Collateral Damage: The Economic Impact of War, 1870–1997[*]

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Conventional wisdom in economic history suggests that wars can be enormously disruptive of economic activity, and especially international trade. Yet nothing is known empirically about these effects in large samples. We study all known bilateral trade data and all known wars for all countries since the 1870s. Using the gravity model, we examine the contemporaneous and lagged effects of international conflict on the trade of belligerent nations and neutrals, controlling for other determinants of trade. We find large and persistent impacts of wars on trade, and hence on national and global economic welfare. A rough accounting indicates that such costs might be of the same order of magnitude as the "direct" costs of war, such as lost human capital, as illustrated by case studies of World War I and World War II.

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Trade is a language which prevents people cutting each other's throats.

—Bruce Chatwin[1]

War is hell.

—William Tecumseh Sherman[2]

1. Introduction

What are the true costs of war and how can they be measured? One might consult the records of statesmen, the popular press, or the pages of scholarly books and journals, but the approaches to this question vary as widely as the precision of the answers. However, it is fair to say that most analyses have at least one thing in common: a focus on the *direct* costs as traditionally measured, meaning primarily the loss of life and the resources used to wage war—essentially, men and materiel. To this, occasionally, are added costs of lost and damaged property, although the accuracy of these figures are much more doubtful.

In this paper we examine some major *indirect* costs of war that have never previously been examined, namely the effect of belligerent conflict on the volume of international trade and the implied costs thereof. Using econometric methods we search for and find a very strong impact of war on trade volumes. Moreover this effect has two important aspects: first, it is persistent, meaning that even after conflicts end, trade does not resume its pre-war level for many years, exacerbating the total costs; second, the effect has a multilateral dimension and, unlike direct costs, which largely effect only the belligerents, trade destruction affects neutral parties, a negative externality.[3]

Our paper is part of the renaissance of research activity on the applied economics of international trade. A growing theoretical and empirical literature provides strong support for the relation of bilateral trade flows to measures of joint economic activity and costs of trade (Anderson and van Wincoop 2004). These so-called gravity model relationships have been

[1] In conversation with James Ivory in Niger, 1973.

[2] In a speech to civil war veterans in Columbus, Ohio, 1880.

[3] In related literature, Hess (2003) estimated the impact of war on consumption losses directly using 1960–1992 data. In work independent of ours, Blomberg and Hess (2004) have studied the impact on trade of various forms of violence, including war and terrorism. Their data covers only the 1968–99 period; our data covers a much longer period including the two great wars.

utilized as benchmarks from which to assess the trade impact of economic disturbances and policy regimes, such as exchange rate variability (Thursby and Thursby 1987), preferential trade arrangements (Frankel, Stein, and Wei 1996), and currency unions (Rose 2000).

The relation of aggregate trade to political disturbances and regimes has received much less attention among economists. This area of analysis has generally been considered to lie more in the domain of political scientists. However, in the political science literature the predominant and most numerous studies have looked at a putative reverse causation—the effect of trade (along with other political variables) on the likelihood of conflict among countries. Few papers have addressed the question of the quantitative impact of conflict itself on trade.

On theoretical grounds, wars and other forms of militarized conflict should reduce trade among adversaries. Military conflict between countries is often accompanied by the imposition of partial or total trade embargoes on the exchange of goods. Conflict may also reduce trade flows by raising the costs to private agents of engaging in international business. The empirical evidence from the few available studies is mixed, however. Pollins (1989a, 1989b), van Bergeijk (1994), and Mansfield and Bronson (1997) estimate gravity models and find that conflict lowers trade.[4] In contrast, Morrow et al. (1998, 1999), Mansfield and Pevehouse (2000), and Penubarti and Ward (2000) also utilize gravity models, but find that the effect of conflict, though negative, is not statistically significant.[5] Time series event studies for selected country pairs have also yielded ambiguous results (e.g., Barbieri and Levy 1999; Anderton and Carter 2001).

In addition to failing to provide any uniform conclusion, these studies suffer from several design defects. First, the samples typically are restricted to "politically relevant" cases, defined as country pairs involving one or more major powers and/or geographically contiguous states. The rationale is to exclude country pairs that are especially unlikely or unable to engage in conflict. While this sample restriction limits data collection needs and raises the frequency of conflicts in the data set, it introduces the possibility of bias in the selected sample.

Secondly, these studies do not take account of the possibility that war may have lagged as well as contemporaneous effects on trade.[6] If war resolves outstanding disputes and creates conditions for profitable exchange soon after war's end, trade may resume rapidly. However,

[4] Mansfield (1994) finds an effect of war on trade at the global level: world trade falls the greater the frequency of conflict among major powers.
[5] Comparisons across these studies are hampered by methodological differences as well.
[6] Pollins (1989b) is an exception, but only considers a lag of one year.

depending on the destructive nature of war on production capacity and trading capabilities, it may take a while to exploit these opportunities. In addition, if the threat of additional military actions in the future remains, trade will recover slowly after the cessation of war.[7] Thus, even with the end of war, trade may remain depressed for several years thereafter, due to the costs and inconveniences of postwar reconstruction, diplomatic tensions, explicit price or quantity controls on trade, and other forms of disruption. How quickly and how much trade rebounds is an empirical question that should be of interest to understanding the overall effects of conflict on trade.

Thirdly, most studies use pooled, rather than panel, estimators that may not adequately control for omitted country- or pair-specific attributes, nor effectively distinguish between the effects of conflict on trade *across country pairs* and the effects *over time.* To combat this problem we turn to a gravity model with panel data using country-pair fixed effects (CPFE) estimation, so that identification of the impact of war is conducted entirely in the time dimension with full control for any time-invariant pair characteristics.[8]

In our paper we analyze the effect of war and other forms of militarized conflict on international trade. A data set covering a large number of countries over the period 1870–1997 enables estimation of this effect across time as well as across countries. By comparing the bilateral trade among belligerent and neutral countries during and after conflicts (holding fixed other factors), we estimate the contemporaneous and lagged effects of war on trade. We then use these coefficient estimates in various counterfactual experiments to calculate the aggregate effects of conflict on world trade, particularly the costs of the two world wars of the 20th century.

Finally, we also hazard a rough estimate of the welfare costs of these trade shocks using an income metric. These costs are then compared to traditional direct costs, such as the valuations of the loss of life. The costs appear to have been relatively large.

[7] An exception is when victorious countries choose to help rebuild the economies of the losers after war, as in the case of the Allied treatment of Germany and Japan after World War II.

[8] The reliance on pooled estimation techniques also complicates analyses of the reverse direction of causality between conflict and trade. Consequently, the conflict literature appears better able to answer the question of *which* countries engage in conflict rather than *when* countries engage in conflict, a point to which we shall return.

2. Methodology and Data

Gravity Model Methodology

The effects of war on international trade are estimated using a conventional gravity model of international trade, which is now the benchmark empirical model for this kind of exercise.[9] In this model we specify the average level of trade between any two countries as a function of the log distance between them, the log of the product of their GDPs, and other control variables, as well as the current and lagged effects of countries at war:

$$\begin{aligned}\ln(\text{Trade}_{ijt}) = {} & \beta_0 + \Sigma_k \gamma_k \text{War}_{ij,t-k} \Sigma_k \lambda_k \text{Neutral}_{ij,t-k} + \beta_1 \ln(Y_i Y_j)_t + \beta_2 \ln(Y_i Y_j / \text{Pop}_i \text{Pop}_j)_t \\ & + \beta_3 \ln\text{Dist}_{ij} + \beta_4 \text{Lang}_{ij} + \beta_5 \text{Border}_{ij} + \beta_6 \text{Landl}_{ij} + \beta_7 \text{Island}_{ij} + \beta_8 \ln(\text{Area}_i \text{Area}_j) \\ & + \beta_9 \text{CurCol}_{ijt} + \beta_{10} \text{Colony}_{ij} + \beta_{11} \text{CurU}_{ijt} + \varepsilon_{ijt}\end{aligned}$$

where i and j denotes countries, t denotes time, and the variables are defined as:

Trade_{ijt} , the average value of real bilateral trade between countries i and j at time t;

War is a binary variable which is unity if i and j were engaged in a war against each other (directly or via colonial relationships) in period t–k, k = 0, 1, …M;

Neutral is a binary variable which is unity if either i or j is neutral while the other is engaged in a war against some third country in period t–k, k = 0, 1, …M;

Y is real GDP;

Pop is population;

Dist is the great circle distance between the capital cities of i and j;

Lang is a binary variable which is unity if i and j have a common language;

Border is a binary variable which is unity if i and j share a land border;

Landl is the number of landlocked countries in the country-pair (0, 1, or 2);

Island is the number of island nations in the pair (0, 1, or 2);

Area is the land mass of the country;

CurCol is a binary variable which is unity if i and j are colonies at time t or *vice versa*;

Colony is a binary variable which is unity if i ever colonized j or *vice versa*;

[9] Gravity models have been much discussed in the literature. Frankel (1997) provides a thorough review of the model; Rose (2000) provides references.

CurU is a binary variable which is unity if i and j are engaged in a currency union at time t;

γ_k , λ_k, β_i are coefficients; and

ε_{ij} represents the myriad other influences on bilateral trade, assumed to be well behaved.

The coefficients of main interest to us are γ_k and λ_k. The former describe the impact of war on log trade levels for adversary country pairs; the latter describes the same impact on adversary-neutral country pairs. The contemporaneous effect of war among countries at war with each other is captured by γ_0, while the lagged effects of a war ending k periods previously is captured by γ_k , k =1,…,M, where M is the maximum lag length. λ_0 and λ_k analogously capture the contemporaneous and lagged effects of war on trade between belligerents and neutral countries.[10]

The model is estimated with a number of techniques below. However, we generally rely on the robust fixed effects "within" estimator, which essentially adds a set of country-pair fixed effects (CPFE) or intercepts to the equation and controls for omitted country characteristics that do not vary across time, including any *time-invariant* component of multilateral resistance (Anderson and van Wincoop 2004). Regrettably, serious data limitations, including a severely unbalanced dataset over more than a century, preclude the inclusion of a fully-specified, time-varying multilateral resistance term. We also include historical measures of currency arrangements to examine the effects of a common currency post-1945 and the gold standard pre-1945 (cf. Glick and Rose 2002; Estevadeordal, Frantz, and Taylor 2003).

Long-Run Dataset

The bilateral trade data were assembled from three main sources: (i) the IMF "Direction of Trade", (ii) Barbieri (1996), and (iii) Mitchell (1992, 1993, 1995).

