PENS
7/25/08
11:50 am

COLLATERAL DAMAGE:
TRADE DISRUPTION AND THE ECONOMIC IMPACT OF WAR*

Reuven Glick and Alan M. Taylor

April 2008

Conventional wisdom in economic history suggests that conflict between countries can be enormously disruptive of economic activity, especially international trade. We study the effects of war on bilateral trade with available data extending back to 1870. Using the gravity model, we estimate the contemporaneous and lagged effects of wars on the trade of belligerent nations and neutrals, controlling for other determinants of trade as well as the possible effects of reverse causality. We find large and persistent impacts of wars on trade, on national income, and on global economic welfare. We also conduct a general equilibrium comparative statics exercise that indicates costs associated with lost trade might be at least as large as the conventionally measured "direct" costs of war, such as lost human capital, as illustrated by case studies of World War I and World War II.

JEL Nos. D74, F02, F10, F14, H56, N40, N70

* We thank Marc Meredith, Sandy Naylor, Thien Nguyen, Michael Simmons, and Radek Szulga for research assistance. We also thank, without implicating: Steven Broadberry; Herb Emery; Niall Ferguson; Claudia Goldin; Mark Harrison; conference participants at the Fifth World Congress of Cliometrics (Venice, July 2004); the CEPR-CREI Conference on "War and the Macroeconomy" (Universitat Pompeu Fabra, June 2005); the Latin American and Caribbean Economic Association Meetings (Paris, October 2005); the Economic History Association Annual Meeting (Toronto, September 2005); the NBER 2005 Development of American History (DAE) Program Meeting; seminar participants at Oxford University; London School of Economics; the Mershon Center of Ohio State University; and members of the Economic History Research list (EH.RES) for helpful comments. The views presented in this paper are those of the authors alone and do not necessarily reflect those of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System.

R. Glick / Economic Research Department, Federal Reserve Bank of San Francisco / 101 Market Street, San Francisco, CA 94105 USA reuven.glick@sf.frb.org, ph (415) 974-3184, fax (415) 974-2168.

A. M. Taylor / Department of Economics, University of California, Davis, NBER and CEPR / One Shields Ave. / Davis, CA 95616 USA amtaylor@ucdavis.edu, ph (530) 752-1572, fax (530) 752-9382.

The most successful war seldom pays for its losses. —Thomas Jefferson

I. 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 scholarly books and journals, but approaches to this question vary as widely as the precision of the answers. Still, most analyses have at least one thing in common: a focus on the *direct* costs, traditionally measured by loss of life and the resources used to wage war—essentially, men and materiel. To these costs, 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 over the period 1870–1997 that have never previously been examined, namely the effect of belligerent conflict on the volume of international trade and consequently on per capita incomes and economic welfare. Using econometric methods we find a very strong impact of war on trade volumes. Moreover these effects have two important characteristics. First, they are persistent: even after conflicts end, trade does not resume its pre-war level for many years, exacerbating total costs. Second, they have a multilateral dimension: unlike the direct costs of war, which largely affect only the belligerents, commercial losses affect neutral parties as well, meaning that wars generate a large negative externality via trade destruction. We use these results to make general equilibrium comparative statics estimates of the impact of World Wars I and II on global trade and income.

Our paper is part of the renaissance of research activity on the applied economics of international trade. A growing theoretical and empirical literature relates bilateral trade flows to measures of joint economic activity and costs of trade. These so-called gravity models have been utilized as benchmarks from which to assess the trade impact of economic disturbances and policy regimes, such as exchange rate variability (e.g., Thursby and Thursby 1987), preferential trade arrangements (e.g., Frankel, Stein, and Wei 1996), and currency unions (e.g., Rose 2000).[1]

On theoretical grounds, wars and other forms of militarized conflict should affect 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. However, the relation of aggregate trade to political disturbances and conflict has not received much attention among economists. Among the few extant studies, Blomberg and Hess (2004) analyze the impact

