The Price is Right
Market Anticipations of the Cost of War

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EARLY DRAFT – DO NOT CITE WITHOUT PERMISSION

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Abstract

Are wars caused by excessive optimism? In other words, do decision makers tend to underestimate the costs of war? Here, we explore how well the contemporaries of interstate wars have assessed their ultimate costs by studying the evolution of financial asset prices throughout the war. The price of government bonds, in particular, is strongly affected by war through inflation and default risks, and proxies the cost of war as estimated by its contemporaries. As conflicts progress, markets adjust their estimate, until the end of the conflict, when bond prices reflect all the information available. Using worldwide weekly government bond yield data from 1517 to 2007, we estimated the market's perceived cost of war both at the onset and at the end of conflict. The discrepancy between the two, measured using an event study with synthetic controls, reveals that costs tend to be underestimated by conflicts' initiators, but correctly assessed by targets. This finding has important implications for our understanding of bargaining, the rationality of decision-makers, and the ability of audiences to correctly reward the risks undertaken by their leaders.

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France was confident of a quick victory when it declared war against Prussia on 16 July 1870. The effective range of its rifles was greater; the *mitrailleuse* was the first rapid-firing weapon deployed in any major conflict; and its army was experienced and professional. Yet France's assurance was shattered in a matter of weeks. The Prussian coalition mobilised much faster a larger and better-trained army, with more advanced technology. The French defeat was swift, its own Emperor was captured, and the resulting loss of Alsace-Lorraine and German unification upset the European balance of power for decades.

History is replete with such examples of miscalculations. But are these stories representative of a larger pattern? Do decision-makers tend to underestimate the costs and risks of war? In other words, are they overoptimistic over their chance of winning, and the cost at which they can achieve those victories? While much has been written about the decision to go to war itself, we know far less about the post-war assessment by countries involved. Was the war costlier than expected, or the outcome disappointing?

The answer to this question has important implications for our understanding of bargaining processes. If states are overoptimistic, then both may indeed go to war with a positive expected utility for war. Yet, while much has been written at the theoretical level on overoptimism as a cause of war, the empirical record is limited. The answer also matters for the literature on domestic audiences and their role in the onset and course of conflict. One important assumption in that literature is that leaders' choices are clearly and unambiguously understood by those who decide their fate. Audiences may, for example, punish leaders for reckless actions that escalate the risk of war. Yet if observers misestimate the risks of war, then there are important implications for our understanding of audience costs and costly signals. For example, can leaders really tie their hands or more generally signal their intentions if the associated risk of war is misestimated?

A major difficulty to assess how contemporaries estimate the costs and risks of the war to come is to measure their beliefs. While careful historical work based on news reports and leaders' exchanges can unveil perceptions in the context of specific wars, the vast majority of conflicts remains ignored. On the quantitative side, proxies have been devised to estimate the uncertainty surrounding war—from secret alliances to the structure of the system—but these proxies are crude, and in any case uncertainty need not mean (over)optimism.

Here, we directly explore how well the contemporaries of interstate wars have assessed their ultimate costs by studying the evolution of financial asset prices throughout the war. The price of government bonds, in particular, is strongly affected by war through inflation and default risks, and as such proxies the expected cost of war as estimated by its contemporaries. As conflicts progress, markets adjust their estimate, until the end of the conflict, when bond prices reflect all the information available. Using worldwide weekly government bond yield data from 1517 to 2007, we estimated the market's perceived cost of war both at the onset and at the end of conflict.

The discrepancy between the two, measured using an event study with synthetic controls, shows that abnormal returns—returns that cannot be explained by factors other than those related to war—are overall not significantly different from zero.

This suggests that markets are efficient and correctly anticipate the costs and risks of conflict.

However, we also expect on the basis of a simple theory that not all war participants will be unbiased in their estimate of the upcoming costs of war. In particular, if states choose the action they believe is most likely to succeed, then they will also tend to choose actions whose probability of success they overestimated, rather than underestimated. This argument, akin to the winner's curse in the context of auctions, implies that initiators are likely to fight precisely because they underestimate the ultimate costs associated with war, and hence will tend to be disappointed in their post-conflict assessment. On the other hand, targets should correctly anticipate the costs and therefore have no abnormal return from the onset to the end of conflict. Our empirical results strongly support these hypotheses.

Optimism and War

The idea that states fight wars because they disagree about their relative power (Blainey 1988) has gained increasing attention over the past few decades. The logic, formalized in a plethora of bargaining games, centers around asymmetric information and incentives to misrepresent to explain why two states may possibly have a positive expected utility for war (e.g., Fearon 1995, Powell 2002). More recently, scholars have attempted to treat more formally the possibility of mutual optimism, leading to results akin to the no-trade results from economics (Fey & Ramsay 2007, Slantchev & Tarar 2011).

States may disagree over their relative power for many reasons. Psychological and cognitive biases may lead to overoptimism. People, for example, tend to be overoptimistic about their future (Weinstein 1980), to overestimate the precision of their own estimates (Oskamp 1965, Tetlock 2017), and to overestimate the degree to which they have control over an outcome (Ellen J. Langer 1975). Overconfidence can also emerge as an evolutionary stable strategy (Johnson & Fowler 2011).

These biases extend to the participants of international politics (Jervis 1976, McDermott 2004). Policymakers may fail to learn from history (Jervis 1988), or fail to reevaluate the strategies that worked best in the past in light of present circumstances (Khong 1992). Similarly, work on bounded rationality emphasizes decision-makers general cognitive limitations (for a review, see Rosati 2000). Organizational biases and bureaucratic politics may also cause misperceptions and miscalculations (Allison 1971). For example, the military branch may exaggerate the probability of success to justify its budget (Halperin & Clapp 2007, Brooks 2008), or itself be subject to biases such as a preference for offensive strategies (Snyder 1989). Gender differences may also account for overoptimism. Thus, overconfidence in war games appears to be stronger in males than in females, and attacks more frequent as a result (Johnson, McDermott, Barrett, Cowden, Wrangham, McIntyre & Rosen 2006).

Unfortunately, empirical evidence for overoptimism is limited. An obvious reason for this empirical scarcity is the difficulty of measuring perceptions and beliefs about aspects of the war such as its cost or the probability of winning.[1] Instead of measuring optimism, some have instead relied on proxies for uncertainty. However, there are two problems with this approach. First, uncertainty does not imply optimism. Second, the proxies used are typically crude and questionable, with some proxying uncertainty using the military balance at the dyadic level (Reed 2003, Slantchev 2004), or at the global level (Bas & Schub 2016*a*). An approach more closely related to measuring optimism relies on the measurement of private capabilities that are not common knowledge, such as secret alliances (Bas & Schub 2016*b*), or secret mobilization (Lai 2004). Yet these are very indirect measures of optimism—private capabilities need not mean overoptimism—and the inferences are therefore questionable.

Case studies do offer evidence of the mechanism (Johnson 2009), but cannot help us understand the prevalence of these biases, and what affects them. One way to avoid the difficulty of measuring beliefs from observations is to study them in laboratory experiments (Quek 2017, Johnson et al. 2006). Unfortunately, experiments face the criticism that they are unable to replicate real-world stakes using simple laboratory games. This criticism is particularly potent in the context of world politics. The equilibrium and empirical outcomes of these games are also often highly susceptible to small changes in the game structure (Fey & Ramsay 2007).