The IMF "Direction of Trade" (DoT) data cover bilateral trade between 217 IMF country-code geographical units between 1948 and 1997 (with many gaps). Bilateral trade on FOB exports and CIF imports is recorded in U.S. dollars; trade is deflated by the U.S. CPI (based to 1985). Since exports and import figures may be available from both countries, there are potentially four measured bilateral trade flows: exports from i to j, exports from j to i, imports into i from j, and imports into j from i. An average value of bilateral trade between a pair of

[10] In the case of multi-year wars, the lags of war are dated from the last year of the conflict We assume that for a war ending at time t, if a new war occurs at time t'>t, the values of the war variable lags of the war at time t are "reset," i.e., for a war occurring at time t, $War_{t-k} = 0$ for $k \geq t-t' \geq 0$.

countries is created by averaging all of the four possible measures potentially available. Observations where all four cells have a zero or missing value are dropped from the sample.[11]

The Barbieri (1996) dataset contains bilateral trade data in current U.S. dollars for some 60 countries during the period 1870–1947.[12] Her data typically measure bilateral trade between countries i and i by summing imports into i from j and into j from i; we divide these figures in half to construct an average value of bilateral trade. The figures are deflated by the U.S. CPI index.

We used data from Mitchell (1992, 1993, 1995) to fill out the sample with missing observations among major trade partners during the period 1870–1947 and to correct obvious errors in Barbieri's data. These data are typically reported in local currency units. We converted them into current U.S. dollar terms using available exchange rate data and then deflated them by the U.S. CPI.

To this dataset, a number of other standard variables are added to estimate a gravity model; these include real GDP, population, and various country-pair characteristics, such contiguity, distance, etc. Population and real GDP data (in constant 1985 dollars) for the 1948–97 period are obtained from three sources. Wherever possible, "World Development Indicators" (taken from the World Bank's WDI 2000 CD-ROM) data are used. When the data are unavailable from the World Bank, missing observations are filled in with comparables from the Penn World Table Mark 5.6, Maddison (1995)[13], and (when all else fails), from the IMF's *International Financial Statistics*. [14] For the 1870–1947 period we draw primarily on data from Maddison (1995; 2001), supplemented by information from Mitchell (various years) and individual country sources. The resulting series are then put into constant 1985 dollars and linked to the 1948–97 series.

The CIA's *World Factbook* is used to provide a number of country-specific variables, including latitude and longitude, land area, landlocked and island status, physically contiguous neighbors, language, colonizers, and dates of independence.[15] These are used to create great-

[11] These data are essentially the same as that used by Glick and Rose (2001).
[12] We use version 1.1. of the Barbieri dataset obtained from the webpage http://pss.la.psu.edu/trd_data.htm. The data actually extend to 1992; we rely on the original source data reported by the DOT for the 1948–1997 period.
[13] Maddison calculates his historical series on GDP and GDP per capita for constant 1990 territorial areas and borders. Whenever possible we make adjustments to GDP to take account of territorial size changes due to wars, etc.
[14] The IFS-based series are calculated by converting national currency GDP figures into dollars at the current dollar exchange rate and then dividing by the U.S. GDP deflator
[15] The website is: http://www.odci.gov/cia/publications/factbook.

circle distance and the other controls. Whenever appropriate, we make changes in land area to reflect territorial changes based on historical sources.

For the 1948–97 period we use the currency union variable constructed by Glick and Rose (2001), defined as country pairs for which money is interchangeable at 1:1 par for an extended period of time.[16] For the pre-1948 period, we set CurU equal to one for counties on the gold standard, allowing for a similar currency effect, following Estevadeordal, Frantz, and Taylor (2003), and using data on gold standard arrangements from Obstfeld and Taylor (2003).[17]

Our measure of war is constructed from the database on militarized interstate disputes (MID) collected by the Correlates of War Project (COW) at the University of Michigan. We use Maoz's dyadic data set DYMID1.1, a revised version of the COW dataset MID2.1 compiled by Jones, Bremer, and Singer (1996).[18] This data set codes the level of hostility reached in a given country's conflict with an opposing state(s), where 2 = "threat of force", 3 = "display of force", 4 = "use of force" (short of war, but including formal declarations of war not accompanied by fatalities), and 5 = "war." We code our war variable as conflicts with hostility level 5 (which generally involve conflicts with more than 1,000 battle deaths), as well as declarations of war (hostility level 4, and HiAct = 20).[19] The data set is extended from 1992 through 1997 with information on "Major Episodes of Political Violence, 1946–1999" from the University of Maryland's Center for Systemic Peace (CSP) and *The Statesman's Yearbook*.[20] Countries at war with a colonial power are treated as being at war with its current colonies, i.e., if country pair i-j are at war, and j-k are in a colonial relationship, then i-k are also assumed to be at war.

[16] Hard fixes at non 1:1 rates (such as those of Hong Kong, Estonia, or Denmark) do not qualify as currency unions under this definition.

[17] On the gold standard and trade see also Flandreau and Maurel (2001) and López-Córdova and Meissner (2003)

[18] The website for the Maoz dataset is http://spirit.tau.ac.il/zeevmaoz.

[19] The COW data set arbitrarily limits the length of conflict at six months for countries that declared war but did not actually fight against their declared adversaries (e.g., various Latin American countries declared war against the Axis powers, but did not actually send troops to the war theaters). We assume that countries declaring war during World Wars I and II were at war until the state of war was formally revoked or the declared adversary was deemed defeated. "HiAct" is short for "highest action in dispute." This is an index representing the type of conflict and supplements the 1–5 hostility level index; the higher the number, generally, the more intense the conflict. See the MID codebook at http://cow2.la.psu.edu.

[20] The CSP webpage is http://members.aol.com/CSPmgm/cspframe.htm. We also cross-checked our conflict coding with the 3.0 version of the COW dataset, which was released after our dataset was assembled; no changes were deemed necessary.

3. Gravity-Based Estimates of the Effect of War on Trade

Benchmark Estimates

We begin by estimating our gravity equation using a country-pair fixed effect (CPFE) panel estimator (with a full set of year-specific intercepts added). The War dummy is allowed to enter contemporaneously and with up to ten yearly lags (denoted War1 to War10). The Neutral variable is initially excluded from the regressor list. Results are presented in Table 1 (the fixed effects for pairs and years are not reported). Since some traditional gravity variables like distance, common border, or number landlocked, are both time-invariant and pair specific, they are collinear with the pair fixed effects and drop out. However, they will reappear in alternative specifications that we employ for robustness checks later on.

The model proves successful on a number of different dimensions. The model fits the data well, explaining almost one-half of the variation in bilateral trade flows. The added control variables are economically and statistically significant with sensible interpretations. For instance, economically larger and richer countries trade more. A common currency encourages trade, as does a common, ongoing colonial relationship.

The key variables of interest in this paper are the γ_k estimates of the "trade destruction" impact of war. The fixed effect "within" estimator measures γ_k by comparing trade for a pair of countries at war to trade for the same pair of countries when not at war. It exploits variation over time and answers the time series question: "What is the effect on trade (now and in the future) of a country being at war?" The coefficients indicate that the contemporaneous and lagged effects on trade are all negative, with significant effects persisting for 8 years or more. The contemporaneous effect is –1.78, implying that trade between two adversaries at war falls by over 80 percent (since $1–e^{-1.78} \approx .83$), relative to its peacetime prewar counterfactual level, a very large reduction. Once the war ends, the extent of trade destruction declines monotonically over time, and trade returns to its "normal" prewar level about a decade later. Trade is still 42% below the prewar level five years after the cessation of war and 21% below even after eight years.[21] These effects are economically large, and generally statistically significant at conventional levels. Dropping the year dummies implies slightly larger effects.

[21] Since $1–e^{-.55} \approx .42$ and $1–e^{-.24} \approx .21$. For lags one to five the coefficients average –.99, implying $1–e^{-.99} \approx .63$, while for lags six to ten they average –.19, implying $1–e^{-.19} \approx .18$.

Robustness Checks: Different Estimators, Subperiods, and Regressors

To provide some sensitivity analysis, the basic methodology is perturbed in a number of different ways. Table 2 reports the robustness of the results to alternative estimators: (i) a random effects panel estimator (which assumes the disturbances are uncorrelated with the random country-pair specific effects); (ii) a maximum-likelihood estimator; (iii) an OLS estimator applied to the pooled data, with standard errors robust to clustering for common country-pair observations; and (iv) an OLS estimator employed with individual country dummies rather than pair dummies. The last specification is now commonplace in gravity modeling, since, rather than using up degrees of freedom with a full set of time-country interactions, it provides a consistent estimate of "average treatment effects" for other controls (like war) even when the multilateral resistance is time varying (Feenstra 2002). Year dummies are included in all cases. The results of Table 2 show that the γ estimates are reasonably insensitive to all of these different estimators. The effects remain: they are consistently large economically, and statistically significant throughout.

We next perturb the model by dividing the sample into two subperiods (1870–1938 and 1939–1997) and also by isolating the effects of World War I and World War II from other wars. The results are reported in Table 3. The results for the full sample from the first column of Table 1 are presented in the first column of Table 3 as a benchmark for comparison. A country-pair fixed effect (CPFE) estimator is employed in all cases. We observe that the effects of wars are negative in both sample subperiods, with the contemporaneous effects slightly higher (in absolute value), but the lagged effects decaying more rapidly, in the 1870–1938 period than in the 1939–1997 period. In the first period, a significantly negative effect of war on trade lasts only four years, compared to nine years in the latter period. Focusing on the effects of the two World Wars alone indicates that their effects on trade are larger than that of other wars. The estimated contemporaneous coefficient for World War I of –3.04 implies a decline in trade of 95%; the corresponding coefficient for World War II of –2.82 implies a similarly high decline in trade of 94%. In the major wars, it would appear that trade between adversaries was almost totally destroyed.

Table 4 augments the results in Table 3 by including the effects of war on trade between belligerents and neutral countries, where these pairs are identified by the dummy variable Neutral. As with the War variable, persistent effects are admitted via ten lags, Neutral1 to Neutral10. The coefficient magnitudes on trade among adversaries are essentially unaffected

relative to prior estimates, but the negative coefficients on the Neutral variables imply that war also depresses trade between belligerents and neutrals. For the full sample, in Table 4, Column 1, trade with neutrals declines by 12 percent in wartime, and the negative effect of war on trade for these pairs persists with a lag for up to seven years with statistical significance. Inclusion of the neutrals does not change the economic and statistical significance of the war effects. Inspection of the subperiod results reported in the other columns of Table 4 reveals the same basic pattern, though the contemporaneous effect of World War I appear to be somewhat smaller (possibly because of greater trade with the United States until its entrance into war in 1917).