[1] In all three cases the literature is vast; we cite only one important example in each case.

on trade of various forms of violence, including war and terrorism, while Martin, Mayer, and Thoenig (forthcoming) estimate the effects of military conflicts on trade. But these analyses focus only on the latter half of the twentieth century; our data span a much longer period including the two great wars of the twentieth century.[2]

The interaction of conflict and international trade has been the focus of much more attention among political scientists, who have been concerned with putative reverse causation—the effect of trade (along with other political variables) on the likelihood of conflict among countries—as well as the impact of conflict itself on trade.[3] Among papers in this literature estimating gravity models, Pollins (1989a, b) finds that less friendly bilateral political relationships dampen trade, Mansfield and Bronson (1997) find that wars reduce trade, and Kesht, Pollins, and Reuveny (2004) find that conflicts, defined as militarized interstate disputes (MIDs) dampen trade. In contrast, Morrow, Siverson, and Taberes (1998, 1999) and Mansfield and Pevehouse (2000) find the effect of MIDs on trade is not statistically significant.[4] Time-series event studies for selected country pairs have also yielded ambiguous results; for example, Barbieri and Levy (1999) find no evidence that war involving non-major power countries reduces bilateral trade over time, while Anderton and Carter (2001) find that wars involving major powers dampen trade both with other major powers as well as minor powers.

The absence of any uniform conclusions in these studies may be attributable to methodological differences in terms of sample characteristics. Typically they restrict their samples to short time-series samples in the post-World War era or 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 dataset, it introduces the possibility of bias in the selected sample.[5] More recent

---

[2] The sample periods of Blomberg and Hess (2004) and Martin, Mayer, and Thoenig (forthcoming) span 1968–99 and 1950–2000, respectively.

[3] For literature reviews, see McMillan (1997), Barbieri and Schneider (1999), Reuveny (2000), Mansfield and Pollins (2001), Schneider, Barbieri, and Gleditsch (2003), and the papers in Mansfield and Pollins (2003).

[4] This literature analyzes the effects of other political variables on trade as well. For example, Gowa (1994), Gowa and Mansfield (1997), and Mansfield and Pevehouse (2000) argue that national security interests influence commercial ties and find that alliances promote trade.

[5] Comparisons across these studies are hampered by differences in various dimensions, including the measure of conflict and sample characteristics. For example, Pollins (1989a, 1989b) uses a continuous measure of conflict constructed from the Conflict and Peace Data Bank (COPDAB) and a sample consisting of 25 countries over the periods 1955–78 and 1960–75. Mansfield and Bronson (1997) analyze the effects of war using a sample of cross

studies using longer datasets and all available country pairs have generally concluded that militarized disputes do reduce trade (e.g., see Russett and Oneal 2001; and Oneal, Russett, and Berbaum 2003, where the sample period spans 1885–1992).

Past studies suffer from several other design defects. First, most of these studies do not take account of the possibility that war may have lagged as well as contemporaneous effects on trade.[6] If the end of a war resolves disputes and allows for exchange, trade may resume rapidly. However, depending on the destruction of production capacity and trading capabilities, it may take a while to exploit these opportunities. In addition, if the threat of military conflict remains, trade may recover slowly.[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 in understanding the overall effects of conflict on trade and economic welfare. In this paper we find that, on a present discounted basis, the costs of war in terms of lost trade are three to four times higher when lagged effects are added to purely contemporaneous effects.

Second, these studies do not take account of the third-country effects of bilateral conflicts. Wars affect not only bilateral trade between belligerent parties, but also trade between war-involved countries and neutral countries. These negative externalities of war can be substantial. In this paper we find cases where, on a global basis, the losses to neutrals are of the same order of magnitude as losses to belligerents.

