars in our sample, in 38 different countries.[21] The second alternative measure is drawn from the Armed Conflict Location and Event Data (ACLED) Project, version 4,[22] which records conflict events for the countries of Africa only. Our dependent variable, $ACLED\ Conflict_{i,t}$, is 1 in a month in which ACLED lists at least one conflict event involving the government and/or an organized group, producing fatalities;[23] 0 otherwise. Model 5, using this dependent variable, includes 42 African countries from 1997 through 2012, with 2612 conflicts (more frequent because the threshold of deaths is just one for this variable). The final alternative dependent variable is drawn from a similar source, the Social Conflict in Africa Database (SCAD), version 3.0.[24] This variable, $SCAD\ Conflict_{i,t}$, also records violent conflicts with one or more fatalities. We again restrict this variable just to conflicts involving the state and/or organized groups.[25] Model 6, which uses this dependent variable, includes 47 African countries from 1990 through 2012, with 3780 conflict events.

Because the dependent variable is conflict onset (rather than incidence), and because the odds of conflict onset are likely to be conditioned on the duration of peace, our multivariate

[21] Because our analysis samples exclude months in which conflicts were already ongoing, the Model 4 $Civil\ War_{i,t}$ sample is somewhat larger (i.e., including more intervening months) than that for $Civil\ Conflict_{i,t}$: some spells of peace violated by lower-intensity conflict continue to be counted as spells of peace if the 1000 death threshold is not reached.

[22] http://www.acleddata.com

[23] That is, it is one if the ACLED *interaction* variable $< 50$ and *fatalities* $> 0$.

[24] https://www.strausscenter.org/scad.html

[25] Specifically, it is one if the SCAD variable *etype* is 3, 7, 8, 9, or 10 and *ndeath* $> 0$.

analysis asks how the covariates affect the amount of time until civil conflict begins. For this we estimate Cox proportional hazards models.

## 4.2 Commodity-Based Independent Variables

To calculate the commodity variables, we assemble the real price index series, $\pi_{j,t}$, for commodity $j$ in month $t$ for 71 different commodities starting in 1960. (See the Data Appendix for more detail.) Define the variable $\mathit{Shock}_{j,t} = \ln \pi_{j,t-1} - \ln \pi_{j,t-13}$, capturing the observed price change from 12 months prior, lagged by one month.

We construct two different measures of price volatility for each commodity. The first, $\mathit{Volatility}_{j,t}$ (*Observed*), is the standard deviation of monthly first differences in the log real price index from $t-13$ to $t-1$: in other words, commodity $j$'s price variability over the prior 12 months, lagged by one month. Recall, however, that the concept at issue in the formal model is anticipated, not observed, volatility. Fortunately, past volatility is a well-performing predictor of future volatility: at the commodity-month level, the correlation between $\mathit{Volatility}_{j,t}$ (*Observed*) and its twelve-month-forward version, the variability from months $t$ to $t+12$, is $r = 0.61$.[26] Because volatility in the past year is what actors observe and base their future expectations on, and because it tends to produce reasonably accurate forecasts, we feel observed volatility is a valid operationalization of our theoretical concept.

However, to speak more directly to the concept, our second and primary measure, $\mathit{Volatility}_{j,t}$ (*Forecast*), consists of model-generated forecasts of latent commodity price volatility. Separately for each commodity, we estimate GARCH(1,1) models of the 12-month-ahead difference[27] in commodity $j$'s log real price index as a random walk with first-order au-

[26] The same is not true for observed commodity price shocks themselves. The correlation between $\mathit{Shock}_{j,t}$ and $\mathit{Shock}_{j,t+13}$ (the latter is the change from month $t$ to $t+12$) is just $r = -0.16$. This is why we have no empirical basis for testing a hypothesis about the impact of expected commodity price trends ($d$ in the formal model): forecasts of commodity price changes based on past trends are notoriously wrong. For example, the IMF reports price forecasts for 42 separate commodities in the semiannual *World Economic Outlook*. Regressing the observed 2008-to-2009 price change against the IMF's forecasted changes published in April 2008 produces a $R^2$ of just 0.023; and for 2012-to-2013 (using the April 2012 forecasts), just 0.068. Even the experts are not capable of making 12-month commodity price trend forecasts much better than chance. For more evidence on this point, see Tomek (1997) and Groen and Pesenti (2011).

[27] The 12-month-ahead difference for commodity $j$ in month $t$ is $\ln \pi_{j,t+12} - \ln \pi_{j,t}$. This has the virtue of

tocorrelation. The estimated variance is a function of the log real price index itself (in month $t-1$) along with parameters for first-order autoregressive heteroscedasticity and a first-order GARCH process. This is a widely-accepted variance forecasting model (Andersen et al. 2006). The technique produces moving forecasts of error variance, or latent commodity price volatility, over the next 12 months. It answers the question, "Given the full history of this commodity price series, how uncertain are we about how much the commodity's real price will change a year from now?" $Volatility_{j,t}$ (*Forecast*) is the standard deviation (or square root) corresponding to this variance estimate, to match the scale of $Volatility_{j,t}$ (*Observed*).[28] $Volatility_{j,t}$ (*Forecast*) and $Volatility_{j,t}$ (*Observed*) are correlated at $r = 0.62$.

So far we have described measures of price shocks and variability at the commodity-month level. To aggregate to the country-month unit of analysis, we obtain annual self-reported or mirrored UN COMTRADE export data for the SITC or HS codes (at up to 6-digit precision) that match each commodity.[29] We then compute $w_{i,j,t-12}$, the share of commodity $j$ in country $i$'s total included commodity exports in the prior calendar year. To ensure that the measures of volatility and shocks are sufficiently exogenous, we exclude commodity $j$ from the weight calculation (hence $w_{i,j,t-12} = 0$) if country $i$ accounted for 10 percent or more of total world exports of commodity $j$ in the prior calendar year.[30] What remains are just the commodities for which the country is a price taker. If a country is a large enough exporter of a given commodity to potentially affect world prices, the commodity is

stripping seasonality out of the difference series, besides focusing the horizon of expectations on the medium rather than the immediate term.

[28]The latent commodity volatility forecast is a strong predictor of future variability: the correlation between $Volatility_{j,t}$ (*Forecast*) and the observed volatility from months $t$ to $t+12$ is $r = 0.66$.

[29]Commodity trade data codes available upon request. Over the 50 years of the sample, many countries significantly alter their commodity export portfolios. It is therefore important to have time-varying export weights. Because our analysis excludes periods with conflict already underway, the one year lag is sufficient to ensure that conflict is not endogenously affecting commodity export shares.

[30]Bazzi and Blattmann (2013) also use a 10 percent cutoff. Our results are wholly robust to alternative cutoff levels, such as 3, 5, 7.5, and 20 percent. The 10 percent cutoff retains 88.9 percent of the average country's total commodity exports (and 99.9 percent of the median country's) while excluding more than 99 percent of the single largest exporters of any commodity in the sample. However, there are five sample countries for which less than 40 percent of commodity exports are included by this criterion: Saudi Arabia, Chile, Colombia, Sri Lanka, and Israel. The *Volatility* and *Shock* results in all models are entirely robust to the exclusion of those countries from the analysis.

not included in our shock and volatility measures for that observation. That is, our variables incorporate only the *exogenous* component of variation in world prices.

With the export weights, the primary country-month-specific explanatory variables are:

$$Volatility_{i,t} = \sum_{j=1}^{71} \left[(w_{i,j,t-12})\ Volatility_{j,t}\right] \quad \text{and} \quad Shock_{i,t} = \sum_{j=1}^{71} [(w_{i,j,t-12})\ Shock_{j,t}]. \qquad (9)$$

The variables $Volatility_{i,t}$ (either observed or forecast) and $Shock_{i,t}$ correspond to the parameters $s$ and $\Delta$ in the formal model, respectively. As per Hypothesis 1 and 2, $Volatility_{i,t}$ should raise the likelihood of conflict onset while $Shock_{i,t}$ should have no effect.

There is significant cross-time as well as cross-country variation for both variables. Countries do not appear to share the same cross-time patterns in commodity price volatility, because they have different export portfolios.[31] Likewise, the "between effects" or cross-sectional differences in country means do not capture much variation in either measure of volatility.[32] Figure 3 displays the range of observed volatility levels by country for the (peace-time) analysis sample; it shows the sample median plus 10th and 90th percentile values for each country. The vast majority of countries in the sample go through spells of high volatility as well as periods of low volatility: only a few are chronically subject to higher levels of export commodity price volatility than average.[33] Note also that the correlation between $Shock_{i,t}$ and $Volatility_{i,t}$ (whether observed or forecast) is minimal ($r < 0.12$). That is because an extreme 12-month price shock *in either direction* (positive or negative) tends to produce high volatility observations or forecasts, while a zero 12-month net change in price may be associated with either low or high volatility.

The average country in the analysis sample received 13.2 percent of its gross domestic

[31] Regressing $Volatility_{i,t}$ on fixed effects for each of the 600 sample months yields $R^2 < 0.22$. Similarly, cross-time variation in volatility is different for every commodity: it is not merely a follow-on effect of price movements for oil or any one commodity group. Back at the commodity-month level, if we regress either variant of $Volatility_{j,t}$ on month-specific fixed effects, we get $R^2 < 0.07$. Very few fluctuations in volatility are shared across commodities or across countries.

[32] If we regress either variant of $Volatility_{i,t}$ on country-specific fixed effects, we get $R^2 < 0.22$.

[33] The few exceptions lie on the far left of the graph. These countries include Botswana, Namibia, Lesotho, Armenia, and Somalia.

product (GDP) from exports of the commodities tracked in these variables (i.e., those for which the country accounted for less than 10 percent of world exports).[34] For reference, the corresponding share of GDP for commodity exporter New Zealand is 4.5 percent; Canada, 3.2 percent; and Australia, 2.3 percent.[35] Our sample of countries is much more commodity dependent in comparison.

### 4.3 Other Variables

The analyses include a number of control variables. The literature holds that dependence on commodities in general and fuel exports in particular may make a state more (or less) prone to civil conflict. We therefore include the variables *Log Commodity Dependence (Fuel)*$_{i,t-12}$ and *Log Commodity Dependence (Non-Fuel)*$_{i,t-12}$, which are the natural log of one plus the state's fuel or non-fuel exports as percent of its GDP, in the calendar year prior to month $t$.[36] Other scholars have emphasized that rising prices of essential food imports could spark civil conflict (e.g., Bellemare 2015, Arezki and Brückner 2011), so we include the variable *Food Import Price Increase*$_{i,t}$, which, like *Shock*$_{i,t}$, measures the 12-month difference in the log price index, from month $t-13$ to $t-1$, but is weighted by imports rather than exports and only counts food commodities.

The analyses control for a number of standard predictors of civil conflict as well, including the (natural log of) the country's total population size and real per capita GDP (in 2012 US dollars), measured in the calendar year prior to month $t$ (from the *World Development Indicators*); a Cold War dummy (1 before 1990, 0 otherwise); and the state's ethnolinguistic fractionalization score using 1985 demographic data (Roeder 2001). To capture the non-monotonic impact of regime type, we include two variables based on the country-year "Unified Democracy Scores" (UDS) from Pemstein, Meserve and Melton (2010), lagged by

[34]The tracked commodities constitute 43.4 percent of the average country's total merchandise exports.

[35]Including commodities in which these countries account for 10 percent or more of world exports, their respective figures are 9.5, 8.7, and 9.0 percent, still lower than the corresponding number, 15.3, for our average sample country.