These results lead to the first major conclusion of this paper: historically, wars have been very damaging for world trade. As might seem obvious, war depresses trade between belligerents, but we can provide an estimate of this effect and it is very large: a decline in trade of about 80 to 90 percent. Moreover, war creates negative externalities on trade even for neutral countries: their trade with belligerents is also adversely affected, being subject to a decline of about 12 percent. Lastly, both of these effects persist for almost ten years, as shown in Figure 1.

In practice, what has this meant for the impact of wars on the world economy? Small wars involve few belligerents but many neutrals. These are likely to have a large global effect only if the belligerents are large countries. But the major wars in history have had catastrophic impacts on world trade: the belligerents accounted for a large share of world trade—with themselves and with neutrals. To illustrate the potential magnitude of these effects we next look at the two World Wars as case studies using our model.

4. Counterfactuals for World Wars I and II

Clearly war depresses world trade both between adversaries and with neutral countries. By how much did World Wars I and II reduce aggregate world trade? In this section we answer this question through use of our estimated gravity equations.

To construct a counterfactual "normal" benchmark level for trade in the absence of war, we assume that trade for each country pair would have stayed at the same level as in the year zero, which is defined as the year before the outbreak of war (1913 for WWI, 1938 for WWII).[22]

[22] We have tried other approaches to check for the sensitivity of this assumption. For example, we also tried a definition of normal that is based on the trend level of trade between the first year before the war and the 10th year after the cessation of war (i.e., 1928 for WWI, 1955 for WWII). From these endpoints, we can linearly interpolate "normal" bilateral trade levels for the years 1914–1927 and 1939–1954 for all country pairs, and use that as the

That is, we set $\text{Trade}_{ijt}^{\text{normal}} = \text{Trade}_{ij0}$. With these imputed "normal" trade levels in the absence of war, we then employ our gravity model war coefficients—from column 1 in Table 4—to calculate the war-induced year-by-year reduction in trade among adversaries as well as belligerent-neutral country pairs from year to year. We can then aggregate all country pairs and compute the ratio of aggregate world trade in the presence of war to the counterfactual level in the absence of war.[23]

Specifically we calculate the fractional wartime reduction in trade for each pair as:

$$\frac{\text{Trade}_{ijt}^{\text{war}}}{\text{Trade}_{ijt}^{\text{normal}}} - 1 = \frac{\text{Trade}_{ijt}^{\text{war}}}{\text{Trade}_{ij0}} - 1 = e^{\left[\sum_k \gamma_k War_{ij,t-k} + \sum_k \gamma_k Neutral_{ij,t-k}\right]} - 1$$

The impact of war on world trade in each year can then be computed as a weighted sum:

$$\left(\frac{\text{Trade}^{\text{war}}}{\text{Trade}^{\text{normal}}} - 1\right)_t = \frac{\sum_{(i,j)} \left(e^{\left[\sum_k \gamma_k War_{ij,t-k} + \sum_k \gamma_k Neutral_{ij,t-k}\right]} - 1 \right) \left(\text{Trade}_{ij0}\right)}{\sum_{(i,j)} \left(\text{Trade}_{ij0}\right)}$$

Although the decomposition is only approximate, we may use this formula to isolate two separate impacts. First, the reduction in world trade due to lost trade among the belligerents:

$$\left(\frac{\text{Trade}^{\text{war}}}{\text{Trade}^{\text{normal}}} - 1\right)_t = \frac{\sum_{(i,j)} \left(e^{\left[\sum_k \gamma_k War_{ij,t-k}\right]} - 1 \right) \left(\text{Trade}_{ij0}\right)}{\sum_{(i,j)} \left(\text{Trade}_{ij0}\right)}.$$

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counterfactual reference level of trade in the absence of war. This made negligible difference to the subsequent calculations, so we elected to use the constant level of trade as a simple benchmark for illustration.

[23] Note that the gravity model estimates of the effect of war on trade require that we have data for actual trade and the regressor variables for at least some country pairs while at war. However, our counterfactual approach allows us to include the trade effects of war even for pairs for whom some or all such data are missing during these war episodes. All it requires is that actual trade data exist at the beginning of the war episodes, i.e., 1913 and 1938. Moreover, by assuming that the estimated war coefficients can be applied even to pair observations not in the underlying estimation because of missing data, we can infer the effect of war on the trade of these pairs as well.

Second, the reduction in world trade due to the impact of war on belligerent-neutral trade:

$$\left(\frac{\text{Trade}^{\text{war}}}{\text{Trade}^{\text{normal}}}-1\right)_t=\frac{\sum_{(i,j)}\left(e^{\left[\sum_k \gamma_k Neutral_{ij,t-k}\right]}-1\right)\left(\text{Trade}_{ij0}\right)}{\sum_{(i,j)}\left(\text{Trade}_{ij0}\right)}$$

Figures 2 and 3 present the results of this exercise for WWI and WWII, respectively, with the impact on *total world trade* shown. The top panel (a) shows the impact on world trade of the destruction of trade between adversaries. The bottom panel (b) shows the impact on world trade of the destruction of trade between belligerents and neutrals. A ratio less than unity implies that trade in the presence of war is less than the (imputed) trade in the absence of war.[24] Dotted lines indicate 95% confidence bands. The effects are, of course, smaller than those shown in Figure 1 since not every pair consisted of two adversaries (or a belligerent and a neutral).

We observe that:

- In the case WWI, war among adversaries reduced world trade by roughly 12% in 1914-1915 and by almost 15% in 1916–1918; the effects then dampened monotonically. The impact on neutrals reduced world trade by an additional 5–8% in the period 1914–18.
- In the case of WWII, war among adversaries reduced world trade by 15% in 1941 and by almost 20% in 1945. The impact on neutrals accounts for a fall off in trade of an additional 8–9% during 1939–41; this effect then decays as the U.S. and other countries shift from neutral to belligerent status.

On the face of it these effects are potentially very large in terms of implied costs for the world as a whole, and even more so for the countries concerned. Cumulating a 12–15% loss of trade over a 5-year to 7-year wartime period and then allowing only a gradual recovery over the next 10 years, represents a significant and persistent economic burden. But this is somewhat conjectural: lost trade isn't lost output. So we now attempt to measure the latter.

[24] Note that the ratio of trade in the presence of war to counterfactual trade in the absence of war is unity by construction in the years before and after the intervals 1914–1927 and 1939–1954.

5. Tallying the Costs of War

What have we learned from this study? Do our results have any revisionist implications for the historical narratives of modern warfare and its wider cost-benefit implications? Although we find evidence suggestive of large economic losses via lost trade, we cannot easily attach a welfare measure to these losses. And it may be thought that these losses would pale in comparison to the horrific losses of life that are included in the traditional direct costs of war. In the major conflicts, when millions perished, or even in the minor ones, we hesitate to place a pecuniary value on even one lost "statistical" life. Can millions of dollars of lost trade really be compared on a balance sheet with millions of dead and wounded?

Nonetheless, to make any comparison among the different costs of war, such a cold calculus is unfortunately necessary. That said we proceed to draw on the ideas of Goldin and Lewis (1975) who made pioneering comparisons between the cost of waging the American Civil War and the cost of alternative counterfactual schemes for settling the North-South conflict (e.g., buying out the slaves). In the Goldin and Lewis approach to valuing lost human capital, the cost of a life lost in the war was valued at the prevailing average real wage, and the cost of a wounded individual at one half of said wage. Such losses could then be amortized at some discount rate to convert the annual lost wages every year (a flow) to a one-time cost (a stock).

The Costs of World War I

Table 5 presents rough estimates of the costs of World War I on this basis, using the best estimates for dead and wounded and computing a proxy real wage level based on Maddison's internationally comparable estimates of GDP per capita and parameter assumptions for labor's share of output (including human capital) and the share of the population in the workforce. Specifically, we assumed that the share of output earned by labor and human capital was two thirds (cf. Mankiw, Romer, and Weil 1992), and the labor force was one half of total population (the rough 1910 average in the sample of Taylor and Williamson 1997). In this case, the percentage loss of output would be exactly equal to 4/3 (2/3 divided by 1/2) times the percentage dead-equivalent population loss, if we assume all dead are of working age.[25]

[25] To a first approximation, the percentage loss of output would equal the "labor plus human capital" share (2/3) times the percentage loss of workforce, which would in turn be twice the percentage loss of population.

At war's end there were 8.6 million dead, 15.4 million wounded, for a total of 16.3 million dead equivalent lost. The losses were unevenly spread. For the Central Powers, Germany and Austria-Hungary accounted for almost half of these losses, 7 million dead equivalent. Among the Allies, France bore a heavy cost with 2.5 million, with Britain losing 1.5 million and Italy 1 million. However, judged with an eye to the scales of different countries, whether population or GDP, the *relative* costs looked rather different. Tiny and empty New Zealand lost 37 thousand (of 1.1 million) by the dead-equivalent measure; massive and populous India lost 83 thousand (of 304 million).

Applying the Goldin-Lewis metric, we find that the costs, measured as *permanent equivalent* flow losses to GDP, were highest on the losing side. Germany (8.5%) and Austria-Hungary (7.5%). Alternate, disputed death counts would also assign Turkey a large cost (see the notes to the Table). France (8.0%) bore a heavy burden, while the other Allies' costs were somewhat lower: Britain (4.4%) and Italy (3.8%). On a proportional basis, three U.K. dominions also paid heavily: New Zealand (4.4%), Australia (3.7%) and Canada (2.3%). Bulgaria (4.9%), Serbia (4.9%), and Rumania (5.6%) witnessed large human costs on a GDP basis as well. In contrast, India's massive economy barely registered a change, and the United States was also little affected. Summing over all these belligerents we find a total flow cost to GDP of 3.4%. It is important to note that this cost was a burden only for this set of belligerent countries; since they comprised approximately 73% of world GDP, the direct human costs as a fraction of total world GDP amounted to around 2.5% of world GDP.[26] Absent demographic data for the war dead, we treat these flow costs as permanent as a first approximation, since most of the combatants were young soldiers with their whole adult working life stretched out before them, and the discounted value of their flow incomes 30 years or more into the future are of second order importance for this type of calculation.

Now let us try to compare these direct human costs of WWI with the indirect costs arising from trade destruction using the estimates from our model. There is some reason to believe that the trade-related costs of war are substantial. Figures 2a and 2b show the predicted size of "lost trade" during and after the war relative to a counterfactual "no war" scenario where trade levels are assumed to persists at their 1913 benchmark level. In Figure 2a, which shows the decline for just the belligerent-belligerent country pairs, the model suggests that the existence of

[26] Maddison's estimate of World GDP for his sample of 56 countries in 1913 was $2,554,075 (in 1990 US$).

a state of war between these countries caused total world trade to fall by approximately 15% during each of the 4 wartime years relative to the benchmark. In Figure 2b, for belligerent-neutral country pairs, the effect of one country in each pair being at war was to reduce total world trade by a further 6%. In each case, the model suggests that trade then recovered gradually along a trend over each of the next 10 years, before returning to its "normal" peacetime level.