Third, most studies use pooled, rather than panel, estimators that may not adequately control for omitted country- or pair-specific attributes, nor distinguish between the effects of

---

sections of countries with available data at five year intervals over the period 1960–90. Mansfield and Pevehouse (2000) examine the effects of MIDs, including wars, over the period 1950–85 for country pairs that are contiguous or included a major power, while Morrow et. al. (1998, 1999) studies the effects of threats to use force, short of actual war, on pairs involving 7 major powers over the period 1907–1990.

[6] Martin, Mayer, and Thoenig (forthcoming) and Oneal, Russet, and Berbaum (2003) are exceptions; both estimate gravity models with distributed lags of conflict as explanatory variables. However, the former consider only the post-war period in their study, while the latter find that the effects of militarized disputes on trade over the period 1885–1992, are short-lived, lasting for only one or two years. This finding is the combined result of several factors: (i) the inclusion of the effects of all MIDs, including low intensity disputes as well as war events, (ii) the omission from the sample of all but the first years of conflict and the specific exclusion of the aftermath years of both World Wars (1915–20 and 1940–1949), which they regard as dramatically atypical, and (iii) the inclusion of a lagged dependent variable in the gravity equation. All of these factors work to dampen the effects of lagged conflict on trade. Reuveny and Kang (1998) and Reuveny (2001) also estimate gravity trade equations with distributed lags of conflict, but only for a small set of country pairs.

[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.

conflict on trade *across country pairs* and the effects *over time*. We use a gravity model with panel data using country-pair fixed effects, so that our identification of war's impact depends only on the time dimension, with full control for any time-invariant pair characteristics.[8]

Fourth, none of these studies compute the aggregate costs of wars due to lost trade. In a novel comparative statics modeling exercise with the gravity model, we account for the possibility that war may endogenously affect the level of multilateral resistance and hence the adjustment of aggregate world trade through both trade destruction and trade diversion. This approach allows us to compute the "general equilibrium" effects of war on trade and income.

Our paper is organized as follows. In the next section we describe our annual dataset covering a large number of countries over the period 1870–1997. We find that wars are relatively rare events, yet roughly 60 percent of countries have been involved in a war at some time in our sample period. In Section III we estimate the effect of war on international trade. We compare bilateral trade among belligerent and neutral countries during and after conflicts (holding fixed other factors) to estimate the contemporaneous and lagged effects of war on trade. Our results are robust in the face of numerous perturbations to the specification and the sample, and we find that reverse causality is statistically insignificant and quantitatively unimportant for our analysis.

In Section IV, we use our 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 twentieth century. We present estimates of the welfare costs of lost trade using an income metric (following Frankel and Romer 1999). These costs are then compared to traditional direct costs, such as the valuation of the loss of life (following Goldin and Lewis 1975). The costs of war due to trade disruption, although typically ignored, were large and shared by belligerents and neutrals alike. Our estimates of the costs of lost trade due to World War I are twice as large as the awful costs of lost human capital. For the bigger, longer, and deadlier conflict of World War II, estimated trade costs are about equal to the estimated human costs. Section V concludes the paper, stressing that the effects of wars on trade should not be neglected and are an important channel through which military conflict affects income and welfare.

[8] Oneal and Russet (2001) and Green, Kim, and Yoon (2001) are exceptions, though they focus on the effect of trade interdependence (and democratic similarity) on the likelihood of conflict among country pairs, rather than the reverse effect of war on trade, which is the focus of this paper.

II. Methodology and Data

A. Gravity Model Methodology

The effects of war on international trade are estimated using a conventional gravity model of international trade. This is now the benchmark empirical model for this kind of exercise and the specification can be derived formally from a general equilibrium model of production, consumption, and trade, as in Anderson and van Wincoop (2003).[9]

For empirical purposes, we model 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:[10]

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

where i and j denotes countries, t denotes time, and the variables are defined as:[11]

- Trade_{ijt} is 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, for 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, for 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;

[9] Anderson and van Wincoop presume separability between the production and consumption decisions, on the one hand, and bilateral trade allocation, on the other, while also assuming symmetric bilateral trade barriers. An alternative approach to deriving the gravity equation (e.g., Bergstrand, 1989; Eaton and Kortum, 2002) presumes that these decisions are inseparable and solves for equilibrium production and consumption as well as trade.