[36]These variables use our commodity data without restriction to those for which the state was a price taker. The fuel category includes petroleum, natural gas, liquified natural gas (LNG), and coal.

one year. *Democracy Score* is the UDS score if the UDS value is positive; 0 otherwise. *Autocracy Score* is the absolute value of the UDS score if the UDS value is negative; 0 otherwise. Higher values of *Democracy Score* and *Autocracy Score* denote a greater degree of democracy and autocracy, respectively, but both may be zero or small, indicating a middle regime category (or "anocracy"). A final variable, *Conflict in Neighbor*, is coded 1 if a 25-death UCDP conflict was underway in a contiguous neighboring state in month $t-1$; 0 otherwise. (This variable uses only 1000-death conflicts for the analysis of civil war onset in Model 4.)

Table 1 contains descriptive statistics for all explanatory variables for the analysis sample.

# 5 Empirical Results

## 5.1 Descriptive Associations

Before turning to the results of multivariate analysis, we first examine the basic descriptive relationship between commodity price volatility and civil conflict onset. Consider the selection of countries shown in Figure 4, which displays the time series for $Volatility_{i,t}$ (*Observed*) with shading over the periods of ongoing (25-death) civil conflicts for each country. What is striking about these examples is that when commodity price volatility reaches a new historical high in a given country, civil conflict tends to break out.

Consider the case of Guinea, where civil conflict began in late 2000. At the time, Guinea's top commodity exports were aluminum, diamonds, and gold (constituting 81 percent of total merchandise export revenues). The world price of gold and aluminum had gone up from the prior year, while that of diamonds had dropped, yielding a near-zero net change in export prices, but all three commodities had exhibited high levels of volatility (with a forecast for the same). Guinea derived nearly a third of its government revenue from fees on commodity exports (Revenue Watch Institute 2011). Rebels sheltering in nearby Liberia and Sierra Leone found this a propitious time to attack (BBC News 2000).

The story of Comoros is particularly revealing (see Figure 5). Comoros, a small and extremely poor country of a half million, is an archipelago of three major islands between Mozambique in southeast Africa and Madagascar. The best agricultural land on the main island, Grand Comore, is dominated by cloves plantations, which account for the bulk (more than two-thirds in the mid-1990s) of export revenue for this commodity-dependent economy. The Anjouan People's Movement (MPA) had for years sought autonomy for their poorer Comoran island (hoping to renew French administration like wealthy neighbor Mayotte). For a period of time in the mid-1990s, global cloves prices were fairly stable, but in 1996 they began to climb and then swing wildly (doubling and then halving from month to month), with corresponding implications for the revenues of the central government on Grand Comore. Civil servants demonstrated in protest against the government's failure to pay deferred wages (Cornwell 1998). President Taki chose this moment to delimit the autonomy of the smaller islands. Fearful there would be no better time for their struggle with Grand Comore and that the central authority's advantage might grow, the MPA declared Anjouan's independence in July 1997. In September the capital sent 300 troops to stop the secessionists, who fought back successfully. The clash produced at least 40 fatalities (Beresford 1997). The government forces withdrew, and over the next few years, with the involvement of a regional security organization, the two sides reached a political settlement. Cloves prices exogenously stabilized during this period as well. It would be helpful to have more direct evidence that the armed conflicts in these country cases were driven by the economic uncertainty around commodity revenues, but the examples at least suggest a link between the two.

The association between commodity price volatility and civil conflict onset is evident in the sample overall as well. Figure 6 shows a Kaplan-Meier graph of the cumulative proportion of spells of peace that end in civil conflict by a given month, for low (below median) and high (above median) values of $Volatility_{i,t}$ (*Observed*) in the full sample. The odds of conflict within the first 72 months are roughly double for the higher volatility cases. This is a statistically significant difference: if we divide the sample into equal halves by value of $Volatility_{i,t}$, a log-rank test of the equality of survival functions of the two categories yields

$p < 0.05$, for both the observed and forecast versions of the variable. Interestingly, using the same procedure, $Shock_{i,t}$ exhibits no statistically significant association with conflict onset.

## 5.2 Multivariate Analysis Results

Table 2 contains the main multivariate analysis results, including the estimates of the Cox proportional hazards of Model 1 (explaining the onset of 25-death civil conflicts using volatility forecasts), Model 2 (using observed volatility instead), Model 3 (like Model 1 but stratified with country-specific fixed effects), and Model 4 (like Model 1 but using the 1000-death threshold). Table 3 gives corresponding results for the two models, estimated for Africa rather than all developing countries, using the lower-threshold civil conflict onset indicators from ACLED (Model 5) and SCAD (Model 6). The $\chi^2$ test statistics reveal adequate fit for all models. Multicollinearity is low.[37] Graphical analysis (through log-log plots of survival) and Schoenfeld residuals tests reveal no signs of a violation of the proportional hazards assumption for $Volatility_{i,t}$ or $Shock_{i,t}$ in any model. The findings for $Volatility_{i,t}$ and $Shock_{i,t}$ are broadly robust to the inclusion of a variable counting the country's number of prior conflict onsets in the sample (which itself does not increase the odds of conflict onset at a statistically discernible level in any case, if added to Models 1 through 4).

In all six models, consistent with Hypothesis 1, $Volatility_{i,t}$ has a positive and statistically significant (two-tailed $p < 0.05$) association with civil conflict onset. Higher levels of volatility increase the likelihood of conflict onset, whether we use model-generated latent volatility forecasts (Model 1) or the observed variability over the past 12 months (Model 2). If (in Model 3) we include country-specific fixed effects (strata in Cox model parlance), thereby adjusting for the fact that 64 of these developing countries never experienced a conflict onset during the sample period, volatility appears to have an even stronger influence on conflict.[38]

[37]For example, if we regress each covariate on all others in Models 1 or 2, the $R^2 \leq 0.40$ for all variables except *Autocracy Score* and *Democracy Score* (for which $R^2 \leq 0.51$). *Volatility* and *Shock* are particularly uncorrelated with other covariates: their $R^2$ values are just 0.07 and 0.13, respectively.

[38]The Model 3 test is quite important. Not all developing countries are equally prone to civil conflict; some may not have organized or even latent rebel groups. Since our theory presumes an organized rebel

Volatility likewise has a stronger effect (Model 4) if we restrict our analysis to just those 61 conflicts that reached the "civil war" 1000-death threshold in at least one year. Volatility also increases the likelihood of outbreak of lower-level political violence involving organized groups or the state, resulting in at least one fatality, in the countries of Africa in the post-Cold War period, using two distinct conflict data sources (Models 5 and 6). This is a striking and consistent set of findings, about a variable no prior study has thought to consider as a contributor to civil conflict.

In contrast, the coefficient estimates in all six models for $Shock_{i,t}$ are never statistically discernible from zero ($p > 0.24$ at a minimum), just as Hypothesis 2 predicts. Once observed, commodity price increases simply have no effect whatsoever on the odds of civil conflict (involving organized actors) at any level of intensity.

How much difference does volatility make? To find out, we generate model predictions simulated 100,000 times from the estimates of Models 1 through 6, holding all other covariates at their sample means, while moving the variable in question from one standard deviation below its mean to one standard deviation above.[39] From this we obtain the estimated hazard ratio at the low reference value. How much greater, in percentage terms, is the hazard ratio at the high value? The answer gives the substantive impact (mean and 95 percent confidence interval) of a "typical" change in the variable in question, expressed as an increase in the cumulative hazard of conflict onset through any time $t$. Figure 7 displays these quantities for selected variables in Model 1 and for *Volatility* in Models 2 through 6.[40] In the first row in Figure 7, an expected 33 percent increase in the hazard of conflict is what we would

actor, the hypothesis about volatility might not apply in countries lacking an organized opposition capable in principle of making demands upon the government or making calculations about the government's future revenues. By including country-specific fixed effects, Model 3 derives its entire analytical leverage from only those countries experiencing conflict onset at some point in the sample. (Similarly, a probit model with such fixed effects would of course drop all countries never entering conflict.) The fact that Model 3's coefficient estimate for *Volatility* is therefore somewhat stronger than in Model 1 indicates that, by including some countries never conceivably "eligible" for conflict, the other models tend to produce attenuated coefficient estimates for the impact of *Volatility.* That is, they may suffer from conservative bias. Note that *Shock*, however, does no better in Model 3 than elsewhere.

[39]For dichotomous variables *Cold War* and *Conflict in Neighbor*, the two values compared are 0 and 1.

[40]The displayed quantity shows the impact of moving from a high to a low value, rather than low to high, for variables marked with (-).

get by switching the April 1965 volatility forecast for Algeria with that for the Dominican Republic. (And indeed the latter experienced an outbreak of violent rebellion that month while the former did not). Models 2 through 6 yield a consistent and somewhat more precise picture. Overall, it appears, *Volatility*'s substantive impact is just a little weaker than the impact of, say, ongoing conflict in a neighboring country. Empirically, export commodity price volatility is not the most important contributor to civil conflict, but it can raise the risks of civil conflict in a substantively meaningful way nonetheless.

The results for most of the other covariates are consistent with the prevailing sense in the literature. For example, in Model 1, as expected, conflict onset is likelier in countries that are more populated, poorer, more ethnically fractionalized, and neighboring a state with a civil conflict already underway. A new outbreak of civil conflict at the 25-death threshold appears to have been somewhat less likely during the Cold War. And, compared to regime types in the middle of the spectrum, strong democracies, and to a lesser extent, strong autocracies, are less likely to experience civil conflicts.

Moving apart from the domain of the familiar, however, we also find that a net 12-month increase in the world prices of a country's imported food tends to *decrease* the odds of civil conflict onset. This finding is not fully robust (e.g., there seems to be no effect either way for the African subsample in Models 5 and 6), but it is certainly not consonant with the view that rebellion thrives where citizens' grievances about changes in the cost of living are highest. This result therefore clashes strongly with Bellemare (2015) and Arezki and Brückner (2011) but is consistent with Hendrix and Brinkman's (2013, 13) claim that "severe food insecurity has a dampening effect on conflict behavior." Why this might be the case is certainly a question worth exploring for the future. What is important for our purposes is that, by controlling for food import price changes, we can more confidently conclude that *Volatility*'s impact is truly driven by expectations about (export) revenues, not consumer costs or state expenditures.[41]

[41] And it is worth noting that *Volatility* is uncorrelated with *Food Import Price Increase* ($r < 0.11$), although *Shock* is weakly correlated with the latter ($r = 0.35$).

The other important finding concerns the two variables measuring the country's export dependence (as a share of GDP) on fuel and non-fuel commodities. Of course, much of the literature has identified fuel export dependence, in particular, as a predictor of civil war (e.g., Fearon and Laitin 2003, Fearon 2005, Thies 2010). It is therefore striking that in all six models, including Model 4 (for which the dependent variable is actually civil war), our variable *Log Commodity Dependence (Fuel)* has no statistically discernible effect on conflict onset. Why not? Interestingly, if we re-run all six models without *Volatility* and *Shock*, the coefficient for *Log Commodity Dependence (Fuel)* increases and becomes statistically significant (although non-fuel commodity dependence does not) in Models 1, 2, and 4. In our analysis, what is really distinctive about petroleum is that (a) it tends to be a large share of some country's exports (the top-ranked commodity out of 71 in the mean share of exports) and (b) its price is more volatile than that of most other commodities (ranking 16th and 20th out of 71 commodities for mean observed and forecast volatility, respectively). (See Data Appendix.) But these two features of petroleum are already embedded in *Volatility*. Thus, what our results are saying is that, outside of these two characteristics, fuel commodities do not have special sway. Whether the country's exports are fuel or not, what really matters is price volatility in the state's overall basket of export commodities, whatever they are.