Using the calculations underlying these figures for each country pair and year we can compute the trade decline for any country or set of countries as a result of war and its lagged effects. Still, lost trade is *not* lost income (nor lost welfare). So these loss figures are not comparable to the direct war cost measures. Can we convert lost trade into a lost output equivalent?

One way to impute the implied loss of income is by using the Frankel and Romer (1999) estimates of the partial derivative of income (or growth) with respect to trade. In our notation, their basic cross-country regression model took the form:

$$\ln\left(\frac{\mathrm{Y}}{\mathrm{N}}\right)_i = \alpha + 2\delta\left(\frac{\hat{\mathrm{Trade}}}{\mathrm{Y}}\right)_i + \theta \mathrm{X}_i + \eta_i,$$

where X is a vector of other control variables and $\hat{\mathrm{Trade}}/\mathrm{Y}$ is the exogenous component of the country's trade share, which is constructed from an underlying first-stage gravity model using distance as an exogenous variable.[27] This two-stage or instrumental variable (IV) approach allows the authors to control for the endogeneity of trade in these regressions, and without this step the OLS estimates of the coefficients are biased. The coefficient of interest to us is δ, the slope of the output-trade or growth-trade relationship. Frankel and Romer (1999, Table 3) give an IV estimate of $\delta = 1.97$ for the trade share.

The Frankel-Romer specification is ideally suited for our purposes since, at least with respect to the economic variables modeled here, we may reasonably treat war as exogenous. Though the distance between a pair of countries never changes, the state of belligerency may fluctuate. Thus, δ is the correct parameter to use in our study to capture the impact of exogenous

[27] In our notation Trade is defined as the average of exports and imports. For Frankel and Romer, it is the sum. For this reason, using our definition, a factor of 2 must be added to the trade share coefficient.

declines in openness, or trade share, such as would be caused by wars. We should note that this formulation of the counterfactual impact deliberately *holds fixed* output levels in every country, thus finessing the question as to whether any given war creates a boost or a drag on the domestic economy of the belligerent, an effect that would also show up in the gravity equation but which we do not seek to estimate. Our interest in the trade channel allows us to finesse the issue, which is just as well given the scarce data on real output during wars. This is not to say such effects are negligible, and these endogenous GDP shocks are the subject of considerable controversy in a parallel literature; recent research suggests they might also be quite large (Hess 2003).

One possible concern is whether we may safely apply the Frankel and Romer (1999) postwar estimates to our WWI and WWII counterfactuals. In a study of the entire twentieth century, Irwin and Terviö (2002) also find statistically significant 2SLS (IV) estimates of the coefficient that exceed the OLS estimate, on multiple cross sections, including for 1913, the start date of our counterfactual. Unfortunately, due to the units used in their study, their coefficients are not comparable in the different cross sections they studied.

Suppose a given war episode that we wish to study starts in period $t = 1$ (for example, in 1914). Let the set of countries be C. We try to assess the permanent income loss due to war and its aftermath relative to an assumed counterfactual constant baseline level of trade corresponding to the actual trade observed in period t=0 (for example, 1913). We can estimate the fractional loss of income in country i at time t using a linear approximation implied by the Frankel-Romer estimated equation:

$$\left(\frac{\Delta Y_{it}}{Y_{i0}}\right) = \sum_j 2\delta\left(\frac{\Delta \text{Trade}_{ijt}}{Y_{i0}}\right) = \sum_j 2\delta\left(\frac{\text{Trade}_{ijt}^{\text{war}} - \text{Trade}_{ij0}}{\text{Trade}_{ij0}}\right)\left(\frac{\text{Trade}_{ij0}}{Y_{i0}}\right).$$

Here, as we defined it above, $\text{Trade}_{ijt}^{\text{war}}$ is the estimated trade for the pair at time t under wartime conditions, assuming the "normal" peacetime level would have been Trade_{ij0} in all years. As we have discussed, the simulation also keeps GDP levels (Y) at their peacetime constant level to isolate the trade-destruction channel. Hence, drawing on our previous calculations, the implied GDP loss in country i at time t is:

$$\left(\frac{\Delta \mathrm{Y}_{it}}{\mathrm{Y}_{i0}}\right)=\sum_{j} 2\delta\left(e^{\left[\sum_{k}\gamma_{k} War_{ij,t-k}+\sum_{k}\gamma_{k} Neutral_{ij,t-k}\right]}-1\right)\left(\frac{\mathrm{Trade}_{ij0}}{\mathrm{Y}_{i0}}\right)$$

We next sum these losses over all pairs (i,j) in a (possibly time-varying) subset of country pairs $V_t = C_{1t} \times C_{2t} \subseteq C \times C$ and calculate their present flow-equivalent value using a discount factor $\beta = 0.95$, such that the flow cost in GDP terms is:

$$\left(\frac{\Delta \mathrm{Y}}{\mathrm{Y}}\right)_{\{V_t\}}=\sum_{t}\sum_{(i,j)\in V_t} 2\delta\beta^{t}(1-\beta)\left(e^{\left[\sum_{k}\gamma_{k} War_{ij,t-k}+\sum_{k}\gamma_{k} Neutral_{ij,t-k}\right]}-1\right)\left(\frac{\mathrm{Trade}_{ij0}}{\mathrm{Y}_{i0}}\right) \qquad (*)$$

Let B_t be the set of belligerents in the war in year *t*, and let N_t be the set of neutrals, that is, the remaining countries. We note that: countries may be belligerent at different times in any given war; by construction, neutral-neutral pairs experience no trade related losses; and only opposing belligerents suffer trade loss, whereas allies do not, due to the definition of the *War* dummy.

We implement the cost calculation for various definitions of $\{V_t\}$ as follows.

- We calculate losses to belligerents on trade with belligerents by setting $V_t = B_t \times B_t$;
- We calculate losses to belligerents on trade with neutrals by setting $V_t = B_t \times N_t$;
- We calculate losses to neutrals on trade with belligerents by setting $V_t = N_t \times B_t$.
- We calculate losses to on all trade by setting $V_t = C \times C$.

Table 6 reports the results of this exercise. Looking at the weighting data, we see that in WWI the belligerent nations accounted for about half of world population, three-quarters of world GDP, and 80% of world trade (counting trade both between belligerents and between belligerent and neutral countries). According to our estimation method, both belligerents *and* neutrals suffered large economic impacts. Lost trade was largest for trade among belligerents, as expected, leading to a permanent flow loss of 2.28% of GDP. The decline in trade involving neutrals caused a further income loss of 0.46%, for a total flow loss of 2.74% of GDP. Neutrals only suffered due to the collapse of trade with belligerents, but this was a large share of their own trade, explaining the large flow cost for them of 2.09% of GDP. On first sight it may seem odd that the small impacts on neutrals seen in Figure 1 can generate such relatively large losses for neutrals (2.09%) compared to belligerents (2.74%), but this follows from two facts. First, not

every pair of belligerents was an adversarial pair. Second, many belligerents were big countries whilst most neutrals were small countries, and (in peacetime) had a large fraction of their trade with belligerents, as the gravity model would predict. The *same* absolute (real) bilateral trade loss shared by any two trading partners must weigh more heavily on the *smaller* country in the pair, since it will dent that country's trade to GDP ratio much more, and hence have a bigger proportional impact on output via the Frankel-Romer specification.[28]

Compared to the human costs, also shown in Table 6, these economic costs were large. As a group, belligerents imposed a human cost on each other equal to 1.90% of lost population, or 3.41% of lost GDP (the GDP impact is larger due to composition effects: among belligerents, it was the richer countries that had higher casualties in WWI). Moreover, there were no global negative externalities in that human costs were essentially zero for neutrals. The total cost to the world as a whole, arising from the belligerents' casualties, was a flow cost of 2.43% of GDP—just smaller than the 2.55% attributed to lost trade. Under these assumptions and metrics, the striking conclusion is that the costs of lost trade due to WWI were just about as large as the awful costs of lost human capital.

The Costs of World War II

We should not expect the same conclusion here. The next world conflict was a very different beast. World War I and previous wars were relatively low technology, confined to battle zones or even battlefields, with little attention given to civilians as targets. World War II was the first high-technology "total war" on a global scale, involving much larger losses of life, greater suffering among civilians, and much more widespread and devastating losses of economic assets (physical capital). Compared to the first war, the second was a third longer in duration, encompassed about twice as many belligerent countries, touched 4 continents instead of 1, and mobilized 110 versus 70 million into the armed services (Nesterov 1990). We should therefore expect all of its attendant direct costs to have been that much higher.

Conversely, could damage to world trade really impose much of a cost after 1938? After all, there wasn't much trade left to damage. Following World War I and the Great Depression, economic isolationism was rampant. By the late 1930s tariffs and quotas had become widespread. In addition, transport costs had risen significantly in the 1920s and 1930s, and the

[28] We assume no change in trade levels among allies and among neutrals.

disintegration of the gold standard had also had a significant impact on trade volumes. Compared to the low barriers and low costs of trade in 1913, the world of 1938 was much closer to autarky. Relative to world GDP, trade volumes were about one half what they had been in 1913, and close to their 1870 levels (Estevadeordal, Frantz, and Taylor 2003).

These concerns notwithstanding, we press ahead and repeat the exercises of Figure 1, Table 5, and Table 6 for World War II. The results are shown in Figure 3 and in Tables 7 and 8. Figure 3 is qualitatively very similar to Figure 2, although the trade losses mount up a little more slowly in 1939–41 for adversaries, as the belligerency slowly spreads. The trough is a little deeper in world War II, however, with almost 20% of world trade destroyed by the adversaries.

Table 7 now includes estimates of civilian casualties in the baseline figures, since this war killed and injured so many noncombatants. We must interpret these figures cautiously, as the labor content of civilian casualties was probably less than that of military casualties, so our methodology will exaggerate the value of civilian losses Given the margins of error on the casualty data, however, this need not cause undue anxiety. The total dead equivalent amounted to 79.5 million by our measure, where some missing data were imputed using the plausible assumption of a stable wounded/dead ratio (Appendix Table A1 supplies the details). Without imputation the figure falls to 46.2 million (penultimate row, table 7), and military casualties amount to about half the total, 34.7 million (final row).