Guidolin & La Ferrara (2010) do study the reaction of markets to conflict onsets, but are concerned with what can be inferred about their true economic costs rather than the exactitude of the market's perceptions and forecasts. More importantly, the data they use is not country-specific, with the exception of the USA, the UK, France, and Japan. As a result, these data are not fine-grained enough to infer the market's reaction to a particular war, except for those involving these four countries. Finally, the limited time-span of their data (1974–2004) precludes the analysis conducted here on the evolution and possible improvement over time of forecasts. Other studies that focus on the reaction of financial markets to the onset of conflict are limited to case studies (Abadie & Gardeazabal 2003, Leigh, Wolfers & Zitzewitz 2003, Amihud & Wohl 2004, Chen & Siems 2004, Hall 2004, Rigobon & Sack 2005, Schneider & Troeger 2006, Brune, Hens, Rieger & Wang 2015, Schneider, Hadar & Bosler 2017). Tetlock (2005) is more specifically focused on the quality of forecasts, but has no data on conflict and also a more limited time-frame.

Here I aim to address the question of optimism directly. Are the contemporaries of wars overoptimistic about their costs? And what affects this bias?

[1] An interesting exception is Lindsey (2016) analysis of naval battles, which is more a test of Gartzke's argument. Lindsey (2016) shows that observable capabilities, such as strength, do not predict the outcome of battles. Because admirals can sail away, they are unlikely to engage in conflict when the odds are against them, so that conflict is only observed when the outcome is difficult to predict. While very innovative, this argument does not, however, test whether wars are caused by overoptimism.

The Initiator's Curse

After the war, some states may find that the war cost less than expected; others that it cost more. I call this difference between the post- and pre-war estimates the ex ante overoptimism (costs are larger than initially expected) or pessimism.[2] I now show that ex ante optimism is to be expected theoretically from war initiators. This bias toward overoptimism need not arise from psychological or cognitive limitations, but simply as a result of unbiased, random errors in countries' expectations about the war to come.

The basic idea is as follows. Suppose that states' estimates of their probability of success (or any other relevant variable) is subject to (possibly random) variation. In other words, they will sometimes overestimate the probability, and sometimes underestimate it. When they choose whether to fight or not to fight, then, they are more likely to choose to fight if they overestimated the probability of winning. In other words, initiators are likely to be overoptimistic. This mechanism is at its core the same as the winner's curse in the context of auctions (Capen, Clapp, Campbell et al. 1971), in that random variations alone can lead to systematic biases by which the winner is, on average, disappointed—she tends to overestimate the value of the good purchased.[3] Just like investment projects similarly tend to have disappointing revenues (Brown 1974), we expect that initiators will tend to become disillusioned about their initial estimate.

To see this more formally, suppose for example that Nature chooses the same true cost of war c_N for every country. c_N is the realization of a draw from a continuous distribution C. However, perhaps because of noisy observations, limited cognition, psychological biases, or any other reason, countries have different priors and hence different beliefs about this cost (the same argument applies to other attributes of war, such as the probability of winning). More specifically, each state observes instead c_i, where the c_i are i.i.d. draws from C on $[\underline{c}, \overline{c}]$ (see fig. 1 for illustration). The joint distribution of c_N and the c_i is $\mathcal{C} = \times_{N,i} C$.

Suppose further that states will initiate conflict if their expected cost of war is lower than a given threshold, i.e., if $c_i < c^*$. For simplicity, we assume that other variables do not enter their calculation, though this has no effect on the argument. It is easy to show that the expected size of the surprise—the difference between the estimated cost and the true cost—for all states is zero, i.e., $E[\text{surprise}_i | c_i] = E[c_N] - E[c_i] = 0$, from which follows what we label as the "efficient market" hypothesis—the idea that contemporaries, on average, correctly estimate the costs and risks of war.[4]

[2]While we often refer to the cost of war throughout this paper, this is really a shortcut to refer to all aspects of the conflict that are likely to affect the economy, including other aspects of the conflict such as who wins and under what conditions.

[3]For a systematic treatment, see Lavergne (2004) and Harrison & March (1984).

[4]Similarly, the probability (as opposed to its magnitude) of a disappointment (i.e., $c_N > c_i$) is $F_{c^*, 1-c_i}$, where F is C's joint cumulative distribution function. Simply put, the probability of surprise for any state i is the probability that i receives a signal that sends her to war, and that Nature chooses a value of c greater than c_i. Note that this is a result in expectation. It is saying that the distribution of surprises for initiators will be biased towards positive surprises. However, it remains possible that Nature chooses $c_N < c_i < c^*$, such that the cost will be lower than anticipated.

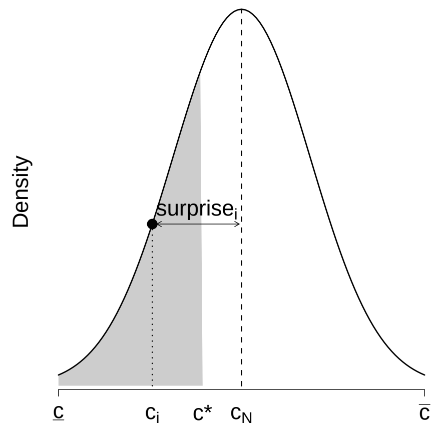


Figure 1. Illustrative distribution of c_i

Hypothesis 1 (Efficient market) *Market participants correctly anticipate the costs of war, given the information available at the onset.*

However, for initiators, the expected surprise is positive, since $E[\text{surprise}_i|c_i < c^*] = E[c_N] - E[c_i|c_i < c^*] > 0$. The magnitude of the disappointment is a function of the distance between c_N and c_i, so that the higher the true costs of war, the higher the surprise. Costless wars will not lead to disappointment, since they are in line or better with expectations, even for initiators.

Hypothesis 2 (Initiators' curse) *Initiators underestimate the cost of large wars.*

Conversely, the cost should be no greater than expected for the target, since $E[c_i] - E[c_i|c_i > c^*] \leq 0$.

Hypothesis 3 (Target's fortune) *Targets underestimate the cost of war.*

Note that over time, and with experience, states may learn this bias, and hence surprise should decrease over time. However, it is unlikely that the same situation will be repeated over and over in a way that states can easily learn. We test this hypothesis but do not expect it to hold.

Hypothesis 4 (Learning) *The magnitude of errors decreases over time*

Estimating beliefs about the cost of war

To know whether contemporaries were overoptimistic about their prospect in a war, we need an estimate of their beliefs about the costs of the coming war. Several measures are possible. Reading newspapers, for example, might give us a sense of the ambient optimism throughout the course of the war (Ramey 2011, Chadefaux 2014), but are unfortunately likely to respond to novelty more than to reflect true underlying concerns or perceptions, and hence do not necessarily reflect optimism or pessimism.

What we need instead is the perception of those who have an incentive to reveal their true estimate of the cost of war. We use here financial markets, and in particular government bond yields, for two main reasons: first because their participants have a stake in correctly estimating the costs and risks of conflict. Through their orders to buy or sell financial assets, market participants reveal their true beliefs about geopolitical risk. And second, markets are excellent information aggregators. We discuss these two arguments in turn.

Government bonds yields reflect information about conflict

Government bonds (or 'sovereign' bonds) are the standard way by which national governments borrow from the market.[5] They are typically issued in exchange for regular interest payments and the promise to repay the principal once the bond reaches its maturity. The price of the bond (and hence its yield) depends on the perceived sovereign risk. A high yield will be demanded when the perceived risk is high, whereas 'safe' countries will be able to borrow at low interest rates. If the yield is too low in relation to the perceived risk, investors will buy other countries' bonds, or alternate financial assets such as equities, commodities (e.g. gold), or even cash. In short, "the free market long-term rates of interest for any industrial nation, properly charted, provide a sort of fever chart of the economic and political health of that nation" (Homer & Sylla 1996).