## 5.3 Robustness Tests

Our results are robust to a number of different variations. First, as Models 1 and 2 reveal, conflict onset results from volatility whether we measure the latter using prior observations or model-generated forecasts. And if we substitute $Volatility_{i,t}$ (*Observed*) for $Volatility_{i,t}$ (*Forecast*) in Models 4, 5, and 6, as well, its coefficient remains positive and statistically significant ($p < 0.02$). Second, the results are not just driven by the experience of African countries. Indeed, the sample medians of both variants of *Volatility* are virtually identical for non-African and African countries (respectively, 0.490 and 0.497, observed; 0.079 and 0.082, forecast). If we re-run Models 1 through 4, splitting *Volatility* into two variables, one for Africa and one for the rest, we fail to reject the null hypothesis that the two variables' coefficients are equal in each case ($p > 0.38$). Third, *Volatility* retains a positive and statistically significant impact even at levels of commodity export dependence on the low side for this sample (which are still high by developed world standards, as noted earlier). If we re-run Models 1 through 6 including an interaction term between *Volatility* and the (price-taking) commodity export share of GDP, the interaction term is never statistically significant ($p > 0.32$). Using those estimates regardless, linear combination tests of the net coefficient for *Volatility*, when export dependence is at its 10th percentile sample value, reject the zero-impact null hypothesis for Models 1, 2, and 5, and yield borderline ($p = 0.06$) results for Models 3 and 4. That is, the impact of volatility does not seem to be conditioned on the degree of export dependence in our sample, and volatility tends to induce conflict onset even for developing countries with lower-than-average but non-zero commodity dependence.

## 5.4 Does *Shock* Work Differently for Different Commodities?

Dube and Vargas (2013) argue that, in the agricultural sector, a drop in export prices increases rebel recruitment and civil conflict because it reduces the opportunity costs of farm labor. Conversely, in the natural resource sector, a rise in export prices causes civil conflict because it raises the value of control over the resource. Could our null findings for the variable *Shock* be conflating different effects for these opposite categories? To find out, we grouped the 71 commodities into "agricultural" and "natural resource" categories, and then re-computed *Shock* separately for each category (using the original $w_{i,j,t-12}$ weights). When we estimate Models 1 through 6 with both resulting *Shock* variables, neither is statistically significant, and post-estimation tests fail to reject the null hypothesis that the two category's *Shock* coefficients are equal, for all six models. We infer that the findings in Dube and Vargas (2013) for Colombia alone do not generalize to the full population of developing countries.

Furthermore, the same null results hold if we group the 71 commodities in other ways, such as "lootable" versus non-lootable goods,[42] fuel versus non-fuel goods, and petroleum versus all other commodities. No matter how we break down the commodity categories, *ex post* observed export commodity price shocks simply have no effect on the onset of civil conflict. It is also worth noting that if we re-estimate Model 1 with pairs of *Volatility* variables calculated separately by commodity category (agricultural/natural resource, lootable/non-lootable, fuel/non-fuel, petroleum/other), there are no statistically significant differences between the coefficients of each pair of *Volatility* indicators.

### 5.5 Does *Volatility* Create Grievances and Lower Opportunity Costs?

We have argued that volatility raises the risk of conflict because its revenue implications intensify commitment problems between the government and rebel groups. The main analyses find evidence consistent with that hypothesis. However, is it possible that volatility's effect is not driven by its revenue implications but rather because it heightens social grievances or lowers the opportunity costs of engaging in mass political action against the state? We consider several observable implications of these alternative explanations.

First, could governments facing volatile commodity-based revenue simply invest less in public goods, such that citizens would develop greater grievances as a result? Keep in mind that no more than a handful of countries exhibit chronically high volatility: most go through low as well as high periods (see Figure 3 again). As a result, developing countries experiencing higher export commodity price volatility are not smaller, poorer, less democratic, or more ethnically fractionalized.[43] In any case, neither the observed or forecast measure of volatility is at all correlated with government expenditures on health ($r = -0.12$ and $r = -0.09$, respectively) or education ($r = 0.05$ for both) as a share of GDP, in the two-fifths of the sample for which such spending data is available.

Second, if volatility's link to civil conflict were due to an increase in public grievances, then

[42] For the purposes of this test, we count petroleum, hard logs, soft logs, and diamonds as "lootable," because those are the licit commodities most commonly reported as sources of rebel income.

[43] The correlations at the country-month unit of analysis of either measure of volatility with GDP, log per capita GDP, UDS regime type score, and ethnolinguistic fractionalization are all $|r| < 0.093$.

export commodity price volatility should also be making citizens express dissatisfaction with their government and catalyzing them to engage in political action such as demonstrations, strikes, or protests. To see if this is the case, we merged our key variables into the World Values Survey (WVS) wave 6 (2011-2012) dataset for the specific month in which each country's survey was conducted. We then regressed respondents' expressed confidence in their government against their country's value of $\textit{Volatility}_{i,t}$ (either version), $\textit{Shock}_{i,t}$, and $\textit{Food Import Price Increase}_{i,t}$, plus a battery of traditional social and demographic indicators (e.g., gender, age, education, income) and country-specific fixed effects. *Volatility* has no discernible effect ($p > 0.24$). The same is true if we analyze whether a respondent engaged in any type of political action as a function of the commodity-related variables.[44] The citizens of countries experiencing greater export commodity price volatility are no less satisfied with their government and are no more likely to (say they) participate in political protests.

Third, if volatility's role in civil conflict were the result of public grievances, or if it lowered the opportunity costs of individuals to take political action against the state, then we should also observe a correlation in the aggregate between volatility and nonviolent, unorganized social protests. The SCAD data source offers an excellent platform to test this alternative hypothesis. Recall that SCAD records thousands of protests, riots, strikes, and other mass political actions. To make the dependent variable used for Model 6, we selected only those SCAD events that produced fatalities and involved organized actors. Now we invert that dependent variable and replicate Model 6, but using only those SCAD events *not* involving organized actors or producing fatalities. How does *Volatility* affect the likelihood of such events? The answer is unambiguous: it has zero effect (specifically, a coefficient of 0.058 and SE of 0.268, yielding $p = 0.83$).

Overall, the picture is clear: there is no evidence to support the alternative interpretation of our findings that suggests volatility is causing conflict because it increases social grievances or lowers an individual's opportunity costs for political protest. Our inference that

[44] Given the coverage of developing countries in this wave of the WVS, these two analyses were able to include 31 and 26 countries, respectively, including over 35,000 respondents.

volatility increases uncertainty about future revenues and capabilities, and thereby enhances commitment problems, is therefore on stronger footing.

## 6 Discussion and Implications

The literature on the connection between commodities and conflict has produced mixed and contradictory results, we argue, because it has neglected the key insights of the bargaining model of war: namely, that mutually observed developments producing shifts in the balance of power cannot catalyze conflict in the absence of information or commitment problems. By themselves, dependence on commodity sources of revenue and observed changes in the prices of those commodities therefore should have no effect on the likelihood of civil conflict. Rather, what causes conflict is uncertainty about future price changes in those commodities. Export commodity price volatility means that one of the rival actors may be much better or worse off in the future, so neither can credibly commit today to not revise its demands in the future once those changes occur.

Commodity dependence thus can make conflict more likely, but only under those volatile conditions – which vary greatly across time for any commodity and any country. Accordingly, this theory thus tells us why some commodity dependent countries are more prone to conflict than others at a given point. It also tells us why some commodities, such as petroleum, appear to be more important determinants of conflict: because they constitute particularly large revenue sources, and because, at certain points, their prices have been especially volatile. There is no durable distinction among commodities, according to our argument, other than that. Finally, the theory explains the literature's empirical findings variously associating commodity price increases with higher, lower, or no risks of civil conflict. The explanation lies in volatility. What matters is unpredictability of anticipated price changes. Observed shocks should have no effect. By conflating retrospective shocks with future volatility, studies focusing solely on price shocks have generated a bundle of mixed findings, which only become consistent when we distinguish the concepts from one another in theory and measure.

This paper thus contributes by drawing a theoretically important conceptual distinction and emphasizing the previously neglected connection between the role of commodities and the field's dominant, rationalist theory of the sources of armed conflict more generally. The basic lessons of this framework help clarify the confusion among the variety of seemingly conflicting theoretical arguments. On that basis, the paper brings to the fore a variable, export price volatility, that contributes significantly to conflict onset in a way that the field has not previously recognized.[45] It also contributes by providing one of the most comprehensive empirical tests of these connections conducted to date, with more commodities, more countries, a long time frame, a more disaggregated temporal dimension (months instead of years), and more disaggregated breakdowns by commodity types in multiple ways. It applies this empirical framework to explain armed intrastate conflict among organized actors over the full range of intensity levels (involving from 1 to 1000-plus casualties per episode). And by drawing on genuinely exogenous world prices, the paper offers a reasonably solid basis for identifying the causal role of the commodity variables.

We conclude by highlighting a number of limitations and remaining questions. First, we have offered a story about conflict processes rooted in the bargaining model, i.e., presuming a (potentially latent) organized opposition group. This perspective is closely matched to the empirical tests, which use indicators of conflict defined by this criterion specifically. However, some conflict dynamics have more to do with the behavior of the mass public, and our theory and evidence do not speak to those dynamics. How might price shocks and volatility in imports or exports affect a consumer's or worker's propensity to lend support to rebels? The auxiliary evidence presented here, we hope, makes clear that export commodity price volatility's effect on conflict onset is not mediated through such processes, but that does not mean there are no important effects on individuals' incentives as a separate matter.

[45] O'Trakoun (2012) is an interesting exception, however.

Second, like other cross-national quantitative studies on this subject, we do not observe whether the government or rebels are deriving more income from commodity sales. This fact has complicated prior studies' efforts to draw inferences about the impact of directional price changes, so it has chiefly been addressed in single-country, single-commodity investigations (e.g., Angrist and Kugler 2008, Dube and Vargas 2013, Nillesen and Verwimp 2009). We do not resolve that challenge, but our inferences about the impact of price shocks are reasonably sound because of another limitation – namely, that our data only include licit commodities, not drugs or illicit product (e.g., "conflict diamonds") trade conducted through irregular markets. It is probably fair to say the income from the commodities covered in our empirical tests chiefly goes to the government (rather than rebels). In any case, our theoretical point still applies: there is no reason price changes in any revenue commodity should affect conflict onset. Furthermore, and this is quite important, volatility should have the same impact regardless of whether rebels or the state capture a commodity's income, *as long as they do not do so in equal proportion.* Future price uncertainty has a monotonic effect on the incentives for conflict of all actors.

Third, our theory concerns conflict onset, not conflict duration. The very reason why volatility should affect onset is because conflict is expected to interrupt the flow of commodity income in the future – this is the logic of preventive war. And indeed Mitchell and Thies (2012) show that conflict reduces commodity production and income. Therefore it is not theoretically or empirically clear that volatility should have the same impact on conflict duration as it does on conflict onset.

Finally, our story is fundamentally about uncertainty about future income. As we have emphasized, such uncertainty varies across time for any given country; the cross-sectional differences are to a great extent less important than the longitudinal ones. Either way, if our argument is correct, a foresighted state may take hedging measures to smooth the future stream of commodity revenue. The development community has recognized for some time that commodity price volatility introduces fiscal problems for such states – though it has not linked that problem to conflict as this paper does. Economists have generated a considerable volume of policy analysis and proposals about commodity income hedging strategies (Borensztein, Jeanne and Sandri 2013, Frankel 2011). A few notable programs in the developing world have even been implemented, such as Chile's Copper Stabilization Fund (United Nations Development Programme 2011, 71). Similarly, counter-cyclical external aid, whether military or economic, conceivably could mitigate the adverse consequences of commodity export price volatility. One such effort, the European Union's STABEX program of price supports for agricultural exports of former colonies, has widely been viewed as a failure (Collier et al. 1999). Recent work also highlights that, for aid-reliant states, uncertainty about aid itself could produce the same effects that commodity price volatility does (Nielsen et al. 2011). Still, our paper suggests an even more important role for counter-cyclical aid, since such aid, if credibly committed, could conceivably sever the connection between commodity volatility and conflict.