The major losses, on a population or GDP basis, are not surprising. The U.S.S.R with 31.5 million dead equivalent tops the list with a 24.8% GDP flow loss, closely followed by Yugoslavia (22.6%) and Poland (23.5%). Germany also suffered large losses in the European theater (16.7%), as did Hungary (10.5%). Japan lost about 8% and its adversary China 5% (but populous China suffered an absolute loss of 19.7 million dead equivalent to Japan's 4.4 million). Occupied France lost 3.3%, Belgium 2.4%, Netherlands 5.5%, but Denmark 0.2% and Norway 0.8%. Britain's loss was 1.7%, less than New Zealand on a proportional basis. USA lost 0.7% by this measure. The loss for all belligerents, as a group, was 6.6% of GDP using the full (imputed) dataset, 4.9% without imputed data, and 3.6% for military casualties only. The latter figure may be compared with the 3.4% figure for World War I from Table 5, suggesting that it was the spread of total war off the battlefield and into civilian life that seriously escalated the level of damage to human capital in the second war.

Table 8 compares human costs to trade costs for World War II. Comparing the human loss to total world GDP, not just belligerents' GDP, leaves a bottom line figure of 5.43% as a global human capital loss on a permanent flow basis. If we think the civilian component is overstated (due to its smaller labor share), the true figure might be between 4% and 5%. The trade costs appear at the foot of the table and are much smaller, as expected. Adversaries cost each other 1.27% of GDP and also paid a further 0.36% due to trade lost with neutrals, for a total loss to the belligerents of 1.64%. The neutrals themselves suffered a loss in trade that we value at 1.10% of their own GDP on a flow basis. Globally, summing these figures, we arrive at a bottom line figure of 1.54% of GDP for the permanent flow costs of World War II.

These results, as compared with those for World War I, make sense. On a human level, World War II was about twice as costly (5.43% in Table 8 versus 2.43% in Table 6) simply because it was bigger, longer and deadlier. With respect to the costs of trade destruction, World War II was only just over half as costly (1.54% in Table 8 versus 2.55% in Table 6) since, although more nations were caught up in the war, overall world trade (relative to GDP) had shrunk to about half its 1913 level by 1938.

6. Conclusion

Our work estimates the economic costs of war arising from the destruction of trade. Econometric analysis suggests that these costs are quantitatively large, statistically significant, and highly persistent. Case studies of the two world wars also demonstrate that these costs can be large (or at least of the same order of magnitude) when compared to more traditional measures of war's costs, such as loss of life.

War is hell: belligerents were aghast at the human toll they suffered as a result of their war, but, on narrow economic grounds, the losses due to trade were of a comparable order of magnitude. Wars kill trade too. Moreover, the negative externalities were huge. The belligerents wrecked the world economy not just for themselves but also for everyone else.

Our study also informs the ongoing debate over whether the costs of war imposed on the belligerents themselves are enough to dissuade them from going to war in the first place. The reluctance of groups of people to sacrifice the gains the from trade could support cooperation and peace among them, an idea so pithily summarized in the epigraph from Bruce Chatwin and

dating back at least to the fourth century writer Libanius.[29] The hypothesis was formally developed by Immanuel Kant and Richard Cobden whose arguments have inspired a modern literature in political science. Some studies reverse our regression model by studying wars as a function of bilateral trade. However, such models generally do very poorly at capturing when particular countries engage in war, although they do pick up some "between" correlation reflecting which countries "on average" engage in war. Hence, we interpret these results as saying that time-series endogeneity is weak, implying it is more fruitful to focus on how large the trade costs of war actually are, as we do, so as to see if they might in fact plausibly offer the supposed disincentive.

Given the large trade costs of war that we find, it might seem reasonable to hope that they would dissuade rational policymakers from armed conflict. But the world wars offer a disturbing counterpoint to this vision and their legacy suggests a different perspective. The large negative trade externalities imposed on neutrals by wars might encourage peaceful countries to try to set limits to the belligerent tendencies of others. Thus the great wars left us multilateral institutions (the League of Nations, the United Nations) in order to save the many from the large negative spillovers generated by the few—as well as to save the belligerents from themselves.

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[29] "God did not bestow all products upon all parts of the earth, but distributed His gifts over different regions, to the end that men might cultivate a social relationship because one would have need of the help of another. And so He called commerce into being, that all men might be able to have common enjoyment of the fruits of the earth, no matter where produced." Libanius, *Orations* (III).

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Table 1: Pooled Panel Gravity Estimates, 1870–1997

	Country Pair Fixed Effects		Country Pair Fixed Effects	
War	-1.78	***	-2.06	***
	(0.09)		(0.09)	
War1	-1.28	***	-1.49	***
	(0.16)		(0.16)	
War2	-1.32	***	-1.45	***
	(0.15)		(0.14)	
War3	-1.12	***	-1.10	***
	(0.13)		(0.13)	
War4	-0.70	***	-0.65	***
	(0.12)		(0.12)	
War5	-0.55	***	-0.50	***
	(0.10)		(0.10)	
War6	-0.37	***	-0.22	**
	(0.09)		(0.09)	
War7	-0.22	***	-0.09	
	(0.08)		(0.08)	
War8	-0.24	***	-0.15	*
	(0.08)		(0.08)	
War9	-0.11		-0.05	
	(0.08)		(0.08)	
War10	-0.03		0.03	
	(0.07)		(0.07)	
Log Distance	—†		—†	
Log Product Real GDPs	0.36	***	0.05	***
	(0.01)		(0.01)	
Log Product Real GDP/capita	0.64	***	0.81	***
	(0.01)		(0.01)	
Common Language	—†		—†	
Common Land Border	—†		—†	
Number Landlocked	—†		—†	
Number Islands	—†		—†	
Log Product Land Areas	0.23	***	0.24	***
	(0.03)		(0.03)	
Current Colony	0.62	***	0.70	***
	(0.07)		(0.07)	
Ever Colony	0.07		0.13	
	(0.15)		(0.16)	
Currency Union	0.21	***	0.28	***
	(0.03)		(0.02)	
R-squared	0.46		0.32	
Year Dummies	Yes		No	
Pair Dummies	Yes		Yes	
Country Dummies	No		No	
Avg. Effect, War -War5	*-1.12*		*-1.21*	

† variable dropped due to collinearity with country pair fixed effects.
Year dummies and constant not reported.
Standard errors in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 2: Pooled Panel Gravity Estimates, 1870–1997: Alternative estimators

	Random Effects		Maximum-Likelihood		OLS, robust, cluster		OLS, robust	
War	-1.79	***	-1.79	***	-1.96	***	-2.06	***
	(0.09)		(0.09)		(0.27)		(0.17)	
War1	-1.25	***	-1.25	***	-1.48	***	-1.60	***
	(0.16)		(0.16)		(0.28)		(0.29)	
War2	-1.27	***	-1.28	***	-1.32	***	-1.53	***
	(0.15)		(0.15)		(0.25)		(0.24)	
War3	-1.09	***	-1.09	***	-0.93	***	-1.26	***
	(0.13)		(0.13)		(0.17)		(0.17)	
War4	-0.68	***	-0.68	***	-0.58	***	-0.81	***
	(0.12)		(0.12)		(0.17)		(0.16)	
War5	-0.51	***	-0.52	***	-0.13		-0.48	***
	(0.10)		(0.10)		(0.13)		(0.11)	
War6	-0.34	***	-0.34	***	-0.13		-0.38	***
	(0.09)		(0.09)		(0.11)		(0.09)	
War7	-0.20	**	-0.21	**	-0.08		-0.25	***
	(0.08)		(0.08)		(0.09)		(0.08)	
War8	-0.22	***	-0.22	***	-0.04		-0.24	***
	(0.08)		(0.08)		(0.09)		(0.08)	
War9	-0.10		-0.10		0.03		-0.14	*
	(0.08)		(0.08)		(0.09)		(0.08)	
War10	-0.02		-0.02		0.14	*	-0.05	
	(0.07)		(0.07)		(0.08)		(0.07)	
Log Distance	-1.38	***	-1.38	***	-1.02	***	-1.20	***
	(0.03)		(0.03)		(0.02)		(0.01)	
Log Product Real GDPs	0.72	***	0.71	***	0.87	***	-0.19	***
	(0.01)		(0.01)		(0.01)		(0.01)	
Log Product Real GDP/capita	0.43	***	0.43	***	0.45	***	1.09	***
	(0.01)		(0.01)		(0.02)		(0.02)	
Common Language	0.38	***	0.38	***	0.44	***	0.43	***
	(0.05)		(0.05)		(0.04)		(0.01)	
Common Land Border	0.49	***	0.50	***	0.31	***	0.12	***
	(0.15)		(0.15)		(0.11)		(0.02)	
Number Landlocked	-0.36	***	-0.37	***	-0.12	***	-0.42	
	(0.04)		(0.04)		(0.04)		(595.77)	
Number Islands	0.07		0.07		0.02		-1.28	
	(0.05)		(0.05)		(0.04)		(731.46)	
Log Product Land Areas	0.02	***	0.03	***	-0.09	***	0.13	***
	0.01		(0.01)		(0.01)		(0.03)	
Current Colony	0.58	***	0.58	***	0.98	***	1.04	***
	(0.07)		(0.07)		(0.25)		(0.05)	
Ever Colony	0.97	***	0.92	***	1.24	***	1.13	***
	(0.12)		(0.12)		(0.13)		(0.02)	
Currency Union	0.16	***	0.16	***	1.00	***	0.91	***
	(0.03)		(0.03)		(0.10)		(0.03)	
R-squared	0.62		N.A.		0.64		0.70	
Year Dummies	Yes		Yes		Yes		Yes	
Pair Dummies	Yes		Yes		No		No	
Country Dummies	No		No		No		Yes	
Avg.Effect, War-War5	*-1.10*		*-1.10*		*-1.07*		*-1.29*	

Year dummies and constant not reported. Standard errors in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 3: Trade Effects of War: Subperiods, 1870–1938 and 1939–1997