A simple model of bond pricing illustrates the effect of the onset of war on bond yields. The price at time t of a government bond with periodic interest payment C (coupons), N payments (e.g. 40 payments for a 10-year bond with quarterly payments), market interest rate r_t (typically the central bank's rate), and value at maturity M (typically 100) can be evaluated as the time-discounted stream (S) of income, which equals the sum of coupon payments plus the discounted value of the repayment at maturity. The expectation is conditional on information I available at time t:

$$P_t = E[S|I_t], \tag{1}$$

$$S = \frac{C}{(1+r_t)^1} + \cdots + \frac{C}{(1+r_t)^N} + \frac{M}{(1+r_t)^N} \tag{2}$$

The current yield is then simply the nominal value of the coupon C as a percentage of the current bond price P_t, i.e., $\text{Yield}_t = C/P_t$.[6]

Wars, in turn, generate three main kinds of sovereign risks for investors. First, the government may fail to pay back its debt, for two main reasons: (a) it may incur so much debt to finance the war that it is unable to repay the principal fully once

[5] This section draws heavily on Chadefaux (2017).

[6] Since bonds are priced at all times, and not just once every quarter, we have two indicators of time. Time t is a continuous variable corresponding to calendar time (e.g. 18 May 2017), whereas $n \in N$ refers to discrete (e.g. quarterly) payment events (e.g. Q2 of 2017).

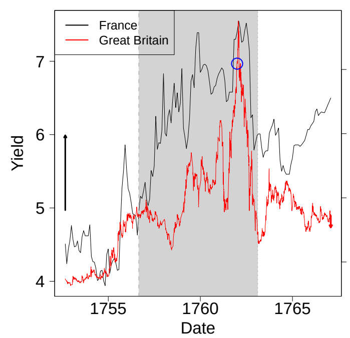
the bond matures; and (b) the economic contraction associated with war reduces fiscal receipts, leading to an unbearable burden of repaying the debt. Either way, the expected value at maturity M decreases or vanishes entirely, thereby driving down the prices of bonds (and hence increasing their yields, as bond prices and yields move in opposite direction). A second, closely related, type of sovereign risk is that periodic interest payments might be reduced or cut entirely (i.e., the number or value of C above may decrease). Finally, even if the government honors the terms of repayment without any 'haircut', a third risk is the inflation in the currency of the bond that is likely to be associated with a costly conflict. In (2) above, the market interest rate i, mostly determined by the central bank and inflation, may increase. This inflation reduces the investor's *real* return, and hence a higher *nominal* yield will be demanded today to compensate for this risk. Note that this last scenario implies that central bank rates may mediate the effect of the onset of war on bond yields—a possibility we explore below.

Together, these risks imply that a bondholder who expects the war to be costly should demand a higher yield today. Investors calculate the expected (and discounted) return from a given bond, and all information available is immediately incorporated into the price (Fama 1991). They trade to reconcile residual differences in their beliefs, and shocks in the yield of bonds therefore signal the emergence of new information that was not expected by market participants. Corrections in bond prices therefore mean that new information is at odds with the market's prior belief. Just as well-anticipated central bank announcements have no effect on asset prices (Poole, Rasche & Thornton 2002), the costs of war should also not be surprising, and hence not cause any unusual variation if correctly anticipated. Abnormal returns, then, imply a surprise at the cost of war.

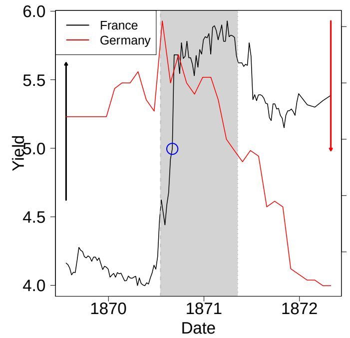
We now illustrate the effect of conflicts' vicissitudes on government bond yields with a few examples. Consider first the evolution of France and Great Britain's yields during the Seven Years War (1756-1763). The war centred around Austria's claim to Silesia against Prussia. France aligned with Austria; Britain with Prussia. The war resulted in the victory of the Anglo-Prussian coalition, and ended France's domination in Europe, to the benefit of Britain.

We first note that France and Britain started with approximately equal yields. Early in the war, France and Austria appeared to be losing, but by 1961 the army of Prussia—Britain's main ally—had shrunk dramatically, and Berlin was under siege. Frederick's ability to remain in power was very much in question. Russia had taken control of Prussia's last port on the Baltic, which greatly facilitated the Russian army's logistics. The balance of power was decisively shifting against Prussia (Stone 2006). This desperate situation is reflected in the dramatic increase in Britain's yields by the end of 1961. Yet a sudden reversal of fortune happened on 5 January 1762, when the Russian Empress Elizabeth died. Whereas she had occupied East Prussia and Pomerania, her successor, Peter III, ended that occupation and mediated a truce between Prussia and Sweden. Immediately, the British bond yields dropped and the war ends soon thereafter. Overall, the defeat left France with an increase in yield of nearly two percentage points, whereas Britain's remained largely unaffected.

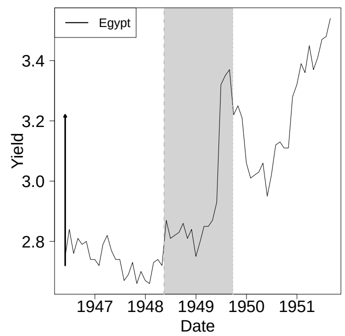
Our second example is the Franco-Prussian war of 1870. The war was a debacle



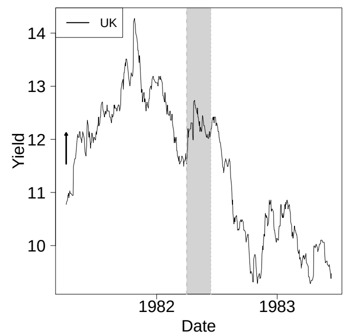
(a) Seven Years War (1756–1763)



(b) Franco-German War (1870–71)



(c) Arab Israeli War (1948–1949)



(d) Falklands War (Apr.–Jun. 1982)

Figure 2. Illustrative government bond yield evolutions. The shaded area delimits the war period. Colored arrows on the left and right depict the change in bond yield ('return') from the beginning to the end of war, for its respective country.

for France, who initiated the conflict but experienced immediate military setbacks, and the humiliating capture of its own Emperor Napoleon III at the battle of Sedan on 2 September, 1870 (circled in fig. 2b). This capture led to a sharp increase in yields, from 4.33% a prior before the capture to 5.68% only a week later (the next available observation)—a dramatic increase for a country whose yield had not crossed the 5% mark at any point over the previous fifteen years. The effect for Germany was the exact opposite: the relatively easy victory boosted the price of its bonds, significantly lowering their yields.

Finally, the Egyptian debacle during the Arab-Israeli War of 1948 led to a sharp increase in its yield, and the effect of the Falklands war on the UK was noticeable but small. Overall, these examples show that yields are highly responsive to political and military shocks.

Efficient Markets

The second major advantage of financial markets as estimators of beliefs is that they incorporate all available information, immediately and, empirical evidence shows, correctly. Competition between market participants is such that prices adjust to fully reflects participants beliefs and information (Malkiel & Fama 1970).[7] This is known as the Efficient Market Hypothesis (EMH).[8] Intuitively, a market is efficient if the equilibrium expected returns—those expected by the market—equal the true expected returns. On the contrary, a market is inefficient if it overlooks or incorrectly uses some of the information available.

One criticism in the context of this study, however, is that while markets may incorporate all public information, they will not be privy to private information. This is problematic if we want to infer what *leaders* believed, since they may reach decisions mainly on the basis of their private information. If so, this study's conclusions would have to be limited to the public's perception and may not apply to decision-makers. Overoptimism from the public need not imply leaders' overoptimism—they may in fact have perfectly estimated the costs of war, but only released optimistic information.