# References


Andersen, Torben G., Tim Bollerslev, Peter Christoffersen and Francis X. Diebold. 2006. Volatility and Correlation Forecasting. In *Handbook of Economic Forecasting*, ed. Graham Elliott, Clive W. J. Granger and Allan Timmermann. Vol. 1 Amsterdam: North Holland pp. 777–878.

Angrist, Joshua D. and Adriana D. Kugler. 2008. "Rural Windfall or a New Resource Curse? Coca, Income, and Civil Conflict in Colombia." *The Review of Economics and Statistics* 90(2):191–215.

Arezki, Rabah and Markus Brückner. 2011. Food Prices and Political Instability. Working Paper WP/11/62. International Monetary Fund.

Bazzi, Samuel and Christopher Blattmann. 2013. Economic Shocks and Conflict: The (Absence of?) Evidence from Commodity Prices. Working paper. Columbia University.

BBC News. 2000. "Civil War Fears in Guinea." http://news.bbc.co.uk/2/hi/africa/986375.stm. October 23.

Bell, Curtis and Scott Wolford. Forthcoming. "Oil Discoveries, Shifting Power, and Civil Conflict." *International Studies Quarterly* .

Bellemare, Marc F. 2015. "Rising Food Prices, Food Price Volatility, and Political Unrest." *American Journal of Agricultural Economics* Forthcoming.

Beresford, James. 1997. "Comoran Rebels Rejoice after Government Rout." *Guardian* p. 13. September 9.

Besley, Timothy J. and Torsten Persson. 2008. The Incidence of Civil War: Theory and Evidence. Working Paper 14585. National Bureau of Economic Research.

Besley, Timothy and Torsten Persson. 2011. "The Logic of Political Violence." *The Quarterly Journal of Economics* 126(3):1411–1445.

Borensztein, Eduardo, Olivier Jeanne and Damiano Sandri. 2013. "Macro-Hedging for Commodity Exporters." *Journal of Development Economics* 101:105–116.

Brückner, Markus and Antonio Ciccone. 2010. "International Commodity Prices, Growth and the Outbreak of Civil War in Sub-Saharan Africa." *The Economic Journal* 120(544):519–534.

Collier, Paul and Anke Hoeffler. 2004. "Greed and Grievance in Civil War." *Oxford Economic Papers* 56(4):563–595.

Collier, Paul, P. Guillaumont, S. Guillaumont Jeanneney and J. W. Gunning. 1999. "Reforming Stabex." *World Economy* 22(5):669–682.

Cornwell, Richard. 1998. "Anjouan: A Spat in the Indian Ocean." *African Security Review* 7(3):51–61.

Debs, Alexandre and Nuno P. Monteiro. 2014. "Known Unknowns: Power Shifts, Uncertainty, and War." *International Organization* 68(1):1–31.

Dube, Oeindrila and Juan F. Vargas. 2013. "Commodity Price Shocks and Civil Conflict: Evidence from Colombia." *The Review of Economic Studies* 80:1384–1421.

Fearon, James. 2005. "Primary Commodity Exports and Civil War." *Journal of Conflict Resolution* 49(4):483–507.

Fearon, James D. 1995. "Rationalist Explanations for War." *International organization* 49(03):379–414.

Fearon, James D. and David D. Laitin. 2003. "Ethnicity, Insurgency, and Civil War." *American Political Science Review* 97(1):75–90.

Financial Post. 2012. "Commodity Trading Houses Cash in on War and Debt." http://tinyurl.com/jwhn3rd. July 25.

Financial Times. 2014. "ISIS Sells Smuggled Oil to Turkey and Iraqi Kurds, Says US Treasury." http://tinyurl.com/lftvmlr. October 23.

Frankel, Jeffrey A. 2011. How Can Commodity Exporters Make Fiscal and Monetary Policy Less Procyclical? HKS Faculty Research Working Paper Series RWP11-015 Harvard University.

Groen, Jan J. J. and Paolo A. Pesenti. 2011. Commodity Prices, Commodity Currencies, and Global Economic Developments. In *Commodity Prices and Markets, East Asia Seminar on Economics*, ed. Takatoshi Ito and Andrew K. Rose. Vol. 20 Chicago: University of Chicago Press pp. 15–42.

Hendrix, Cullen S and Henk-Jan Brinkman. 2013. "Food Insecurity and Conflict Dynamics: Causal Linkages and Complex Feedbacks." *Stability: International Journal of Security & Development* 2(2):1–18.

Humphreys, Macartan. 2005. "Natural Resources, Conflict, and Conflict Resolution: Uncovering the Mechanisms." *Journal of Conflict Resolution* 49(4):508–537.

Le Billon, Philippe. 2001. "The Political Ecology of War: Natural Resources and Armed Conflicts." *Political Geography* 20(5):561–584.

Lujala, Päivi. 2010. "The Spoils of Nature: Armed Civil Conflict and Rebel Access to Natural Resources." *Journal of Peace Research* 47(1):15–28.

Mitchell, Sara McLaughlin and Cameron G. Thies. 2012. "Resource Curse in Reverse: How Civil Wars Influence Natural Resource Production." *International Interactions* 38:218–242.

New York Times. 2014. "SEAL Team Raids a Tanker and Thwarts a Militia's Bid to Sell Libyan Oil." http://tinyurl.com/kvtkdun. March 17.

Nielsen, Richard, Michael Findley, Zachary Davis, Tara Candland and Daniel Nielson. 2011. "Foreign Aid Shocks as a Cause of Violent Armed Conflict." *American Journal of Political Science* 55(2):219–232.

Nillesen, Eleonora and Philip Verwimp. 2009. "Grievance, Commodity Prices and Rainfall: A Village-level Analysis of Rebel Recruitment in Burundi." *MICROCON Research Working Paper 11* .

O'Trakoun, John. 2012. Price Fluctuations and Political Conflict. Working paper. Boston College.

Pemstein, Daniel, Stephen Meserve and James Melton. 2010. "Democratic Compromise: A Latent Variable Analysis of Ten Measures of Regime Type." *Political Analysis* 18(4):426–449.

Reiter, Dan. 2003. "Exploring the Bargaining Model of War." *Perspectives on Politics* 1(1):27–43.

Revenue Watch Institute. 2011. "EITI Reports: Results and Analysis." http://data.revenuewatch.org/eiti/.

Roeder, Philip G. 2001. "Ethnolinguistic Fractionalization (ELF) Indices, 1961 and 1985." http://weber.ucsd.edu/~proeder/data.htm.

Ross, Michael L. 2004*a*. "How Do Natural Resources Influence Civil War? Evidence from Thirteen Cases." *International Organization* 58:35–67.

Ross, Michael L. 2004*b*. "What Do We Know About Natural Resources and Civil War?" *Journal of Peace Research* 41(3):337–356.

Ross, Michael L. 2011. "Will Oil Drown the Arab Spring: Democracy and the Resource Curse." *Foreign Affairs* 90:2–7.

Rustad, Siri Aas and Helga Malmin Binningsbø. 2012. "A Price Worth Fighting For? Natural Resources and Conflict Recurrence." *Journal of Peace Research* 49(4):531–546.

Smith, Benjamin. 2004. "Oil Wealth and Regime Survival in the Developing World, 1960-1999." *American Journal of Political Science* 48(2):232–246.

Sorens, Jason. 2011. "Mineral Production, Territory, and Ethnic Rebellion: The Role of Rebel Constituencies." *Journal of Peace Research* 48(5):571–585.

Spatafora, Nikola and Issouf Samake. 2012. Commodity Price Shocks and Fiscal Outcomes. Working Paper WP/12/112 International Monetary Fund.

Tarar, Ahmer. 2013. "Military Mobilization and Commitment Problems." *International Interactions* 39:343–366.

Thies, Cameron G. 2010. "Of Rulers, Rebels, and Revenue: State Capacity, Civil War Onset, and Primary Commodities." *Journal of Peace Research* 47(3):321–332.

Tomek, William G. 1997. "Commodity Futures Prices as Forecasts." *Review of Agricultural Economics* 19(1):23–44.

United Nations Development Programme. 2011. *Towards Human Resilience: Sustaining MDG Progress in an Age of Economic Uncertainty.* United Nations.

US Energy Information Administration. 2013. "Russia." http://www.eia.gov/countries/country-data.cfm?fips=RS. November 26.

Walter, Barbara F. 2002. *Committing to Peace: The Successful Settlement of Civil Wars.* Princeton University Press.

Walter, Barbara F. 2009. "Bargaining Failures and Civil War." *Annual Review of Political Science* 12:243–261.

World Bank. 2010. *Boom, Bust and Up Again? Evolution, Drivers and Impact of Commodity Prices: Implications for Indonesia.* Jakarta: World Bank Office Jakarta.

Wright, Joseph, Erica Frantz and Barbara Geddes. Forthcoming. "Oil and Autocratic Regime Survival." *British Journal of Political Science* . http://dx.doi.org/10.1017/S0007123413000252.

Table 1: Descriptive Statistics for Main Analysis Sample ($N = 59829$)

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| *Volatility (Forecast)* | 0.092 | 0.056 | 0 | 1.049 |
| *Volatility (Observed)* | 0.057 | 0.038 | 0 | 0.688 |
| *Shock* | 0.005 | 0.215 | -1.453 | 1.733 |
| *Log Commodity Dependence (Fuel)* | 0.748 | 1.244 | 0 | 5.741 |
| *Log Commodity Dependence (Non-Fuel)* | 1.858 | 0.998 | 0.001 | 6.378 |
| *Log Population* | 15.526 | 1.619 | 11.645 | 21.019 |
| *Log Real Per Capita GDP* | 7.692 | 1.258 | 1.992 | 11.777 |
| *Cold War* | 0.468 | 0.499 | 0 | 1 |
| *Autocracy Score* | 0.493 | 0.504 | 0 | 2.112 |
| *Democracy Score* | 0.243 | 0.390 | 0 | 1.998 |
| *Food Import Price Increase* | -0.010 | 0.208 | -1.433 | 1.596 |
| *Conflict in Neighbor* | 0.431 | 0.495 | 0 | 1 |
| *Ethnolinguistic Fractionalization* | 0.487 | 0.275 | 0 | 0.984 |