	1870-1997	1870-1938	1939-1997	1870-1938 World War I only	1939-1997 World War II only
War	-1.78 ***	-2.09 ***	-1.83 ***	-3.02 ***	-2.74 ***
	(0.09)	(0.10)	(0.11)	(0.12)	(0.17)
War1	-1.28 ***	-1.39 ***	-1.32 ***	-2.14 ***	-1.14 ***
	(0.16)	(0.19)	(0.18)	(0.24)	(0.29)
War2	-1.32 ***	-0.88 ***	-1.55 ***	-1.32 ***	-1.88 ***
	(0.15)	(0.16)	(0.17)	(0.19)	(0.26)
War3	-1.12 ***	-0.46 ***	-1.28 ***	-0.66 ***	-1.32 ***
	(0.13)	(0.17)	(0.15)	(0.19)	(0.19)
War4	-0.70 ***	-0.34 **	-0.76 ***	-0.67 ***	-0.98 ***
	(0.12)	(0.15)	(0.13)	(0.18)	(0.18)
War5	-0.55 ***	-0.10	-0.63 ***	-0.20	-0.62 ***
	(0.10)	(0.13)	(0.11)	(0.16)	(0.13)
War6	-0.37 ***	-0.06	-0.42 ***	-0.15	-0.39 ***
	(0.09)	(0.12)	(0.10)	(0.14)	(0.11)
War7	-0.22 ***	0.02	-0.25 ***	-0.01	-0.23 **
	(0.08)	(0.12)	(0.09)	(0.13)	(0.10)
War8	-0.24 ***	0.04	-0.28 ***	0.01	-0.27 ***
	(0.08)	(0.11)	(0.09)	(0.13)	(0.10)
War9	-0.11	0.13	-0.16 *	0.06	-0.21 **
	(0.08)	(0.11)	(0.09)	(0.12)	(0.10)
War10	-0.03	0.11	-0.07	0.04	-0.08
	(0.07)	(0.10)	(0.08)	(0.11)	(0.10)
R-squared	0.46	0.31	0.17	0.31	0.15
Avg. Effect, War-War5	*-1.12*	*-0.88*	*-1.23*	*-1.34*	*-1.45*

Country pair fixed effect estimates. Controls not reported: distance, GDP, GDP per capita, language, land border, landlocked, islands, land area, current colony, ever colony, currency union, year dummies, and constant.
Standard errors in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 4: Trade Effects of War: Effect on Neutrals Included

	1870-1997		1870-1938		1939-1997		1870-1938 World War I only		1939-1997 World War II only	
War	-1.87	***	-2.12	***	-1.92	***	-3.04	***	-2.82	***
	(0.09)		(0.10)		(0.11)		(0.12)		(0.17)	
War1	-1.32	***	-1.41	***	-1.36	***	-2.15	***	-1.16	***
	(0.16)		(0.19)		(0.18)		(0.24)		(0.29)	
War2	-1.35	***	-0.86	***	-1.58	***	-1.30	***	-1.89	***
	(0.15)		(0.16)		(0.17)		(0.19)		(0.26)	
War3	-1.15	***	-0.47	***	-1.31	***	-0.65	***	-1.34	***
	(0.13)		(0.17)		(0.15)		(0.19)		(0.19)	
War4	-0.74	***	-0.38	**	-0.80	***	-0.71	***	-1.01	***
	(0.12)		(0.15)		(0.13)		(0.18)		(0.18)	
War5	-0.57	***	-0.11		-0.65	***	-0.21		-0.64	***
	(0.10)		(0.13)		(0.11)		(0.16)		(0.13)	
War6	-0.39	***	-0.09		-0.44	***	-0.19		-0.39	***
	(0.09)		(0.12)		(0.10)		(0.14)		(0.11)	
War7	-0.24	***	0.00		-0.26	***	-0.04		-0.24	**
	(0.08)		(0.12)		(0.09)		(0.13)		(0.10)	
War8	-0.24	***	0.02		-0.28	***	-0.02		-0.27	***
	(0.08)		(0.11)		(0.09)		(0.14)		(0.10)	
War9	-0.11		0.10		-0.15	*	0.02		-0.21	**
	(0.08)		(0.11)		(0.09)		(0.12)		(0.10)	
War10	-0.03		0.12		-0.07		0.04		-0.08	
	(0.07)		(0.10)		(0.08)		(0.11)		(0.10)	
Neutral	-0.13	***	-0.04		-0.12	***	-0.04		-0.12	***
	(0.01)		(0.03)		(0.01)		(0.03)		(0.01)	
Neutral1	-0.07	***	-0.02		-0.07	***	-0.02		-0.06	***
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral2	-0.04	**	0.07	*	-0.04	**	0.07	*	-0.03	
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral3	-0.05	***	0.00		-0.04	**	0.01		-0.03	*
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral4	-0.09	***	-0.08	*	-0.08	***	-0.08	*	-0.08	***
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral5	-0.07	***	-0.03		-0.07	***	-0.02		-0.06	***
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral6	-0.09	***	-0.08	*	-0.09	***	-0.08	*	-0.08	***
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral7	-0.05	**	-0.08	*	-0.04	**	-0.08	*	-0.03	
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral8	0.01		-0.09	**	0.01		-0.08	**	0.02	
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral9	0.02		-0.09	**	0.03		-0.09	**	0.04	*
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
Neutral10	0.02		-0.01		0.02		-0.01		0.03	
	(0.02)		(0.04)		(0.02)		(0.04)		(0.02)	
R-squared	0.46		0.31		0.16		0.31		0.15	
Average Effect, War-War5	*-1.17*		*-0.89*		*-1.27*		*-1.34*		*-1.47*	
Average Effect, Neu-Neu5	*-0.07*		*-0.02*		*-0.07*		*-0.01*		*-0.06*	

Country pair fixed effect estimates. Controls not reported: distance, output, output per capita, language, land border, landlocked, islands, land area, current colony, ever colony, currency union, year dummies, and constant. Standard errors in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 5: Human Costs of World War I

(b) Costs					Maddison (1990$)		
	Dead	Wounded	Dead equivalent	1913 Pop. (mil.)	Cost ($mil.)	1913 GDP ($mil.)	Cost/GDP
France	1,398,000	2,000,000	2,398,000	39.8	11,114	138,665	8.0%
Belgium	13,000	44,686	35,343	7.7	198	32,347	0.6%
Italy	578,000	947,000	1,051,500	36.6	3,629	94,845	3.8%
Portugal	7,000	13,751	13,876	6.0	23	7,467	0.3%
Britain	723,000	1,662,625	1,554,313	47.4	10,172	233,248	4.4%
Canada	60,383	155,799	138,283	7.9	818	34,916	2.3%
Australia	54,890	158,199	133,990	4.8	919	24,861	3.7%
New Zealand	16,500	41,432	37,216	1.1	255	5,781	4.4%
India	59,296	46,969	82,781	303.7	74	204,242	0.0%
Rumania	250,000	120,000	310,000	7.4	718	12,807	5.6%
Serbia	45,000	133,148	111,574	3.0	157	3,205	4.9%
Greece	5,000	21,000	15,500	2.7	33	4,344	0.8%
Russia	1,811,000	1,450,000	2,536,000	154.0	5,017	229,143	2.2%
USA	114,000	205,690	216,845	97.6	1,529	517,383	0.3%
Bulgaria	88,000	152,390	164,195	4.4	335	6,792	4.9%
Germany	2,037,000	4,207,028	4,140,514	65.1	20,089	237,332	8.5%
Austria-Hungary	1,100,000	3,620,000	2,910,000	51.4	10,571	140,268	7.5%
Turkey	236,000	400,000	436,000	15.0	703	18,195	3.9%
All belligerents	8,596,069	15,379,717	16,285,928	855.5	66,354	1,945,840	3.4%

Sources: See text and notes. Dead and wounded: Military casualties only. Data from Ferguson (1999), except Canada, Australia, New Zealand and India from Bogart (1919), with authors' adjustments (see below). Incomes and populations: Maddison (2004), adjusted to 1913 land borders, using Maddison (1995, 2001), except Austria-Hungary: for Hungary the Maddison GDP per capita is $2,098, for Austria it is $3,465; a population-weighted average for Austria and Hungary give $2,731. GDP is computed based on a total census population in 1910 of 51.356 million from Mitchell (1992).

Notes: Dead equivalent are dead plus one half wounded. Cost (flow cost) is calculated as real wage times dead equivalent. Real wage is proxied by real GDP per capita times labor's share (estimated as 2/3) divided by labor share of population (estimated as 1/2). Austria-Hungary: for Hungary the Maddison GDP per capita is $2,098, for Austria it is $3,465; an average between Austria and Hungary would give $2,781.5. GDP is then computed based on a total population in 1910 of 51.356 million based on Mitchell (1992). We made several adjustments to the death counts for four countries, as follows. We found that the above Bogart-Fergsuon casualty data closely match most other tabulations in current use, e.g., Broadberry and Harrison (2005). An important original source for all these authors is Urlanis (1971). There is agreement among most authors including Urlanis as to the death counts for almost all countries, and the consensus is usually close to the figures presented in the original U.S. War Department study of 1924. However, most sources show considerable disagreement with Urlanis in the case of four countries (see: e.g., http://users.erols.com/mwhite28/warstat1.htm), where Urlanis has a very high estimate of deaths. We cannot discount Urlanis, however, since he had special access to Soviet archives, which may lend his counts greater precision in some cases. The four countries, with corresponding ranges of alternate death toll estimates, are: Belgium (low "consensus" 13,000; high Urlanis 38,000), Serbia (low 45,000–128,000; high 278,000), Greece (low 5,000; high 26,000), and Turkey (low 236,000–450,000; 804,000). As a sensitivity check, we recalculated costs for these 4 countries using the lowest of these ranges of estimates. Costs for these particular countries change markedly in this case, but the overall costs of the war do not change (since these are countries with small GDP weights). The table shows the results with the low estimates.

Table 6: Economic Costs of World War I: Human versus Trade

	Belligerent Countries	Neutral Countries	World
Weighting data			
1913 population (million)	855	916	1,771
1913 GDP (1990$ million)	$1,945,840	$780,225	$2,726,065
1913 trade (1985$ mil.) w/allies	$44,830	—	$44,830
1913 trade (1985$ mil.) w/belligerents	$19,671	$16,487	$36,158
1913 trade (1985$ mil.) w/neutrals	$16,487	$3,509	$19,995
1913 trade (1985$ mil.) total	$80,988	$19,995	$100,983
	Losses of Belligerents	Losses of Neutrals	Losses of World
Human costs	(a)	(b)	(c)
Population loss, dead equivalent (%)	1.90%	—	0.92%
Permanent flow loss of GDP (imputed)	3.41%	—	2.43%
Trade costs with Belligerents	(d)	(e)	(f)
Permanent flow loss of trade (%)	4.87%	1.61%	1.21%
Permanent flow loss of GDP (imputed)	2.28%	2.09%	2.22%
Trade costs with Neutrals	(g)	(h)	(i)
Permanent flow loss of trade (%)	1.61%	—	1.33%
Permanent flow loss of GDP (imputed)	0.46%	—	0.33%
Trade costs, total	(j)	(k)	(l)
Permanent flow loss of trade (%)	6.48%	1.61%	2.54%
Permanent flow loss of GDP (imputed)	2.74%	2.09%	2.55%

Notes: The definition of belligerents is those countries ever involved in WWI during years 1914 to 1918. This does not correspond exactly with the gravity-model belligerent dummy at all times: some countries may be omitted, and not all were belligerents for the entire war (e.g., the United States).
Sources: Weighting data on population and GDP from Maddison's (1995) "world" 199-country imputed totals and the corresponding data for belligerents as listed in Table 5. Trade data are from the authors' data; see text.
(a) based on Table 5 and its underlying calculations;
(b) zeroes assumed;
(c) based on a weighted average of (a) and (b);
(d) see text and Table 4, Column 1; GDP costs depend on trade share;
(e) see text and Table 4, Column 1; GDP costs depend on trade share;
(f) based on a weighted average of (d) and (e) using belligerent and neutral shares of world trade and GDP, respectively.
(g) as (d);
(h) zeroes assumed;
(i) based on a weighted average of (g) and (h) using belligerent and neutral shares of world trade and GDP, respectively.
(j) based on a sum of (d) and (g).
(k) based on a sum of (e) and (h).
(l) based on a sum of (f) and (i).