We offer two responses to this argument that private information limits our study's scope. The first is that over- or under-optimism from market participants would still be interesting as a measure of *audiences'* perceptions of the costs and risks of war. While we could not make inferences about leaders' beliefs, we could learn about signaling to domestic audiences and the ability of the public to correctly punish their leaders on the basis of the available information. This is especially relevant for the literature on the fate of leaders (e.g., Bueno de Mesquita & Siverson 1995), since disappointed audiences are more likely to punish leaders for the war. In other words, objective criteria such as the outcome, duration or magnitude of the war are unlikely to be sufficient to explain the reaction of audiences to leaders' choices. Instead, these objective criteria need to be compared to the public's expectations. Disappointment may arise even from a short and successful war if the expected cost was smaller.

Second, it is in fact theoretically and empirically likely that prices do incorporate not only public, but also private information held by leaders. There are two reasons for this. First, some form of collusion between private investors and the government is plausible. Members of the cabinet often leak information to journalists or acquaintances, whether purposefully or not. In fact, the information need not even be public

[7]The EMH relies on three possible theoretical arguments (Shleifer 2000). First, we could assume that all investors are rational at all times, which would automatically imply market efficiency. Second, even irrational investors can support the EMH, as long as that irrationality is not correlated across investors, and hence as long as the errors cancel out. Finally, even if irrationality is correlated, only a few savvy investors are needed to take advantage of this opportunity to arbitrage, thereby bringing prices to their levels expected under the EMH.

[8]From Fama (1976): in an efficient market, $f(Y_t|I_{t-1}) = f^m(Y_t|I^m_{t-1})$, where $Y_t = (y_{1t}, \ldots, y_{nt})$ is the vector of bond yields at time t for countries $1 \ldots n$, I_{t-1} the set of all information available at $t-1$, I^m_{t-1} is the set of information used by the market, $f^m(Y_t|I_{t-1})$ is the density function for Y_t as estimated by the market, and $f(Y_t|I_{t-1})$ is true density function implied by I_{t-1}, as chosen by Nature.

to have an impact on markets. Only a few savvy investors are needed to take advantage of this opportunity to arbitrage. There is strong empirical evidence for this 'strong' form of the EMH—the idea that prices may in fact incorporate not only public, but also private information (e.g., the seminal review by Malkiel & Fama 1970). Second, prices as we observe them incorporate the intervention of a key insider in the bond market: the Central Bank, who may intervene in the bond market on the basis of its private information—whether directly through purchases, or indirectly through interest rates. We consider the role of the central bank in more detail below.

In short, under the efficient market hypothesis, there should be no bias in the market's estimation of the ultimate cost of conflict. Any such bias could be exploited by market participants, and hence should quickly disappear. Put yet another way, no variable(s) at the onset of conflict should be able to predict profitable returns.

Identification Strategy

Market efficiency implies that bond prices fully reflect the market's beliefs about future changes, given all available information today. This includes potentially indirect factors affected by the conflict, such as changes in the central bank's rate or inflation. The market will try to guess the central bank's response to the conflict and build these expectations into the price. Failure to anticipate these changes are still failures to anticipate the costs of conflict. In other words, prices have the advantage of capturing the total effect of the conflict on yields, including indirect effects through central bank rates, inflation, or debts. Using a mediation analysis, we examine below in more details the paths through which conflicts affect yields—direct and indirect effects—but for now our interest is on the total effect of conflict on yields.

We follow the standard literature in financial economics to analyze the return of assets (here bond yields) over a period of time following an event (here the onset of conflict) by calculating cumulative abnormal returns—the difference between the long-run return on the yields of country i and the return of a benchmark yield, which we define below.[9] Thus the cumulative abnormal return for country i and conflict c is:

$$CAR_{ic} = r_{ic} - E[r_{ic}],$$

where $r_{ic} = (Y_{ie} - Y_{io})/Y_{io}$ is country's i yield return from the onset of conflict ($t = o$) to its end ($t = e$), and $E[r_{ic}]$ is the expected return on government yields in the absence of conflict, which is estimated using various techniques such as synthetic

[9] Although there is a large literature on appropriate metrics for these long-run abnormal returns, the Cumulative Abnormal Return (CAR) and the Buy-and-Hold Abnormal Return are standards in the field. CAR is a test of the null hypothesis that the mean weekly abnormal return of yields during the event is zero, whereas our hypothesis here is that the abnormal return over the entire duration of the event is zero. Our approach is instead equivalent to the 'buy-and-hold' abnormal returns (BHAR) approach. For a good review, see Barber & Lyon (1997). To understand intuitively why using the CAR would be inappropriate in this case, consider the following simple example (borrowed from Barber & Lyon (1997)). Suppose that the yield of country i has weekly returns of 0% in the first week, and 44% in the second. Contrast this with reference country j, with returns of 20% and 20%. The CAR in this case would be $\sum_{t=1}^{2}(r_{it} - r_{jt}) = 4$, whereas $BHAR_{ic} = r_{i,[t2-t0]} - r_{j,[t2-t0]} = 0$.

controls, described below.[10] Loosely, we are comparing the return of a treated unit (a country in conflict) to a normal return. Note that this setup can be seen as a special form of Difference-in-Difference estimation, especially since we take great care to ensure that our control countries are as similar as possible to the treated countries (see below on synthetic controls, and in particular fig. 4)—an issue we address now.[11]

Measuring 'abnormal' returns necessitates the comparison to an expected return ($E[r_{ic}]$). This is particularly important for studies with long event windows, since they leave more time for returns to be affected by changes unrelated to the conflict, such as worldwide economic shocks or global technological innovations. Without comparing to an expected return, we would run the risk of erroneously interpreting an increase in yield as a correction resulting from war disappointment, when in reality it would simply have been a reaction to a shock shared with other countries and unrelated to the war.

Ideally, we would like to compare the change in yield of the country at war to the change had the war not happened, but this is obviously not possible.[12] Our strategy is therefore twofold. First, we follow Fama, Fisher, Jensen & Roll (1969) and assume that expected returns are a linear function of the average contemporaneous bond yield in the world, which we denote by $E^m[r_{ic}]$ (or r^m).[13] By including average bond yield prices, we hope to isolate the price path of i's bond yield from the impact of general shocks to the market. A drawback of this approach, however, is that the world average bond yield may not be a particularly good estimate of a specific country's yield. This problem is not particularly important in a model of, say, equity market, where the very large number of observations is likely to cancel out any particular error term. Here, however, we have a more limited number of countries, with potentially important market power. I therefore rely on an additional method to estimate what the yields would have been in the absence of war: the synthetic control method.

The basic idea underlying the synthetic control method is to compare the evolution of yields for country i with a weighted combination of other countries' yields—the 'synthetic' yield (Abadie, Diamond & Hainmueller 2015). Abadie & Gardeazabal (2003) pioneered this technique to estimate the economic costs of conflict, using the Basque country as a case study. The weights are chosen so that the pre-conflict yields approximate as closely as possible those of country i. The procedure used to estimate the synthetic yield is detailed in appendix A, but the basic idea is to split the pre-war time series into a learning and a testing set. The set of countries to populate the synthetic basket are then chosen in a way that minimizes the out-of-sample sum of squared errors in the testing set. These countries are then combined into a unique vector by a linear combination of the weights estimated in the learning set.[14]

For illustration, we display the results of this synthetic control method to the case of the Franco-Prussian war of 1870, discussed above. Figure 3 shows the evolution of government bond yields for France prior to and after the onset of war. The synthetic

[10]In financial economics, (log) returns are typically used instead of prices. The main purpose is to be able to measure all prices (or yields) in the same metric, despite unequal price values. The log is also typical because prices are typically log-normally distributed, so logging them makes the distribution normal.