Table 2: Cox Proportional Hazard Models of Civil Conflict: All Developing Countries

| Unit = Country-Month<br>145 Countries<br>Years: 1963-2012 | Model 1<br>Volatility<br>(Forecast)<br>(SE) | Model 2<br>Volatility<br>(Observed)<br>(SE) | Model 3<br>Country<br>Fixed Effects<br>(SE) | Model 4<br>1000<br>Deaths<br>(SE) |
|---|---|---|---|---|
| Volatility (Forecast) | 2.455* | — | 5.799* | 4.286* |
| | (1.249) | | (2.761) | (1.749) |
| Volatility (Observed) | — | 4.193* | — | — |
| | | (1.676) | | |
| Shock | 0.247 | 0.201 | -0.671 | 0.061 |
| | (0.348) | (0.342) | (0.570) | (0.621) |
| Log Commodity Dependence (Fuel) | 0.108 | 0.106 | -0.227 | 0.201 |
| | (0.065) | (0.065) | (0.184) | (0.103) |
| Log Commodity Dependence (Non-Fuel) | -0.145 | -0.152 | -0.088 | -0.137 |
| | (0.087) | (0.087) | (0.225) | (0.138) |
| Log Population | 0.264** | 0.267** | 0.072 | 0.281** |
| | (0.051) | (0.051) | (0.624) | (0.087) |
| Log Real Per Capita GDP | -0.222** | -0.222** | -0.265 | -0.304* |
| | (0.077) | (0.077) | (0.220) | (0.122) |
| Cold War | -0.363* | -0.332 | 0.030 | 0.376 |
| | (0.183) | (0.184) | (0.517) | (0.319) |
| Autocracy Score | -0.417* | -0.428* | -0.331 | -0.553 |
| | (0.211) | (0.211) | (0.443) | (0.361) |
| Democracy Score | -1.022* | -1.015* | -0.374 | -1.406 |
| | (0.411) | (0.413) | (0.773) | (0.768) |
| Food Import Price Increase | -1.088** | -1.027** | -0.734 | -1.199* |
| | (0.355) | (0.357) | (0.491) | (0.577) |
| Conflict in Neighbor | 0.419** | 0.408* | 0.595 | 0.355 |
| | (0.161) | (0.161) | (0.334) | (0.274) |
| Ethnolinguistic Fractionalization | 1.176** | 1.165** | — | 0.457 |
| | (0.313) | (0.313) | | (0.493) |
| $N$ | 59829 | 59829 | 59829 | 63065 |
| Average Months per Country | 412.6 | 412.6 | 412.6 | 434.9 |
| # Peace Spells | 308 | 308 | 308 | 191 |
| # Conflict Onsets | 186 | 186 | 186 | 61 |
| log likelihood | $-831.4$ | $-830.4$ | $-134.5$ | $-268.0$ |
| $\chi^2$ | 146.9** | 148.9** | 19.7* | 53.2** |

2-tailed $p < 0.01$, **; $p < 0.05$ *
Annual variables are lagged by one year and monthly variables by one month.
Coefficients, not hazard ratios, are reported above.

Table 3: Cox Proportional Hazard Models of Civil Conflict: Africa Only

| All Civil Conflicts with Fatalities<br>Unit: Country-Month | Model 5<br>ACLED<br>Data<br>(SE) | Model 6<br>SCAD<br>Data<br>(SE) |
|---|---|---|
| Volatility (Forecast) | 2.283** | 1.978* |
| | (0.559) | (0.770) |
| Shock | 0.138 | 0.108 |
| | (0.188) | (0.236) |
| Log Commodity Dependence (Fuel) | -0.013 | 0.050 |
| | (0.034) | (0.044) |
| Log Commodity Dependence (Non-Fuel) | -0.043 | 0.003 |
| | (0.044) | (0.058) |
| Log Population | 0.341** | 0.484** |
| | (0.037) | (0.049) |
| Log Real Per Capita GDP | -0.108* | -0.124* |
| | (0.046) | (0.058) |
| Autocracy Score | 0.169 | -0.354* |
| | (0.171) | (0.178) |
| Democracy Score | -0.043 | 0.175 |
| | (0.267) | (0.307) |
| Food Import Price Increase | 0.099 | -0.157 |
| | (0.226) | (0.271) |
| Conflict in Neighbor | 0.239** | 0.403** |
| | (0.087) | (0.105) |
| Ethnolinguistic Fractionalization | 0.531** | 0.196 |
| | (0.176) | (0.206) |
| $N$ | 7896 | 12288 |
| # Countries | 42 | 47 |
| Years | 1997-2012 | 1990-2012 |
| Average Months per Country | 188 | 261.4 |
| # Peace Spells | 2632 | 3813 |
| # Conflict Onsets | 2612 | 3780 |
| Average Spell Duration (Months) | 3.03 | 3.28 |
| log likelihood | $-2095.5$ | $-1506.1$ |
| $\chi^2$ | 141.5** | 156.3** |

2-tailed $p < 0.01$, **; $p < 0.05$ *

Annual variables are lagged by one year and monthly variables by one month.

Coefficients, not hazard ratios, are reported above.

# Data Appendix

## Civil Conflict Data

Our list of civil conflict episodes is from version 4-2014 of the UCDP/PRIO Armed Conflict Dataset (Gleditsch et al. 2002; Themnér and Wallensteen 2014).[46] A civil conflict is a "contested incompatibility that concerns government or territory or both where the use of armed force between two parties results in at least 25 battle-related deaths" (Gleditsch et al. 2002, 618-9). Only conflicts between the government of a state and a formally organized political opposition group are included in the UCDP/PRIO list; spontaneous, disorganized violence is not counted.

## Commodity Data

We compile data on a total of 71 distinct commodities. These include all 68 commodities for which monthly world prices are reported by the World Bank's "Pink Sheet," UNCTAD, or the International Monetary Fund (IMF).[47] As a supplement, we use the monthly average price of US imports from the world (from the USITC[48]) for 3 essential commodities (diamonds, cashews, and cloves) not reported by the principal sources. This is reasonable because, according to UN COMTRADE data, the US was the world's first or second top importer for diamonds and cashews each year, and, for cloves, the annual correlation of the real US import price with the rest of world import price over the sample years is 0.91. We convert nominal prices to real prices using the monthly US consumer price index series from the US Bureau of Labor Statistics (`http://www.bls.gov/cpi`), and we index each commodity real price series with its January 1990 price as the benchmark.

Table 4 lists all 71 commodities, along with data source, and the first year in our sample

[46] `http://www.pcr.uu.se/research/ucdp/datasets/ucdp_prio_armed_conflict_dataset/`

[47] `http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1304428586133/pink_data_m.xlsx` (World Bank); `http://unctadstat.unctad.org` (UNCTAD); `http://www.imf.org/external/np/res/commod/index.aspx` (IMF).

[48] `http://dataweb.usitc.gov`.

for which monthly price series are available. The table also displays summary statistics for commodity-month-level variables $Volatility_{j,t}$ (as both observed and forecasted) and $Shock_{j,t}$ (note: these are not country-month-level statistics). From these statistics we see that commodities differ over the sample period — some are chronically more volatile than others, with cloves, diamonds, bananas, oranges, swine, and sugar leading the list. However, nearly all (except diamonds and cloves) go through periods of virtually zero volatility as well. The table also shows the share of each commodity in the average country's total eligible (price-taking) commodity export portfolio, along with the corresponding share for the country most dependent on that given commodity. Some commodities, such as phosphate, potash, cloves, hard logs, rubber, and others, are negligible for the average country but are a leading commodity export for others nonetheless. Note that price changes for non-petroleum commodities are not chiefly a function of petroleum price shocks: using the commodity-month data, if we regress $Shock_{j,t}$ for all other commodities on that of petroleum, the $R^2$ is just 0.073.