Table 7: Human Costs of World War II

					Maddison (1990$)		
	Dead	Wounded	Dead equivalent	1938 Pop. (mil.)	Cost ($mil.)	1938 GDP ($mil.)	Cost/GDP
Belgium	88,000	132,000	154,000	8.4	990	40,466	2.4%
Brazil	943	4,222	3,054	39.5	5	50,376	0.0%
Australia	23,365	72,196	59,463	6.9	466	40,639	1.1%
Canada	37,476	64,062	69,507	11.5	420	52,060	0.8%
India	24,338	155,597	102,137	454.2	91	303,593	0.0%
New Zealand	10,033	29,896	24,981	1.6	215	10,365	2.1%
South Africa	6,840	30,793	22,237	10.5	65	22,965	0.3%
United Kingdom*	357,116	490,996	602,614	47.5	5,022	297,619	1.7%
China	11,310,224	16,752,951	19,686,700	513.3	14,718	288,549	5.1%
Czechoslovakia	225,000	337,500	393,750	15.4	1,491	43,951	3.4%
Denmark	3,800	5,700	6,650	3.8	51	21,765	0.2%
France	563,324	925,000	1,025,824	42.0	6,093	187,402	3.3%
Greece	413,300	619,950	723,275	7.1	2,575	18,901	13.6%
Netherlands	207,900	302,860	359,330	8.7	2,509	45,593	5.5%
Norway	10,000	15,000	17,500	2.9	101	12,734	0.8%
Poland*	5,798,178	657,366	6,126,861	34.7	17,783	75,656	23.5%
Philippines	118,000	177,000	206,500	15.9	418	24,252	1.7%
USA*	298,131	811,510	703,886	130.5	5,735	799,357	0.7%
USSR	18,000,000	27,000,000	31,500,000	168.6	90,063	362,451	24.8%
Yugoslavia	1,505,000	2,225,000	2,617,500	15.4	4,722	20,938	22.6%
Bulgaria	20,000	30,000	35,000	6.2	74	9,962	0.7%
Finland	84,000	53,000	110,500	3.7	528	13,123	4.0%
Germany*	4,280,000	8,400,000	8,480,000	67.3	50,207	299,753	16.7%
Hungary	490,000	470,000	725,000	9.2	2,560	24,342	10.5%
Italy*	395,263	416,000	603,263	44.1	2,655	145,878	1.8%
Japan*	1,972,000	4,810,000	4,377,000	71.9	14,258	176,051	8.1%
Rumania	500,000	550,000	775,000	19.7	1,280	24,526	5.2%
All belligerents	46,742,231	65,538,599	79,511,531	1760.0	225,642	3,413,267	6.6%
All belligerents (missing data=0)*	*36,742,231*	*18,958,697*	*46,221,580*	*1760.0*	*166,277*	*3,413,265*	*4.9%*
All belligerents (military losses only)	*19,395,617*	*30,555,675*	*34,673,455*	*1760.0*	*121,640*	*3,413,265*	*3.6%*

Sources: See text and notes. Dead and wounded include both military and civilian casualties; some missing data are imputed except for rows marked *. See Appendix Table A1 for details and sources. Incomes and populations are from Maddison (2004), adjusted to 1938 borders using Maddison (1995, 2001); Czechoslovakia data are 1937 values and South Africa data are interpolated using 1913 and 1950 values.

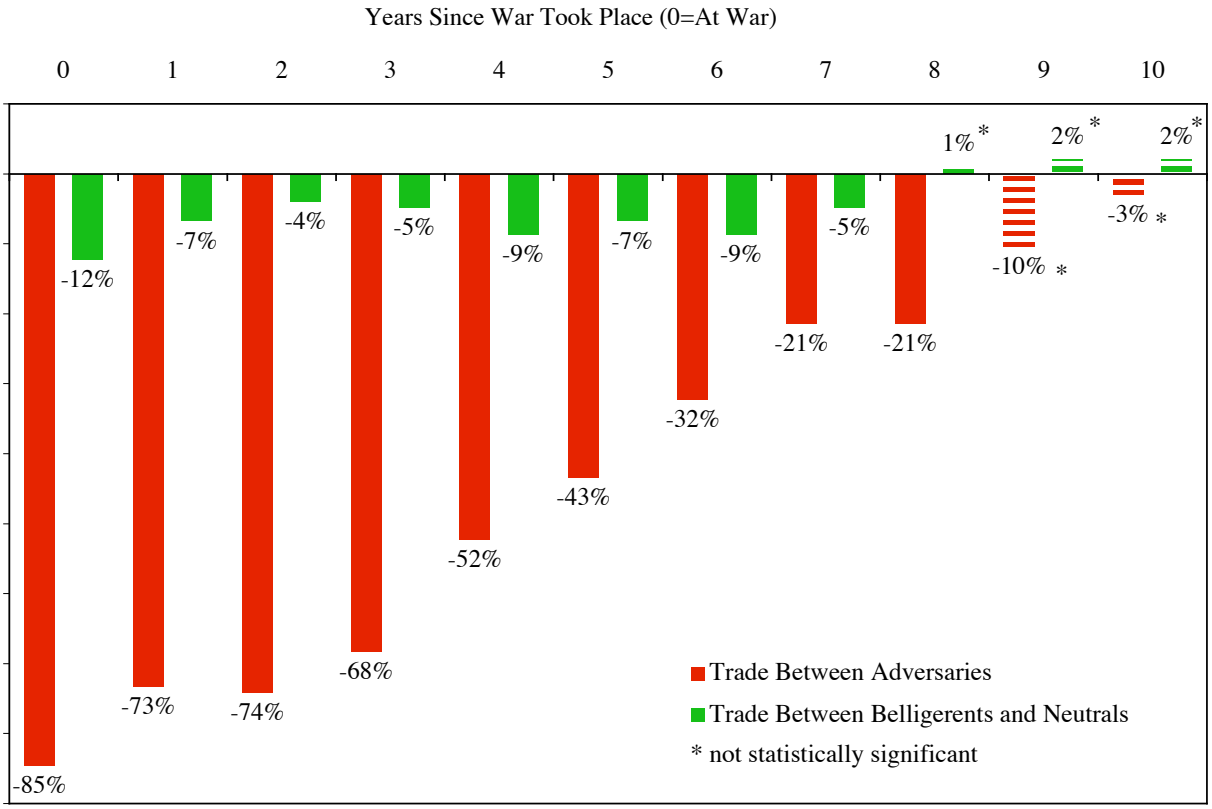
Notes: Dead equivalent are dead plus one half wounded. Cost (flow cost) is calculated as real wage times dead equivalent. Real wage is proxied by real GDP per capita times labor's share (estimated as 2/3) divided by labor share of population (estimated as 1/2).

Table 8: Economic Costs of World War II: Human versus Trade

	Belligerent Countries	Neutral Countries	World
Weighting data			
1938 population (million)	1,760	489	2,249
1938 GDP (1990$ million)	$3,413,265	$731,461	$4,144,726
1938 trade (1985$ mil.) w/allies	$38,378	—	$38,378
1938 trade (1985$ mil.) w/belligerents	$15,302	$10,697	$25,999
1938 trade (1985$ mil.) w/neutrals	$10,697	$770	$11,467
1938 trade (1985$ mil.) total	$64,377	$11,467	$75,844
	Losses of Belligerents	Losses of Neutrals	Losses of World
Human costs	(a)	(b)	(c)
Population loss, dead equivalent (%)	4.52%	—	3.54%
Permanent flow loss of GDP (imputed)	6.59%	—	5.43%
Trade costs with Belligerents	(d)	(e)	(f)
Permanent flow loss of trade (%)	6.30%	2.13%	1.57%
Permanent flow loss of GDP (imputed)	1.27%	1.10%	1.24%
Trade costs with Neutrals	(g)	(h)	(i)
Permanent flow loss of trade (%)	2.13%	—	1.99%
Permanent flow loss of GDP (imputed)	0.36%	—	0.30%
Trade costs, total	(j)	(k)	(l)
Permanent flow loss of trade (%)	8.43%	2.13%	3.56%
Permanent flow loss of GDP (imputed)	1.64%	1.10%	1.54%

Notes: The definition of belligerents is those countries ever involved in WWI during years 1939 to 1945. This does not correspond exactly with the gravity-model belligerent dummy at all times: some countries may be omitted, and not all were belligerents for the entire war (e.g., the United States), and some switched sides (e.g., Italy).
Sources: Weighting data on population and GDP from Maddison's (1995) "world" 199-country imputed totals and the corresponding data for belligerents as listed in Table 7. Trade data are from the authors' data; see text.
(a) based on Table 7 and its underlying calculations;
(b) zeroes assumed;
(c) based on a weighted average of (a) and (b);
(d) see text and Table 4, Column 1; GDP costs depends on trade share;
(e) see text and Table 4, Column 1; GDP costs depends on trade share;
(f) based on a weighted average of (d) and (e) using belligerent and neutral shares of world trade and GDP, respectively.
(g) as (d);
(h) zeroes assumed;
(i) based on a weighted average of (g) and (h) using belligerent and neutral shares of world trade and GDP, respectively.
(j) based on a sum of (d) and (g).
(k) based on a sum of (e) and (h).
(l) based on a sum of (f) and (i).