[11]In contrast, event studies typically estimate normal returns using an aggregate market index.

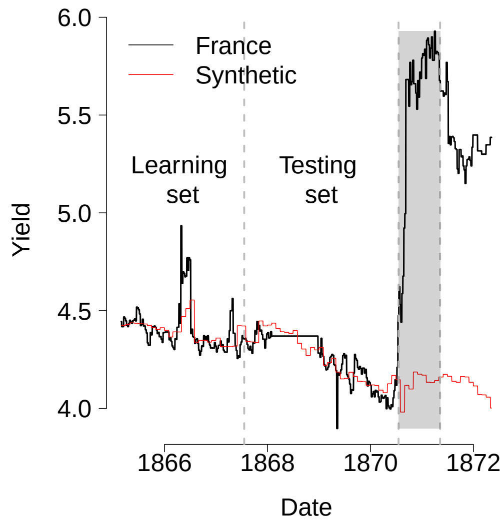


Figure 3. Illustration of the Synthetic Control time series for France prior to the 1870 Franco-German war. The shaded area delimits the war period.

yield, in red, is obtained as:

$$Y_{\text{France}} = 3.92 + 0.06Y_{\text{Italy}} - 0.08Y_{\text{Spain}} + 0.09Y_{\text{Chile}}$$

We note that the synthetic yield—our counterfactual yield path—is very close to France's yield not only in the learning period, but also in the testing period. This lends credibility to the idea that it also approximates France's yields in the absence of war.

This result is not limited to France in 1870. More generally, we can compare the average prediction error of the various control methods by comparing their ability to approximate the time series of interest in times of peace. A close fit in peace time would give us confidence that the prediction in war time is a good counterfactual for what would have happened to country i in the absence of war. We therefore compared the out-of-sample performance of various control methods, including: a naive constant mean return model ($E^{\tau}[r_{it}] = \tau$); using all the other countries' average bond yield (i.e., $E^{m}[r_{it}] = \frac{1}{N}\sum_{j \neq i} r_{jt}$); using a lagged dependent variable ($E^{l}[r_{it}] = r_{it-1}$); and finally using the synthetic control approach described above. For each method and each observation in our data, we calculated the absolute errors (i.e., $= |\hat{y} - y|$), where smaller numbers indicate a better fit to the observed data.[15]

The controls are typically not selected to resemble the treated unit.

[12]On the fundamental problem of causal inference, see Holland, Glymour & Granger (1985).

[13]Fama et al. use the overall market return.

[14]Here we rely exclusively on the pre-war yield path of other countries to form the synthetic control. An alternative would be to also use other variables, such as their inflation rate or central bank rate. However, gaps in the data render this method unfeasible. Moreover, in conflicts for which the data was actually available, we found that we obtained better results using the yield path only.

[15]Similar results are obtained using the mean squared error.

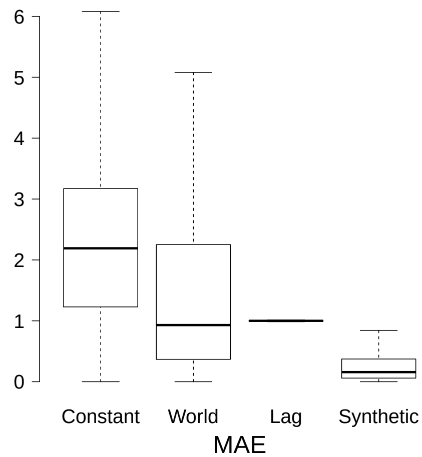


Figure 4. Out-of-sample performance of various control methods. Each boxplot displays the distribution of out-of-sample absolute errors, i.e., $|\hat{y}_i - y_i|$, where $\hat{y}_i$ is estimated using one of the four control methods.

Our results, displayed in figure 4, show that the synthetic control method yields better out-of-sample forecast than any other method considered. Particularly impressive is the fact that it even improves upon a lagged dependent variable model, even though yesterday's value of an asset often tends to be an excellent predictor of today's. This is probably due to the fact that the synthetic control method is able to immediately incorporate information about shocks through their effects on the synthetic basket, whereas the lagged dependent variable is not (or rather, it does so with a lag, causing larger error).

Overall, we estimate three types of models:

$$r_{ic} = \gamma E^m[r_{ic}] + \mathbf{X}_{ic}\boldsymbol{\beta} + u_i + \varepsilon_{ic} \qquad \text{(Country at war)}, \tag{3}$$
$$E^s[r_{ic}] = \gamma E^m[r_{ic}] + \mathbf{X}_{ic}\boldsymbol{\beta} + u_i + \varepsilon_{ic} \qquad \text{(Synthetic)}, \tag{4}$$
$$r_{ic} - E^s[r_{ic}] = \gamma E^m[r_{ic}] + \mathbf{X}_{ic}\boldsymbol{\beta} + u_i + \varepsilon_{ic} \qquad \text{(Difference)}, \tag{5}$$

where r_{ic} is measured as the log of the return on a bond yield from the first observation immediately following the onset of the conflict (o) to the time immediately following its end (e).[16] $E^s[r_{ic}]$ refers to the value of r_{ic} as predicted by the synthetic control, and $E^m[r_{ic}]$ is the value of r_{ic} as predicted by the average contemporaneous bond yield in the world (i.e., $E^m[r_{it}] = \frac{1}{N}\sum_{j \neq i} r_{jt}$). We obtain very similar results with

[16] We use the observation that immediately follows the onset of conflict because we are interested in the market's estimate of the costs and risks of conflict, given that conflict is certain. Using observations prior to its onset would also include the variability associated with the uncertainty about the probability of onset (see Chadefaux 2017). For the same reason, we choose the observation that immediately follows the end of war, so that all the uncertainty about a possible continuation of war is removed.

different specifications, such as using other control methods (the constant or lagged method), or by treating $E^s[r_{ic}]$, the synthetic control, as a variable instead (and hence allowing it a weight different from 1). $\mathbf{X}_{ic}$ is a matrix of covariates and a constant, and $\boldsymbol{\beta}$ its associated vector of coefficients. u_i is a country-specific fixed effect and ε_{ic} an observation-level disturbance.

Results: Are Contemporaries Overoptimistic?

Data on government bond yields from 1816 to 2007 were collected from *Global Financial Data*. The country-level time series are either weekly or monthly depending on the country and period. The 10-year bond was used to the extent it existed, and instruments with shorter maturities were used otherwise.[17] Because many countries never issued them, or only recently started to, data are limited to 45 countries and an average of 3,788 observations by country (see fig. A1 for details). Even though this sample may be biased towards countries with well-established financial systems (typically advanced democracies), it still exhibits significant variation in terms of GDP, polity and historical background.[18]

We analyzed the evolution of these yields for all 1,521 interstate country-conflicts with a starting date between 1816 to 2007. Data on conflict onsets were obtained from the Correlates of War (CoW) and the Militarized Interstate Disputes (MIDs) datasets (Sarkees & Wayman 2010).[19]

Control variables include the the number casualties ('Deaths (log)'); whether the country initiated the conflict ('Initiator'); and the duration of conflict ('Duration (log)'), all from the MIDs data.[20] Polity scores were obtained from the Polity IV data (Marshall, Jaggers & Gurr 2002). The change in central bank rate; in inflation rate (Inflation); and in Government debt levels (Debt) over the course of the war were

[17]This should have little impact on the results, since we are comparing bonds with their previous value. The only drawback is that bonds with shorter maturities may respond differently to distant events, but the direction of the change should not be affected. The inclusion of a dummy variable for bonds with shorter maturities had no significant effect on our results.