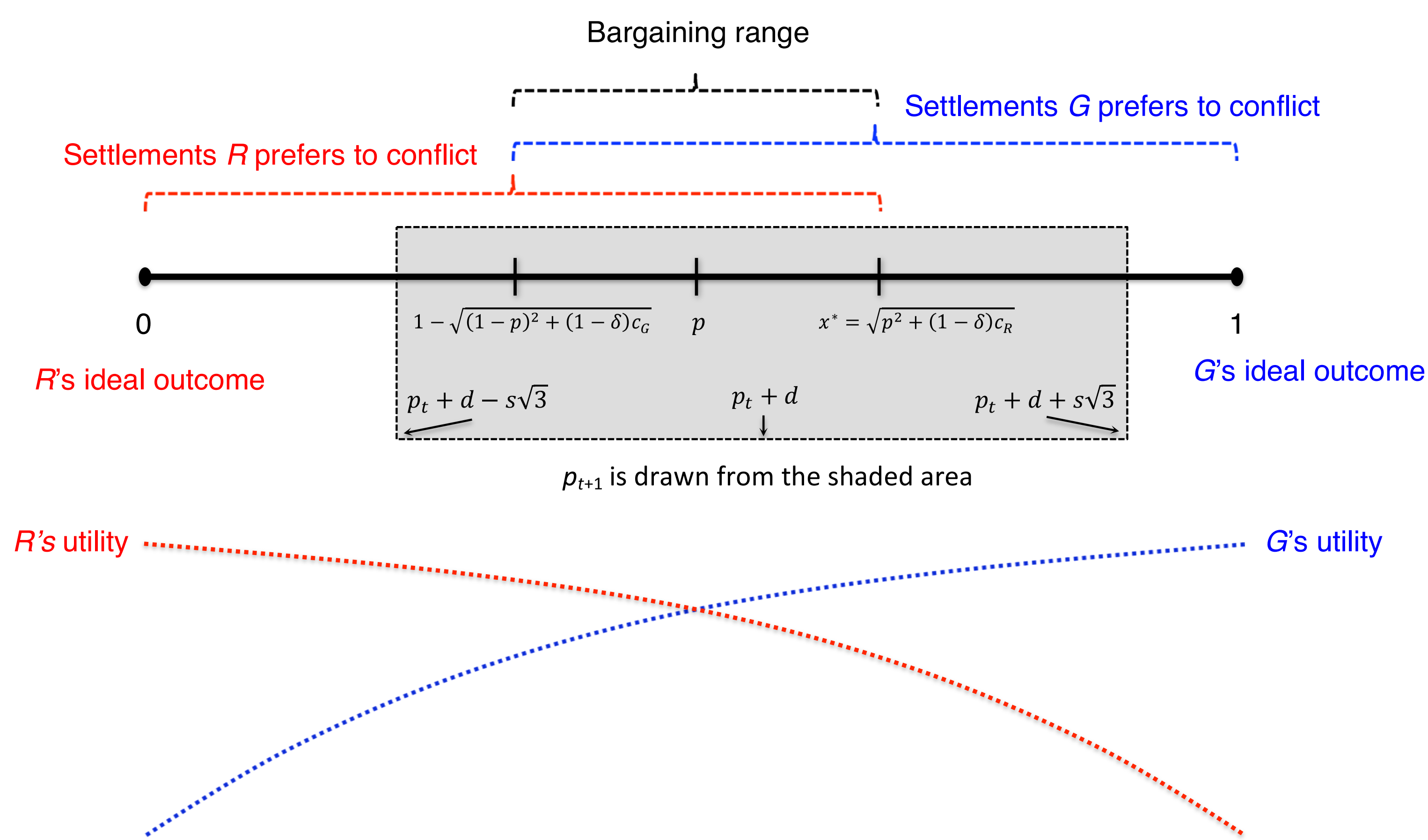



Figure 1: The bargaining space

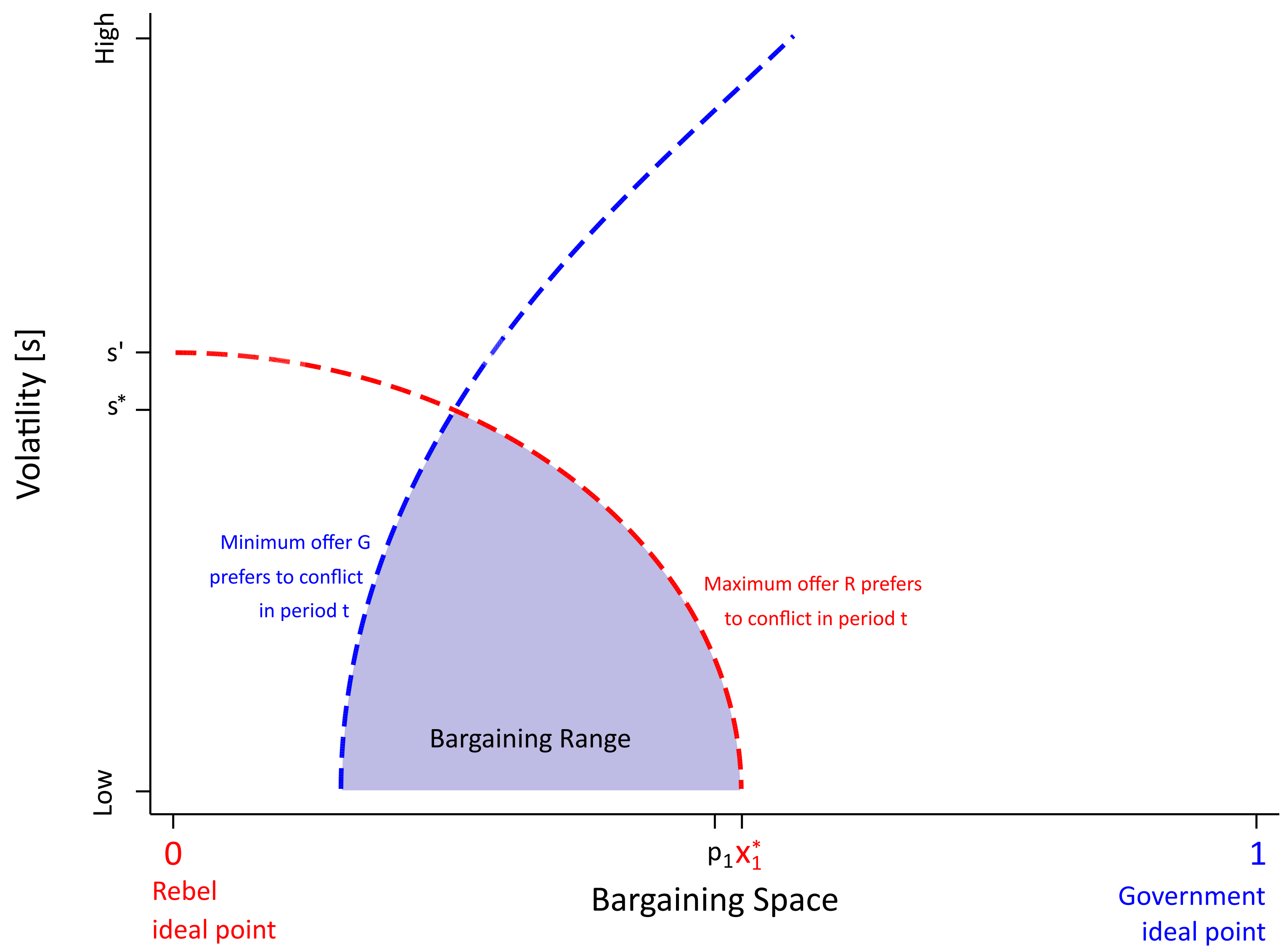



Figure 2: The bargaining range shrinks as volatility increases

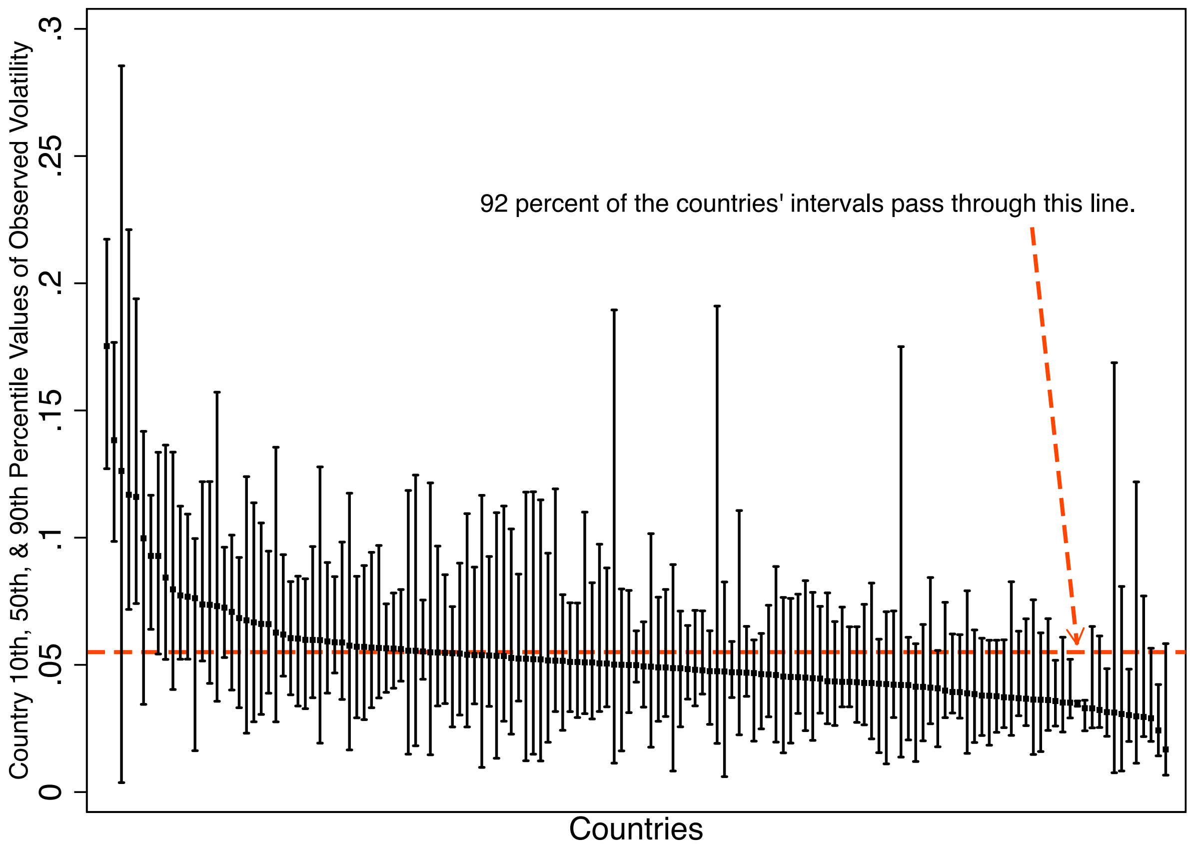
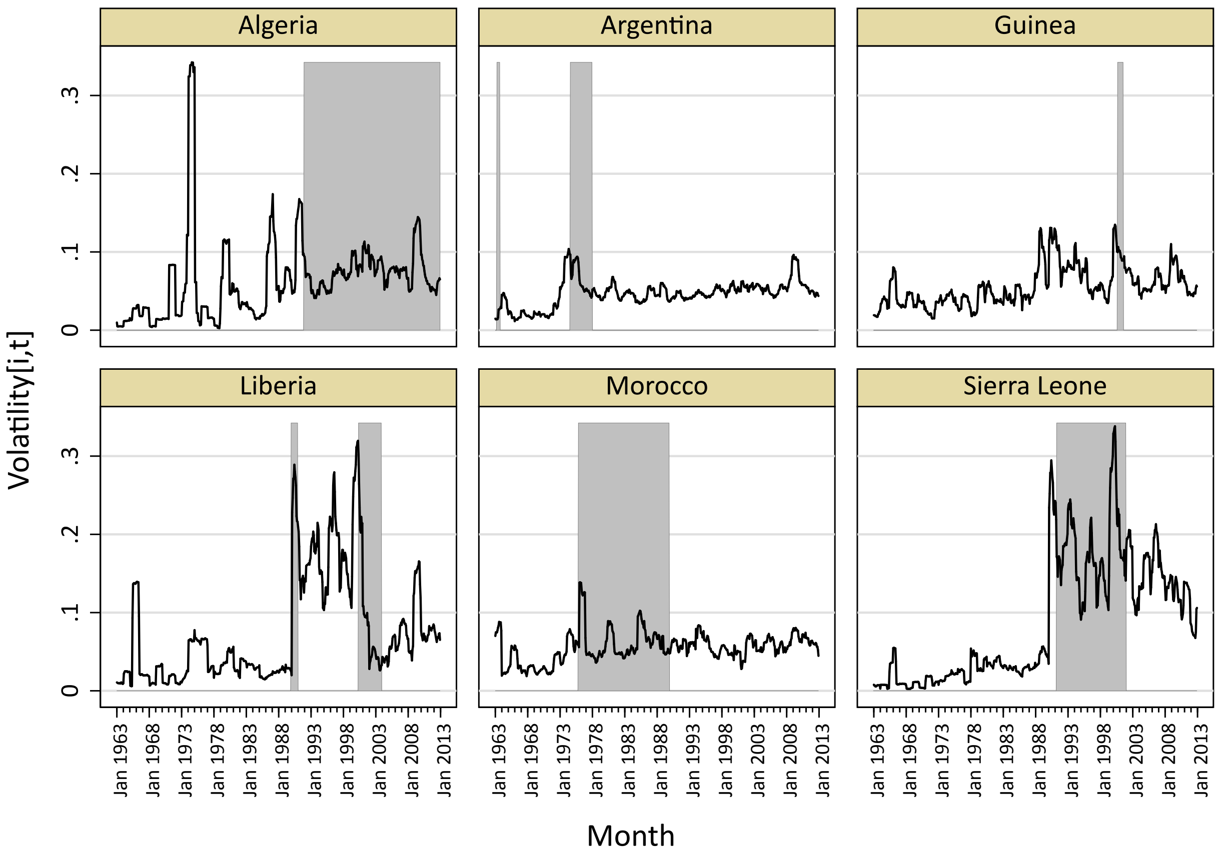



Figure 3: Sample Median, 10th, and 90th Percentile Values of $Volatility_{i,t}$ ($Observed$) by Country




Note: Observed volatility shown on y-axis. Shaded regions indicate periods of civil conflict.