Figure 1
Impact of War on Trade For A Given Country Pair
Contemporaneous Impact and Lags 1 through 10



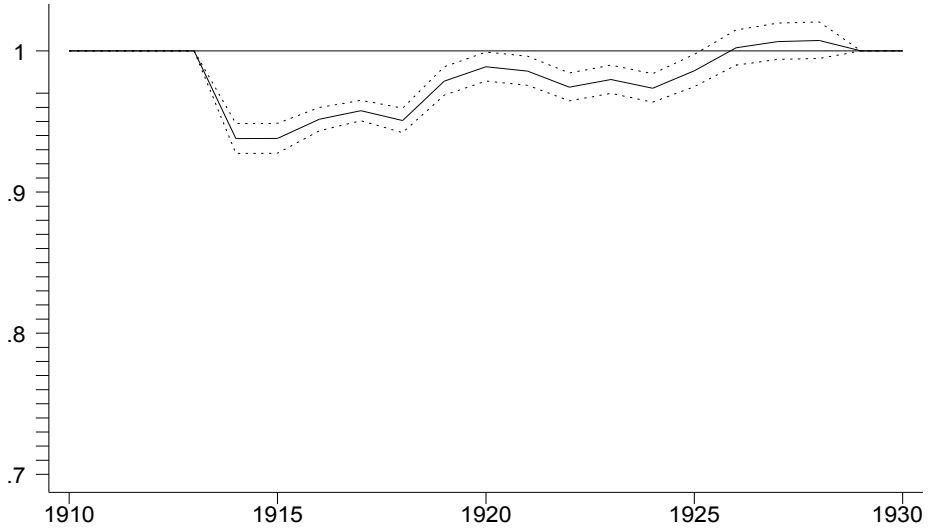
Source: Table 4, Column 1.

Figure 2
Impact of World War I on Total World Trade

Predicted Wartime Level Relative to Assumed Counterfactual Peacetime Level (1913 level)

(a) Overall Decline in Aggregate World Trade Due to Losses from Adversary Country Pairs

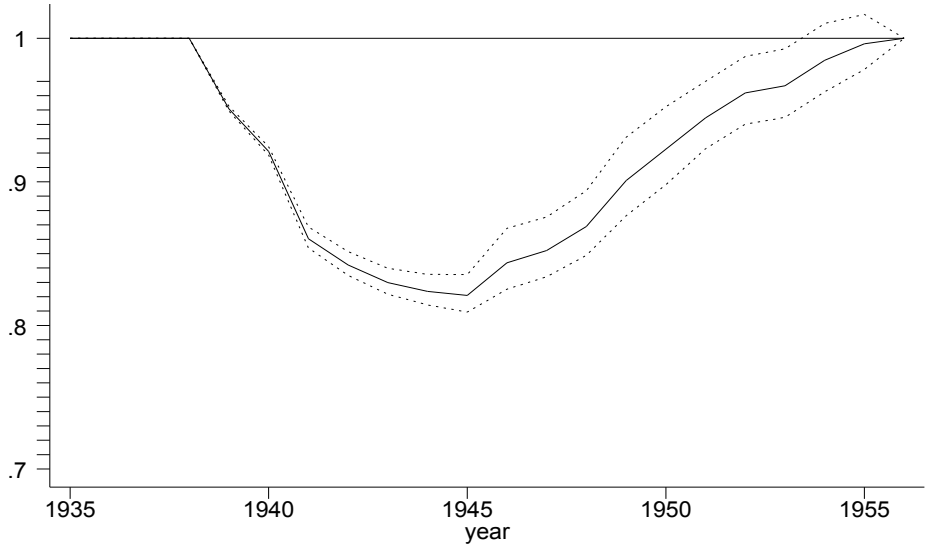
(b) Overall Decline in Aggregate World Trade Due to Losses from Belligerent-Neutral Country Pairs



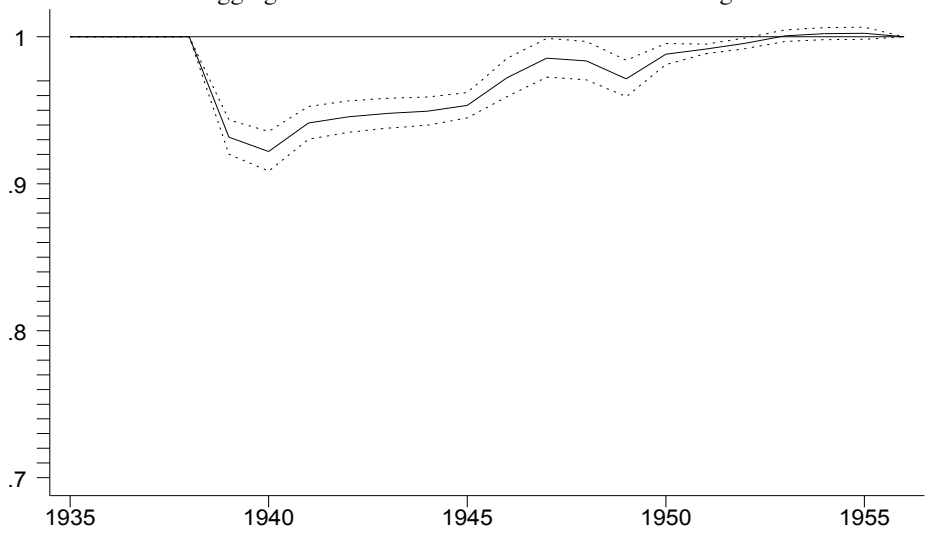
Notes and Sources: Authors' calculations. See text.

Figure 3
Impact of World War II on Total World Trade
Predicted Level Relative to Assumed Counterfactual Peacetime Level (1938 level)

(a) Overall Decline in Aggregate World Trade Due to Losses from Adversary Country Pairs



(b) Overall Decline in Aggregate World Trade Due to Losses from Belligerent-Neutral Country Pairs



Notes and Sources: Authors' calculations. See text.

Appendix Table A1: Estimating World War II Casualties

Italic figures denote imputed data—see notes.

Country	Military Deaths	Military Wounded or Missing	Civilian Deaths Due to War	Civilian Wounded or Missing	Total Deaths	Total Wounded or Missing	Dead Equivalent	Dead Equivalent, (no imputed data)
Belgium	12,000	*18,000*	76,000	*114,000*	88,000	132,000	154,000	88,000
Brazil	943	4,222	*0*	*0*	943	4,222	3,054	3,054
Australia	23,365	39,803	*21,595*	32,393	23,365	72,196	59,463	59,463
Canada	37,476	53,174	*7,259*	10,888	37,476	64,062	69,507	69,507
India	24,338	64,354	*60,829*	91,243	24,338	155,597	102,137	102,137
New Zealand	10,033	19,314	*7,055*	10,582	10,033	29,896	24,981	24,981
South Africa	6,840	14,363	*10,953*	16,430	6,840	30,793	22,237	22,237
U.K.	264,443	277,077	92,673	213,919	357,116	490,996	602,614	602,614
China	1,310,224	1,752,951	*10,000,000*	15,000,000	11,310,224	16,752,951	19,686,700	2,244,324
Czechoslovakia	10,000	*15,000*	215,000	*322,500*	225,000	337,500	393,750	225,000
Denmark	1,800	*2,700*	2,000	*3,000*	3,800	5,700	6,650	3,800
France	213,324	400,000	350,000	*525,000*	563,324	925,000	1,025,824	763,324
Greece	88,300	*132,450*	325,000	*487,500*	413,300	619,950	723,275	413,300
Netherlands	7,900	2,860	200,000	*300,000*	207,900	302,860	359,330	209,330
Norway	3,000	*4,500*	7,000	*10,500*	10,000	15,000	17,500	10,000
Poland	123,178	236,606	5,675,000	420,760	5,798,178	657,366	6,126,861	6,126,861
Philippines	27,000	*40,500*	91,000	*136,500*	118,000	177,000	206,500	118,000
U.S.A.	292,131	671,801	6,000	139,709	298,131	811,510	703,886	703,886
U.S.S.R.	11,000,000	*16,500,000*	7,000,000	*10,500,000*	18,000,000	27,000,000	31,500,000	18,000,000
Yugoslavia	305,000	425,000	1,200,000	*1,800,000*	1,505,000	2,225,000	2,617,500	1,717,500
Bulgaria	10,000	*15,000*	10,000	*15,000*	20,000	30,000	35,000	20,000
Finland	82,000	50,000	2,000	*3,000*	84,000	53,000	110,500	109,000
Germany	3,500,000	5,000,000	780,000	3,400,000	4,280,000	8,400,000	8,480,000	8,480,000
Hungary	200,000	*300,000*	290,000	170,000	490,000	470,000	725,000	575,000
Italy	242,322	66,000	152,941	350,000	395,263	416,000	603,263	603,263
Japan	1,300,000	4,000,000	672,000	810,000	1,972,000	4,810,000	4,377,000	4,377,000
Romania	300,000	*450,000*	200,000	100,000	500,000	550,000	775,000	550,000
Totals	19,395,617	30,555,675	27,454,305	34,982,924	46,742,231	65,538,599	79,511,531	46,221,580

Sources: Casualty data were taken from http://www.worldwar2database.com/html/frame4.htm, with supplementary data taken from http://users.erols.com/mwhite28/ww2stats.htm.

Notes on Imputed Data: As a preliminary step, missing data for dead or wounded (civilians and military) were imputed by four methods: 1. All missing data set to zero; 2. Assume that for each country the number of wounded equaled 1.5 times the number of dead; 3. Assume that the proportion of wounded to dead for countries with missing data was the same as for those with data. For method 3, the following regression was run: WOUNDED = $a + b$*DEAD. For military casualties we found: 17 observations, a = 56,207 (t=*0.38)* and b = 1.57 (t=10.33), R^2=.88. For civilian casualties there were too few observations (7) so the regressions produced insignificant estimates. Thus, the regression in method 3 justifies the rule of thumb used in method 2. In this table, we show two counts based on methods 1 and 2, with the same rule of thumb applied to both civilian and military casualties.

Other Notes: Germany total includes Austrian casualties. According to some sources Austrian military deaths were 280,000 and military wounded were 350,000, which would be 8% and 7% of the combined Austrian/German total, respectively. USSR total does not include an estimated 2 to 2.5 million civilians who died fleeing the Red Army during the Soviet invasion and expulsion from today's Western Poland and Czechoslovakia. China civilian deaths are very rough estimates. It is very doubtful that civilian deaths were zero under the Japanese occupation. One website mentions an estimate of 22,000,000 civilian deaths which is of "doubtful accuracy"; another has an implausibly low figure of 115,000. Furthermore the military casualties are only those of the Nationalists and do not include those of the Communists. Another source estimates 11 million civilian dead due to Japanese occupations in Asia, although this includes countries other than China, e.g. Burma. Based on the latter figure we make a rough estimate of 10 million civilian dead in China. For this reason, our 5% GDP loss for China should be considered a very rough upper bound. Poland's figures are subject to disagreement; our figures may be low; Bullock estimates military deaths at 850,000.