[18]One concern could be that a state with a more developed financial market may face higher costs than a country with a less mature financial infrastructure. Indeed, countries with less developed financial markets may be able to finance the war through other means, such as coercion, natural resources, budget surpluses. As a result, the reaction of bond markets may be reduced in those countries. However, this concern is addressed (a) by the variation in our data, which encompasses countries with various levels of development and (b) by controling for the advancement of the financial markets using proxies such as GDP per capita and inflation rates.

[19]As a robustness check, I also conducted the same analysis using the Gibler-Miller-Little (GML) MID dataset—a corrected version of the MIDs data—with nearly identical results (Gibler, Miller & Little 2016). The GML dataset corrects many potential errors in the MIDs data. Of particular interest here are the many corrected start and end dates, as their precise identification is crucial to our ability to draw inferences.

[20]To determine who initiated the war or the MID, Small & Singer (1982) relied on who started combat, i.e., the actor whose army made the first attack on their opponent's armies or territories. The initiator of a MID is the actor who either started combat or displayed force. One limitation of the data is that the initiator may not be the one who provoked the war, but merely the one who attacked first.

calculated from Reinhart & Rogoff (2009); GDP per capita (GDPPC), whether the country is on the Gold standard and the exchange rate type were also gathered from the same source. The outcome of the conflict is coded as either a loss or 'not a loss'.[21] Relative power is also included as the ratio of country i's capabilities to the sum of those of her opponents, where capabilities are measured using the Correlates of War's National Material Capabilities (CINC, from Singer 1987). Summary statistics are reported in table A1

As a first approach to our data, we plotted on Fig. 5 the median return on the yield at the time of onset, as a function of the time since onset.[22] The plot shows that markets overall seem to be fairly good at estimating the costs of war. The grey line thus shows little change from the onset throughout the course of the war. This is in line with our expectations from hypothesis 1. There is, however,

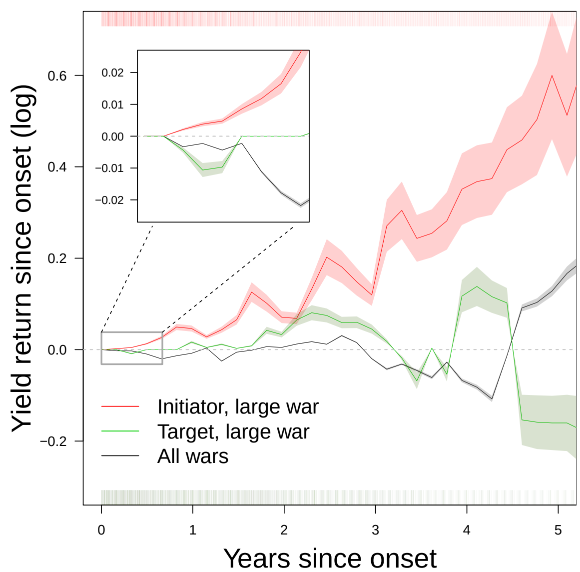


Figure 5. Median yield return ($(y_{it} - y_{iw})/y_{iw}$) since war onset. Rug plots at the bottom (top) represent the density of the corresponding data. Large wars are those with at least 1,000 battle deaths.

a clear difference between the effect of costly wars on initiators and targets. The surprise associated with large wars is substantive for initiators, yet inexistant for targets. This is remarkable, as one might have expected large wars to be surprising for all participants, yet targets seem to anticipate well the costs associated with these conflicts. Furthermore, the surprise increases as the conflict progresses for initiators, yet remains more or less constant for targets. This suggests support for hypotheses 2 and 3, a result that the multivariate analysis will confirm.

[21] Both the MIDs and CoW dataset use a nominal variable with six categories for the outcome. Including a dummy variable for each category, rather than the dichotomized version used here, had no effect on our main results.

[22] I.e., the median of $(y_{it} - y_{io})/y_{io}$.

We now confirm these results more formally by estimating the determinants of each country-conflict's abnormal yield returns. Table I reports the results of fitting equations (3), (4) and (5) by ordinary least squares (OLS).[23] Three main models were evaluated (table I). In the first ('Constant model'), we regressed the returns over the war period on a constant only, excluding any other covariates. In the second ('Total effect model'), we regressed the returns over the war period on a number of covariates, but excluded mediating variables such as central bank rates. In the third ('Indirect Effects Model'), we included these mediating variables. Each model was then evaluated with a different dependent variable, corresponding to equations (3), (4) and (5): the return on yields for the country at war ('at war'); for the synthetic country ('placebo'); and for the difference between the two ('diff.'). The idea is that variables related to war that cause a change in yield returns—a surprise—should affect the country at war, but not the placebo country. The difference between the two, then, is the abnormal return—the difference in returns between the country at war and the placebo (synthetic) country.

With only a constant, the first model ('Constant model') tests hypothesis 1 that, on average, there are no abnormal returns over the duration of the conflict. If the constant is significantly different from zero, then on average conflicts tend to lead to an adjustment in yields. However, we find no support for this argument. Instead, the EMH seems to apply here: on average, markets correctly estimate the costs of war. This applies to the returns of the country at war, the placebo country, and the abnormal returns (difference model).

However, we find strong support for hypothesis 2: when wars are costly, as proxied by the number of casualties, the return on initiators' yield is high (the coefficient on Initiator $\times$ Deaths is positive, significant, and large). This holds true for the country at war but not for the placebo country, as we would expect. The corresponding coefficient for the difference between the country at war and the placebo is also highly significant in both the total effect and the indirect effect models, again reinforcing the finding that large wars are surprising to initiators only. The effect is illustrated in figure 6. Moreover, as expected, the effect of large casualties on targets (initiator = 0) is to actually reduce their yield (the coefficient on Deaths is negative and significant).

The duration and the outcome, however, are not significant. This is not particularly surprising, as a conflict may be lost yet have a low cost; and last long but at a low intensity—and hence with only a limited effect on the economy. Relative power is also insignificant, though in the expected direction: a larger relative power implies lower costs, and hence a lower possible surprise (a war between the US and Nicaragua is unlikely to affect US bonds much, even if expected costs double).

We also find no evidence of an effect of regime type on the magnitude of the surprise. The effect of polity is negative in all specifications, but never significant. This is particularly interesting given the theoretical and empirical support for the idea that

[23]Standard errors are clustered by conflict to account for possible error dependence across observations associated with a given conflict (clustering by country as well has little effect on the results).

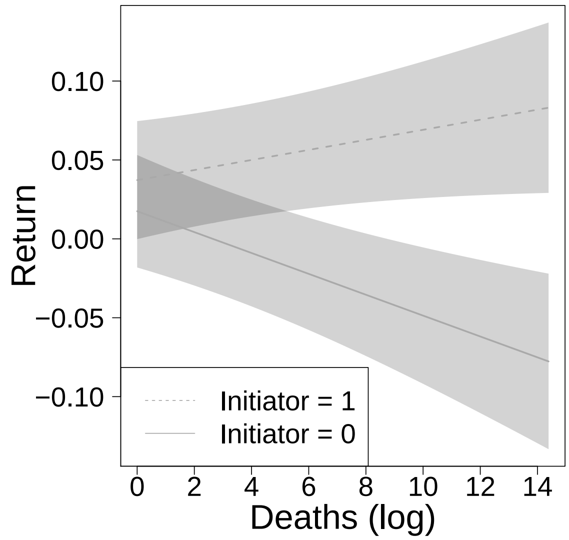


Figure 6. Predicted abnormal return (column (6) in table I) as a function of initiator type and casualties. All other variables held at their median values.

democracies are better at conveying their intentions and resolve. But in fact, democracies are quite capable of being secretive as well. Moreover, democratic initiators are not more likely to win than non-democratic initiators (Rasler & Thompson 2016, p. 155), so it is not surprising that democratic audiences are no less likely to be disappointed than their non-democratic counterparts.