Figure 4: Civil Conflicts Occur at Times When Volatility Peaks: Some Examples

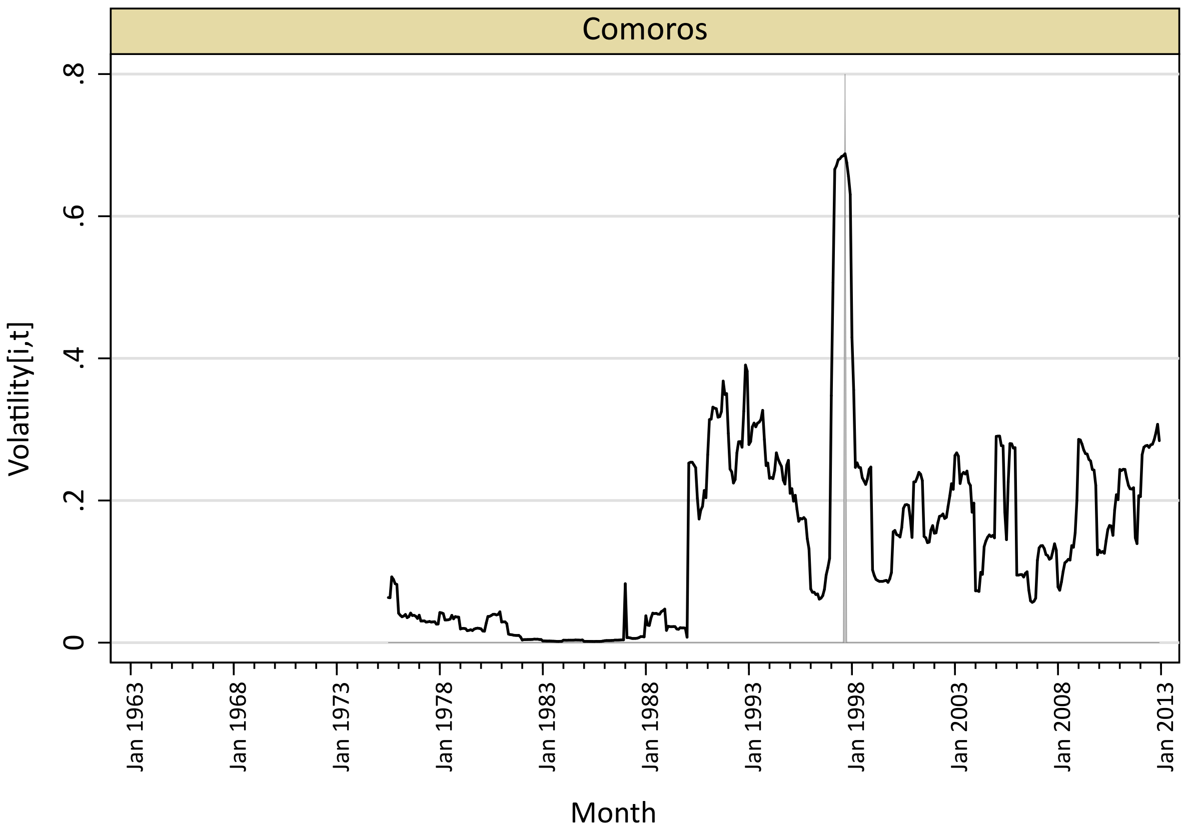



Figure 5: Volatility and Civil Conflict in Comoros

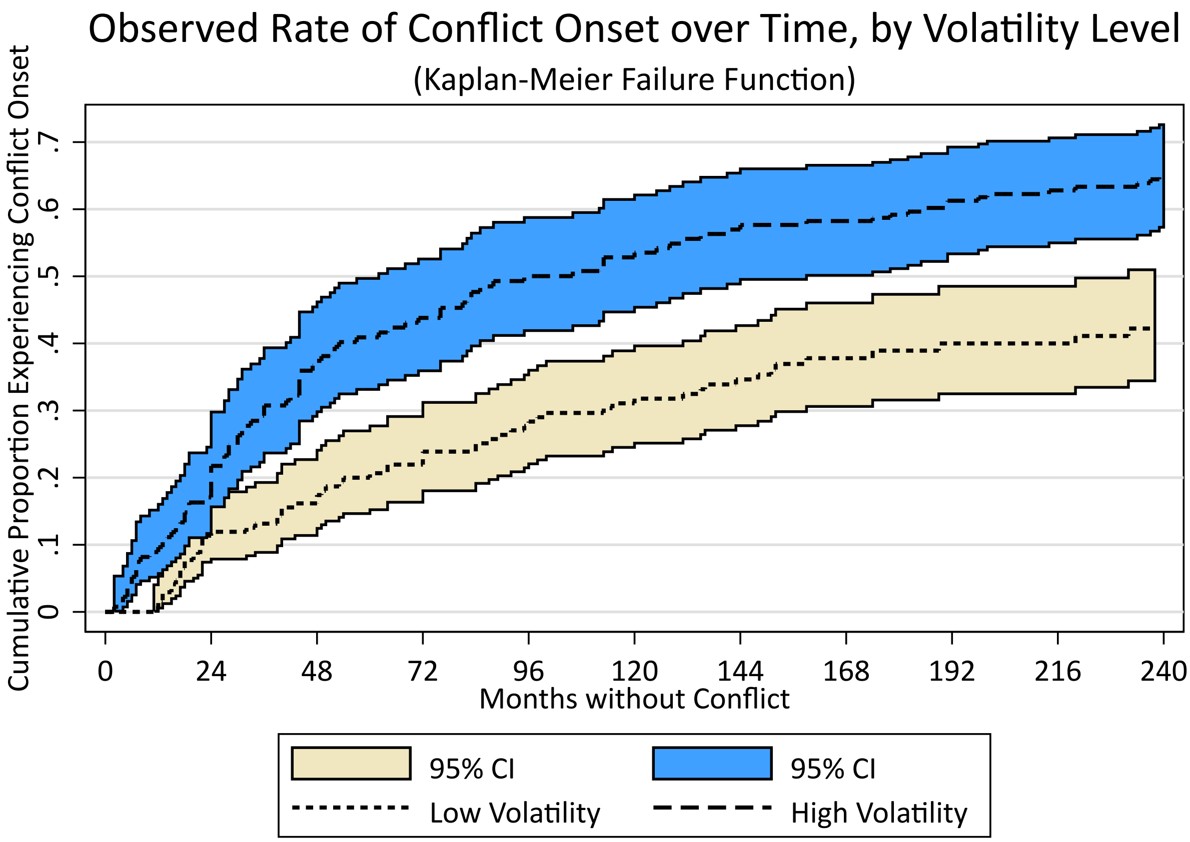



Figure 6: Descriptive Analysis of Conflict Onset Rate by (Observed) Volatility Level

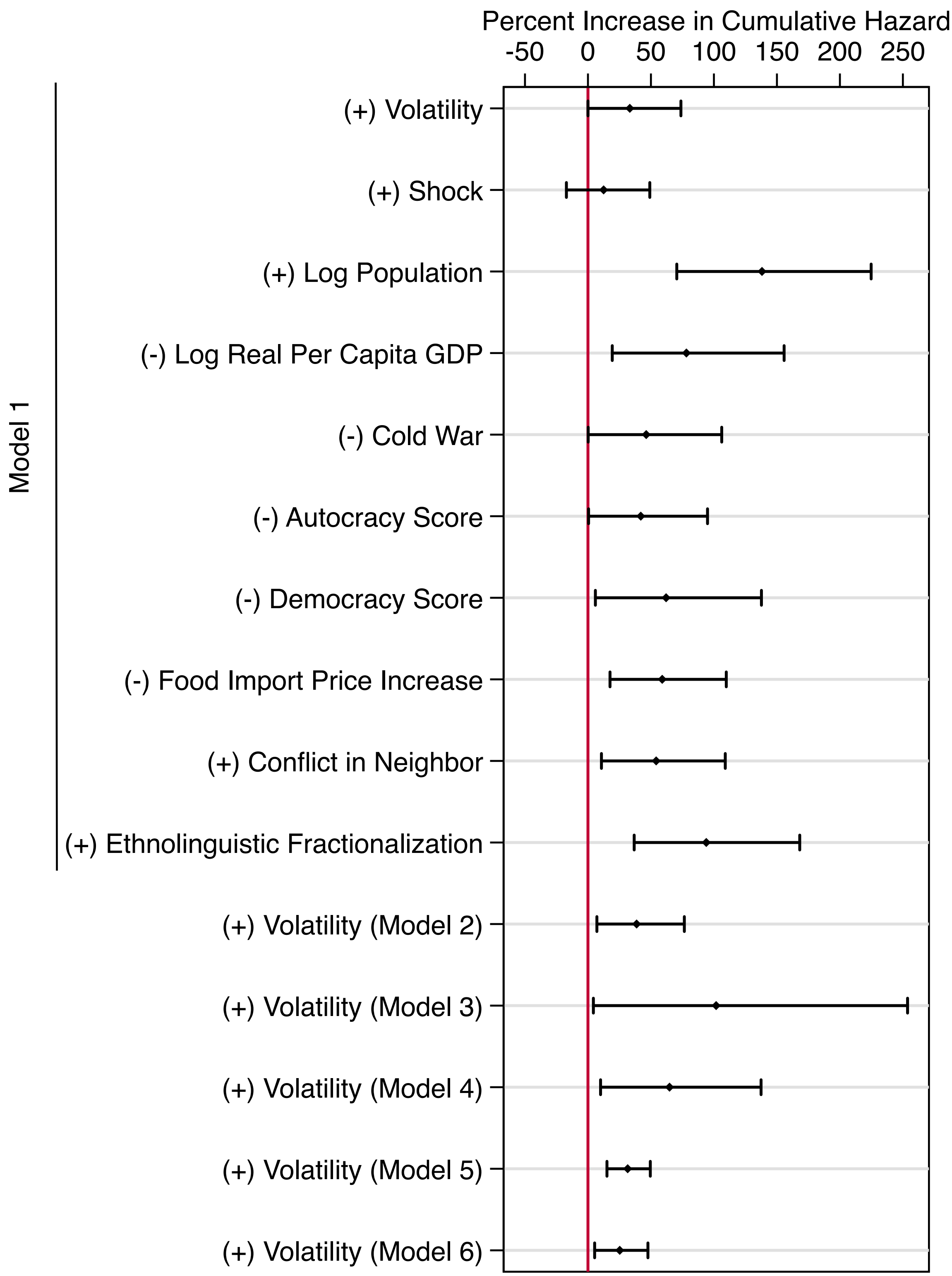



Figure 7: Estimated Substantive Impact of Selected Variables on the Cumulative Hazard of Conflict Onset at Time $t$ (Mean and 95 % Confidence Interval)

Table 4: Commodities and Descriptive Commodity Statistics

| | | | Forecast $Volatility_{j,t}$ | | | Observed $Volatility_{j,t}$ | | | $Shock_{j,t}$ | | | Avg | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commodity | Source | Start | Mean | Min | Max | Mean | Min | Max | Min | Max | SD | Share | Share |
| petroleum | WB | 1963 | 0.097 | 0.003 | 0.731 | 0.063 | 0.001 | 0.357 | -1.03 | 1.74 | 0.34 | 14.6 | 99.6 |
| coal | WB | 1970 | 0.051 | 0.018 | 0.207 | 0.043 | 0.001 | 0.179 | -0.87 | 0.93 | 0.26 | 1.6 | 34.8 |
| natural gas | WB | 1963 | 0.077 | 0.004 | 0.852 | 0.058 | 0.001 | 0.179 | -0.96 | 0.89 | 0.22 | 1.9 | 65.2 |
| LNG | WB | 1977 | 0.040 | 0.005 | 0.389 | 0.031 | 0.001 | 0.125 | -0.52 | 0.53 | 0.19 | 0.9 | 24.8 |
| cocoa | WB | 1963 | 0.093 | 0.076 | 0.247 | 0.062 | 0.024 | 0.163 | -0.69 | 0.99 | 0.27 | 1.6 | 40.4 |
| coffee | UNCTAD | 1963 | 0.097 | 0.032 | 0.271 | 0.058 | 0.009 | 0.162 | -0.74 | 1.15 | 0.31 | 6.4 | 84.0 |
| tea | WB | 1963 | 0.064 | 0.025 | 0.311 | 0.055 | 0.006 | 0.190 | -0.57 | 0.75 | 0.18 | 1.1 | 42.3 |
| coconut oil | WB | 1963 | 0.117 | 0.046 | 0.276 | 0.068 | 0.019 | 0.166 | -1.23 | 1.55 | 0.43 | 0.2 | 6.4 |
| copra | WB | 1963 | 0.119 | 0.054 | 0.265 | 0.067 | 0.023 | 0.165 | -1.32 | 1.40 | 0.43 | 0.4 | 18.7 |
| groundnuts | WB | 1980 | 0.108 | 0.056 | 0.572 | 0.068 | 0.007 | 0.203 | -1.03 | 0.94 | 0.34 | 0.7 | 30.5 |
| groundnut oil | WB | 1963 | 0.091 | 0.021 | 0.431 | 0.053 | 0.009 | 0.238 | -0.77 | 0.84 | 0.30 | 0.2 | 16.7 |
| palm oil | UNCTAD | 1963 | 0.107 | 0.036 | 0.224 | 0.067 | 0.016 | 0.162 | -1.01 | 0.93 | 0.32 | 0.3 | 8.2 |
| palm kernel oil | UNCTAD | 1963 | 0.124 | 0.062 | 0.380 | 0.073 | 0.015 | 0.170 | -1.40 | 1.39 | 0.43 | 0.1 | 5.9 |
| soybeans | WB | 1963 | 0.077 | 0.034 | 0.289 | 0.050 | 0.014 | 0.200 | -0.83 | 1.17 | 0.22 | 0.3 | 25.8 |
| soybean oil | WB | 1963 | 0.092 | 0.062 | 0.183 | 0.057 | 0.025 | 0.133 | -0.89 | 0.93 | 0.29 | 0.2 | 3.9 |
| soybean meal | WB | 1963 | 0.091 | 0.043 | 0.376 | 0.057 | 0.007 | 0.279 | -1.38 | 1.47 | 0.26 | 0.8 | 12.2 |
| sunflower oil | UNCTAD | 1963 | 0.095 | 0.063 | 0.177 | 0.059 | 0.022 | 0.127 | -0.90 | 0.92 | 0.30 | 0.2 | 11.4 |
| olive oil | IMF | 1980 | 0.056 | 0.034 | 0.094 | 0.038 | 0.012 | 0.094 | -0.60 | 0.49 | 0.19 | 0.2 | 14.3 |
| pepper | UNCTAD | 1963 | 0.100 | 0.048 | 0.187 | 0.064 | 0.009 | 0.170 | -0.98 | 0.93 | 0.31 | 0.2 | 3.9 |
| barley | WB | 1963 | 0.079 | 0.020 | 0.209 | 0.053 | 0.005 | 0.133 | -0.75 | 0.74 | 0.22 | 0.3 | 5.1 |
| maize | WB | 1963 | 0.075 | 0.034 | 0.124 | 0.050 | 0.001 | 0.113 | -0.64 | 0.72 | 0.22 | 0.9 | 15.7 |
| sorghum | WB | 1963 | 0.076 | 0.024 | 0.147 | 0.052 | 0.011 | 0.117 | -0.55 | 0.71 | 0.21 | 0.1 | 3.3 |
| rice | WB | 1963 | 0.076 | 0.041 | 0.259 | 0.051 | 0.014 | 0.192 | -0.71 | 1.08 | 0.28 | 1.3 | 36.1 |
| wheat | WB | 1963 | 0.077 | 0.033 | 0.185 | 0.049 | 0.005 | 0.177 | -0.64 | 1.06 | 0.23 | 1.3 | 20.2 |
| bananas | WB | 1963 | 0.184 | 0.071 | 0.314 | 0.142 | 0.030 | 0.378 | -0.85 | 0.80 | 0.22 | 1.7 | 54.3 |
| oranges | WB | 1963 | 0.154 | 0.093 | 0.464 | 0.128 | 0.017 | 0.265 | -0.67 | 0.85 | 0.23 | 0.8 | 25.0 |
| sugar | WB | 1963 | 0.156 | 0.069 | 0.297 | 0.097 | 0.025 | 0.220 | -1.52 | 1.60 | 0.49 | 5.1 | 88.9 |
| beef | WB | 1963 | 0.058 | 0.032 | 0.129 | 0.041 | 0.012 | 0.106 | -0.69 | 0.43 | 0.16 | 1.8 | 37.8 |
| poultry | WB | 1963 | 0.022 | 0.003 | 0.073 | 0.015 | 0.001 | 0.047 | -0.22 | 0.23 | 0.07 | 0.4 | 12.4 |
| swine | IMF | 1980 | 0.137 | 0.098 | 0.251 | 0.104 | 0.037 | 0.267 | -1.10 | 0.95 | 0.31 | 0.5 | 15.8 |
| lamb | WB | 1971 | 0.055 | 0.041 | 0.091 | 0.039 | 0.012 | 0.104 | -0.55 | 0.46 | 0.16 | 0.2 | 6.0 |
| fish meal | UNCTAD | 1963 | 0.083 | 0.044 | 0.318 | 0.050 | 0.016 | 0.221 | -1.10 | 1.26 | 0.30 | 0.3 | 16.7 |
| shrimp | WB | 1975 | 0.058 | 0.037 | 0.109 | 0.040 | 0.010 | 0.093 | -0.55 | 0.44 | 0.17 | 4.1 | 61.5 |
| tobacco | WB | 1963 | 0.030 | 0.002 | 0.292 | 0.018 | 0.007 | 0.065 | -0.32 | 0.27 | 0.11 | 2.1 | 61.8 |
| cotton | WB | 1963 | 0.076 | 0.018 | 0.218 | 0.041 | 0.005 | 0.156 | -0.86 | 0.96 | 0.26 | 4.9 | 77.7 |
| cottonseed oil | UNCTAD | 1963 | 0.092 | 0.054 | 0.256 | 0.060 | 0.018 | 0.190 | -0.99 | 0.97 | 0.29 | 0.0 | 0.9 |

Commodities and Descriptive Commodity Statistics, continued

| | | | Forecast $Volatility_{j,t}$ | | | Observed $Volatility_{j,t}$ | | | $Shock_{j,t}$ | | | Avg | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commodity | Source | Start | Mean | Min | Max | Mean | Min | Max | Min | Max | SD | Share | Share |
| linseed oil | UNCTAD | 1963 | 0.095 | 0.040 | 0.224 | 0.058 | 0.011 | 0.175 | -0.89 | 1.38 | 0.36 | 0.0 | 1.4 |
| rapeseed oil | IMF | 1980 | 0.105 | 0.074 | 0.400 | 0.069 | 0.018 | 0.270 | -0.80 | 0.68 | 0.27 | 0.1 | 0.7 |
| wool | IMF | 1980 | 0.072 | 0.050 | 0.119 | 0.051 | 0.019 | 0.102 | -0.65 | 0.62 | 0.24 | 1.4 | 58.7 |
| cattle hides | UNCTAD | 1963 | 0.107 | 0.031 | 0.271 | 0.073 | 0.009 | 0.213 | -1.12 | 0.94 | 0.29 | 0.6 | 6.8 |
| rubber | WB | 1963 | 0.090 | 0.044 | 0.254 | 0.054 | 0.011 | 0.177 | -0.79 | 0.91 | 0.29 | 2.0 | 57.1 |
| jute | UNCTAD | 1963 | 0.087 | 0.049 | 0.377 | 0.055 | 0.006 | 0.188 | -1.24 | 0.94 | 0.31 | 0.2 | 24.5 |
| sisal | UNCTAD | 1963 | 0.052 | 0.015 | 0.187 | 0.030 | 0.001 | 0.083 | -0.82 | 0.97 | 0.25 | 0.1 | 5.0 |
| hard logs | WB | 1963 | 0.071 | 0.022 | 0.198 | 0.044 | 0.002 | 0.138 | -0.67 | 0.92 | 0.23 | 1.7 | 68.0 |
| hard sawnwood | WB | 1963 | 0.044 | 0.012 | 0.132 | 0.027 | 0.002 | 0.094 | -0.60 | 0.36 | 0.14 | 1.4 | 28.0 |
| plywood | WB | 1979 | 0.061 | 0.012 | 0.150 | 0.038 | 0.002 | 0.113 | -0.44 | 0.77 | 0.17 | 1.5 | 12.3 |
| woodpulp | WB | 1979 | 0.059 | 0.042 | 0.220 | 0.035 | 0.003 | 0.104 | -0.59 | 0.56 | 0.23 | 1.2 | 26.4 |
| soft logs | IMF | 1980 | 0.090 | 0.069 | 0.193 | 0.061 | 0.022 | 0.166 | -0.39 | 0.53 | 0.16 | 0.4 | 7.4 |
| soft sawnwood | IMF | 1980 | 0.089 | 0.053 | 0.178 | 0.061 | 0.011 | 0.155 | -0.43 | 0.31 | 0.12 | 1.4 | 26.1 |
| uranium | IMF | 1980 | 0.089 | 0.044 | 0.347 | 0.051 | 0.007 | 0.226 | -0.88 | 1.10 | 0.31 | 0.1 | 8.3 |
| phosphate | WB | 1963 | 0.030 | 0.005 | 0.410 | 0.040 | 0.001 | 0.333 | -1.55 | 2.05 | 0.38 | 0.9 | 63.8 |
| DAP | WB | 1967 | 0.081 | 0.038 | 0.515 | 0.054 | 0.008 | 0.210 | -1.43 | 1.07 | 0.35 | 0.3 | 9.6 |
| TSP | WB | 1963 | 0.062 | 0.002 | 0.291 | 0.044 | 0.002 | 0.224 | -1.60 | 1.28 | 0.36 | 0.0 | 0.7 |
| urea | WB | 1963 | 0.126 | 0.002 | 3.244 | 0.087 | 0.001 | 0.428 | -1.12 | 1.39 | 0.41 | 0.7 | 11.8 |
| potash | WB | 1963 | 0.048 | 0.003 | 0.632 | 0.030 | 0.001 | 0.143 | -1.05 | 1.21 | 0.25 | 0.4 | 30.2 |
| aluminum | WB | 1963 | 0.068 | 0.004 | 0.230 | 0.040 | 0.001 | 0.155 | -0.81 | 0.85 | 0.22 | 4.6 | 75.2 |
| copper | WB | 1963 | 0.093 | 0.050 | 0.225 | 0.062 | 0.001 | 0.166 | -0.92 | 0.87 | 0.30 | 4.1 | 88.1 |
| lead | WB | 1963 | 0.103 | 0.055 | 0.217 | 0.062 | 0.012 | 0.157 | -1.03 | 1.05 | 0.31 | 0.5 | 13.1 |
| tin | WB | 1963 | 0.076 | 0.024 | 0.171 | 0.044 | 0.008 | 0.119 | -0.88 | 0.67 | 0.25 | 0.6 | 20.5 |
| nickel | WB | 1963 | 0.082 | 0.003 | 0.300 | 0.056 | 0.001 | 0.202 | -1.17 | 1.49 | 0.33 | 0.5 | 21.2 |
| zinc | WB | 1963 | 0.093 | 0.033 | 0.299 | 0.054 | 0.010 | 0.180 | -0.96 | 1.38 | 0.32 | 0.9 | 16.2 |
| manganese | UNCTAD | 1963 | 0.058 | 0.005 | 0.870 | 0.037 | 0.001 | 0.243 | -1.53 | 1.57 | 0.32 | 0.2 | 5.2 |
| tungsten | UNCTAD | 1963 | 0.088 | 0.003 | 0.355 | 0.052 | 0.001 | 0.160 | -0.76 | 0.92 | 0.31 | 0.1 | 4.8 |
| gold | WB | 1963 | 0.063 | 0.002 | 0.294 | 0.037 | 0.001 | 0.151 | -0.56 | 0.96 | 0.21 | 2.9 | 51.5 |
| platinum | WB | 1963 | 0.070 | 0.017 | 0.217 | 0.043 | 0.001 | 0.154 | -0.72 | 0.68 | 0.23 | 0.3 | 10.9 |
| silver | WB | 1963 | 0.102 | 0.003 | 0.453 | 0.061 | 0.001 | 0.304 | -1.10 | 1.71 | 0.30 | 0.6 | 7.3 |
| iron | WB | 1963 | 0.185 | 0.001 | 1.594 | 0.037 | 0.001 | 0.196 | -1.18 | 1.04 | 0.23 | 3.3 | 67.2 |
| steel | WB | 1979 | 0.037 | 0.020 | 0.184 | 0.023 | 0.004 | 0.090 | -0.48 | 0.65 | 0.18 | 11.5 | 78.9 |
| cloves | USITC | 1989 | 0.525 | 0.314 | 1.079 | 0.316 | 0.137 | 0.718 | -1.34 | 1.23 | 0.49 | 0.3 | 47.5 |
| cashews | USITC | 1989 | 0.047 | 0.026 | 0.091 | 0.027 | 0.009 | 0.076 | -0.36 | 0.41 | 0.16 | 0.4 | 32.9 |
| diamonds | USITC | 1989 | 0.248 | 0.165 | 0.602 | 0.223 | 0.104 | 0.537 | -0.94 | 1.11 | 0.26 | 4.4 | 82.2 |