As expected, the data does not support hypothesis 4—the idea that market participants would adjust their estimate over time and correct for past underestimations of war in an initiator. In line with the EMH, traders should exploit any pattern with predictive power, and hence short the bonds of initiators after the onset of war. However, this learning is a lot to expect when conflicts occur in very different countries, at very different times, and under very different circumstances. Under these conditions, this time really does seem to be different. In addition, the rather low number of past observation does not facilitate learning—as opposed to potentially high-frequency trading.

Of the potential mediators (Indirect effects model), only the central bank's rate is significant and highly influential. This is not surprising, as the short-term interest rate (r_t in equation 2) is directly controlled by the central bank, and long rates are risk-adjusted averages of expected future short rates (Diebold, Piazzesi & Rudebusch 2005). However, we note that the inclusion of these mediators has no substantive effect on our main results. This means that even the direct effect of costly wars (as proxied by deaths) has a significant impact on markets' surprise (as opposed to its total effect, direct + indirect effect through changes in the central bank's rate, inflation, etc.).

Conclusion

To our knowledge, this study is the first to systematic attempt to measure beliefs about the costs and outcome of war. Whereas prior work has relied on indirect proxies such as a the existence of secret capabilities, markets let us instead measure beliefs about the likely course of war directly.

In addition, a simple theory—the 'initiator's curse'—predicts that markets should correctly forecast the cost of conflict—a result we confirm empirically, since the size of the surprise—the abnormal return during the war—is not significantly different from zero if we consider all states and all wars. However, we also find that this result hides important differences. In particular, initiators are, on the contrary, likely to be surprised by costly wars. This is all the more striking that targets show no such surprise for equally costly conflicts.

To be clear, however, these results do not mean that initiators make mistakes in initiating the war. In fact, they disproportionately tend not to lose them (they lose only 3% of the wars in our dataset, as opposed to 20% for targets). The results imply that initiators expected the war to be less costly than it ended up being, but they might still have decided to fight knowing what they did by the end of the war.

Overall, our results thus suggest that contemporaries tend to underestimate the costs and risks associated with war. While we cannot satisfyingly answer the question of whether this optimism causes war—we would need to observe not only beliefs in cases where war happens, but also where it did not—we can tell that overoptimism was present in a large number of the wars that did occur. Moreover, the optimism may not be limited to public audiences, but may well extend to leaders. Indeed, markets may proxy not only for perceptions based on publicly available information, but also for leaders' own perceptions and information. If this strong form of the efficient market hypothesis holds, and hence if markets do incorporate private information, then our results are a strong test for the argument that war is caused by optimism.

Table I. Returns and abnormal returns regressions

	Constant model			Total Effect Model			Indirect Effects Model		
	At war (1)	Placebo (2)	Diff. (1)-(2)	At war (4)	Placebo (5)	Diff. (4)-(5)	At war (7)	Placebo (8)	Diff. (7)-(8)
Constant	0.0047	0.0027	0.0014	0.0387	0.0252	0.0132	0.0132	0.0012	0.0118
	(0.0031)	(0.0021)	(0.0024)	(0.0242)	(0.0189)	(0.0117)	(0.0195)	(0.0164)	(0.0091)
r^m (log)				−0.0414	0.1746**	−0.2205	0.1838**	0.2006**	−0.0162
				(0.2195)	(0.0543)	(0.1924)	(0.0610)	(0.0514)	(0.0244)
Initiator				0.0181	0.0198	−0.0015	0.0119	0.0176	−0.0056
				(0.0140)	(0.0118)	(0.0067)	(0.0101)	(0.0095)	(0.0057)
Deaths (log)				−0.0107*	−0.0032	−0.0076**	−0.0077*	−0.0008	−0.0069**
				(0.0045)	(0.0039)	(0.0025)	(0.0037)	(0.0035)	(0.0026)
Initiator × Deaths				0.0139*	0.0041	0.0100**	0.0106*	0.0029	0.0076*
				(0.0058)	(0.0044)	(0.0035)	(0.0047)	(0.0040)	(0.0031)
Duration (log)				0.0048	0.0052	−0.0003	0.0060	0.0058*	0.0002
				(0.0047)	(0.0037)	(0.0019)	(0.0032)	(0.0028)	(0.0016)
Initiator × Duration				−0.0088	−0.0074	−0.0016	−0.0061	−0.0066*	0.0004
				(0.0053)	(0.0041)	(0.0025)	(0.0038)	(0.0033)	(0.0018)
Lost				0.0546	0.0292	0.0248	0.0056	0.0135	−0.0078
				(0.0337)	(0.0255)	(0.0221)	(0.0222)	(0.0238)	(0.0157)
Initiator × Lost				0.0051	−0.0113	0.0172	0.0242	0.0116	0.0125
				(0.0353)	(0.0295)	(0.0216)	(0.0294)	(0.0299)	(0.0198)
Polity				−0.0015	−0.0004	−0.0011	−0.0002	−0.0000	−0.0002
				(0.0013)	(0.0006)	(0.0011)	(0.0006)	(0.0005)	(0.0005)
GDPPC (Thousands)				0.0001	−0.0000	0.0002	0.0005	0.0009	−0.0003
				(0.0023)	(0.0011)	(0.0016)	(0.0017)	(0.0013)	(0.0009)
Relative Power				−0.0060	−0.0079	0.0018	−0.0058	−0.0031	−0.0026
				(0.0135)	(0.0073)	(0.0097)	(0.0089)	(0.0066)	(0.0054)
Date (Century)				−0.0572	−0.0736	0.0130	−0.0611	−0.0776	0.0138
				(0.1350)	(0.0629)	(0.0892)	(0.0870)	(0.0638)	(0.0492)
ΔGDPpc							0.0890	0.0352	0.0539**
							(0.0489)	(0.0379)	(0.0142)
ΔCentral Bank rate							0.2271**	0.1713**	0.0558**
							(0.0297)	(0.0268)	(0.0104)
ΔDebt (perc. GDP)							−0.0170	−0.0286	0.0114
							(0.0415)	(0.0414)	(0.0132)
N	2295	2275	2275	1615	1606	1606	1126	1120	1120
R^2	0.1190	0.1420	0.0167	0.0529	0.1463	0.0853	0.3467	0.3667	0.1384

Significant at $^{*}p < .05$; $^{**}p < .01$.
Robust standard errors clustered by conflict. Country fixed effects included in all models.

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Appendix A Synthetic control method

We detail here the procedure followed to obtain a synthetic yield for each country conflict in our data. Suppose there are J countries other than i or any other country also involved in the war. Let $\mathbf{W}^* = (w_1, \ldots, w_J)$ be a vector of (possibly negative) weights, where w_j^* denotes the weight given to country j to form i's synthetic yield.[24]

To generate a synthetic yield that approximates as closely as possible the yields of country i, we select $\mathbf{W}^*$ in the following way. Let $\mathbf{Y}_k^L = \{Y_k\}_{t-l}^t$ be country k's vector of yields for each period preceding a cutoff date $t < o$, where o is the onset date. In other words, $\mathbf{Y}_k^L$ is the learning set. Similarly, define $\mathbf{Y}_k^T = \{Y_k\}_{t+1}^o$ as the testing set. For each combination K of $(1, \ldots, J)$ countries (there are 2^J such combinations), we first calculate $\mathbf{W}_K$ as

$$\mathbf{W}_K = \operatorname*{argmin}_{\mathbf{W}} (\mathbf{Y}_i^L - \mathbf{W}\mathbf{Y}_{k \in K}^L)^2,$$

where $\mathbf{W} \in R^J$ denotes the set of all possible combinations of weights. We then select $\mathbf{W}^*$ among the set of all $\mathbf{W}_K$ such that

$$\mathbf{W}^* = \operatorname*{argmin}_{W_K} (\mathbf{Y}_i^T - \mathbf{W}_K\mathbf{Y}_{k \in K}^T)^2.$$

Intuitively, we are first fitting the learning data by minimizing the sum of squared residuals for each combination of countries K. In step two, we evaluate on out-of-sample data (the testing set) the performance of a given combination of country and their weights, and select the best-performing combination to form the synthetic control. The synthetic control for country i and conflict c is then simply $\mathbf{W}^*\mathbf{Y}_{k \in K}$.

[24]Technically this is not a synthetic control as proposed by Abadie, Diamond & Hainmueller (2015), which only allows for positive weights. However, we obtained much better out-of-sample fits by extrapolating and allowing negative weights.

Appendix B Additional tables and figures

Table A1. Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Max
r_{ic} (Return for country at war)	2,295	0.004	0.151	−3.680	1.946
r_c^m (World return)	2,295	0.000	0.120	−0.977	1.077
r_{ic}^S (Synthetic control)	2,275	0.002	0.098	−1.330	1.697
Initiator	2,087	0.839	0.368	0	1
Deaths (log 1+)	2,295	1.664	3.013	0	14.389
Duration (log 1+)	2,295	3.455	2.426	0	8.823
Lost	2,087	0.060	0.237	0	1
Polity	2,224	3.843	6.973	−10	10
GDPPC (1,000s)	2,007	7.250	7.046	0.448	31.357
Relative power	1,881	0.604	0.338	0.001	0.999
Δ GDPPC	2,005	0.016	0.120	-0.401	2.678
Δ Central Bank rate	1,765	0.014	0.201	-0.784	2.5
Δ Debt (% GDP)	1,737	0	0.201	-0.784	2.5

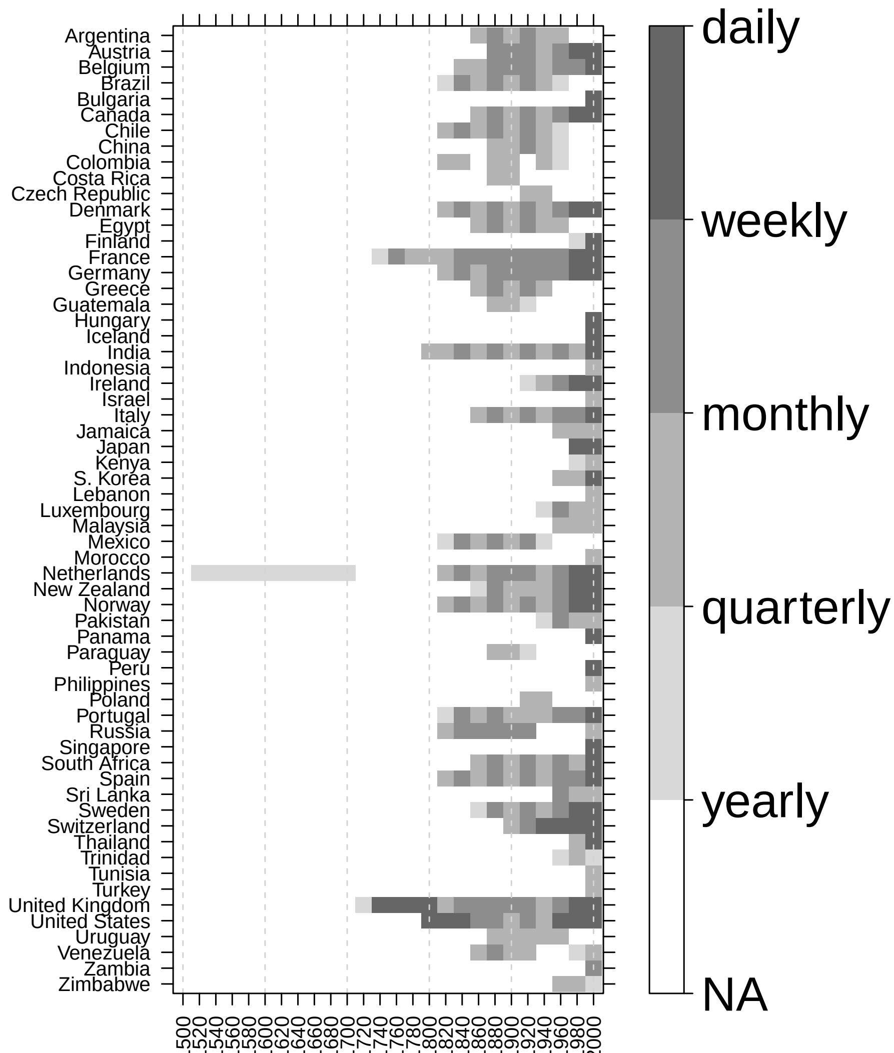

Figure A1. Availability of bond data. Each square displays the number of observations (bond yield) for each country-decade.

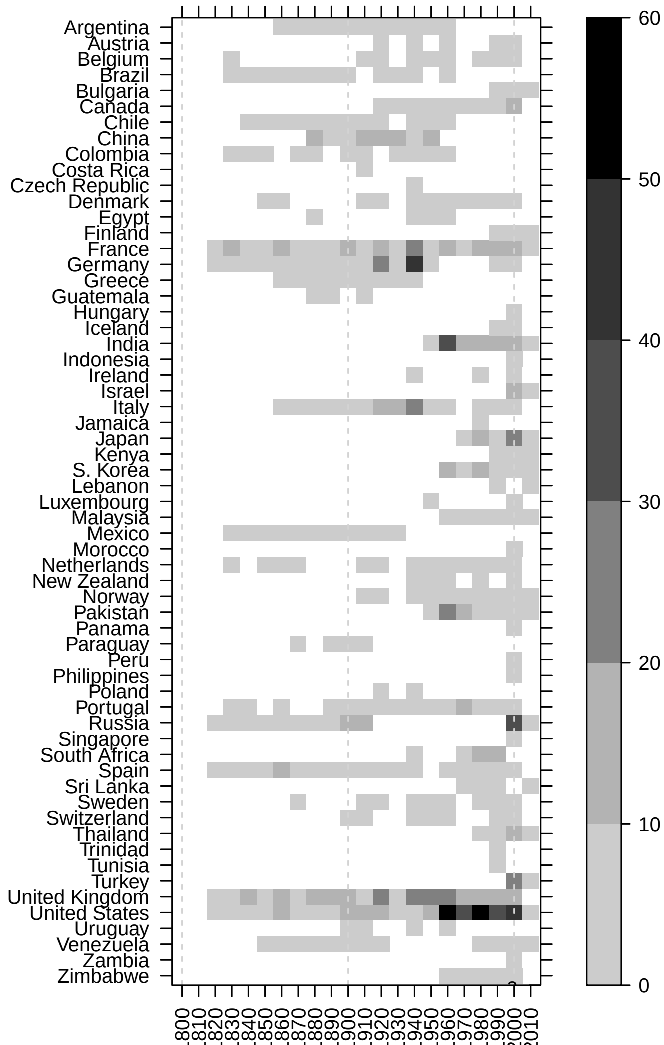

Figure A2. Conflict Onsets. Each square displays the number of conflicts per country-decade.