[10] Our specification is a log linearization representation of Anderson and van Wincoop's theoretical gravity equation in which trade flows depend on incomes, bilateral trade barriers, and (unobserved) multilateral resistance effects. As discussed in the text, we obtain consistent estimates of the coefficients of the trade equation through the use of fixed effects for the multilateral resistance terms. In the comparative statics calculations in Section IV we take account of the general equilibrium dependence of trade flows on the multilateral resistance effects by perturbing and solving the nonlinear system of equations for trade and resistance.

[11] Our set of control variables include the "usual suspects," following Rose (2000) and Glick and Rose (2002), but is not meant to be exhaustive. Other studies have estimated the effects of such factors as participation in free trade arrangements as well as membership in international governmental organizations, such as the World Trade Organization (see Rose 2004).

- 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*;
- EverCol is a binary variable which is unity if i ever colonized j or *vice versa*;
- CurUGold is a binary variable which is unity if i and j are engaged in a currency union or, before 1945, if they are on the gold standard at time t;
- γ_k, λ_k, β_i are coefficients; and
- ε_{ijt} 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, which have not been studied before. In fact, in what follows, all the other coefficients take on typical values that are consistent with the large empirical gravity literature.

The γ_k coefficients describe the impact of war on log trade levels for adversarial belligerent-belligerent (or BB) country pairs; the λ_k coefficients describe the same impact on belligerent-neutral (or BN) country pairs. The contemporaneous effect of war on trade between 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. The coefficients λ_0 and λ_k analogously capture the contemporaneous and lagged effects of war on trade between belligerents and neutral countries.[12]

The model is estimated with a number of techniques below to test robustness. The coefficients of main interest to us, the γ_k and λ_k, are qualitatively similar under different estimators. For our main conclusions we rely on the more conservative and robust fixed effects "within" estimator, which 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 2003,

[12] 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 first war are "reset" to zero at the time the subsequent war begins, i.e., $War_{t-k} = 0$ for $k \geq t'-t$.

2004). Regrettably, serious data limitations, including a severely unbalanced dataset over more than a century, preclude the inclusion of a full set of time-varying multilateral resistance terms.

B. Dataset

The bilateral trade data were assembled from three main sources: (i) the IMF; (ii) Barbieri (1996a); and (iii) Mitchell (1992, 1993, 1998).

The IMF *Direction of Trade* (DoT) data cover bilateral trade between 217 IMF country-code geographical units between 1948 and 1997 (with many gaps). Measures of FOB exports and CIF imports are recorded in U.S. dollars; we deflate these data 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 countries is created by averaging all of the four possible measures potentially available. Observations where all four figures have a zero or missing value are dropped from the sample.[13] The Barbieri (1996a) dataset contains bilateral trade data in current U.S. dollars for some 60 countries during the period 1870–1947.[14] Her data typically measure bilateral trade between countries i and j 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. We again deflated using the U.S. CPI index. We used data from Mitchell (1992, 1993, 1998) to fill missing observations among major trade partners during the period 1870–1947 and to correct errors in Barbieri's data. The data are typically reported in local currency. We converted to current U.S. dollar terms using exchange rate data and then deflated by the U.S. CPI.[15] Further details are provided in the Data Appendix.

Other standard variables were then added to estimate a gravity model; these include real GDP, population, and various country-pair characteristics, such contiguity, distance, etc. Real GDP and per capita GDP data (in constant 1985 dollars) for the 1948–97 period are obtained

[13] The dataset is essentially the same as that used by Glick and Rose (2002). Using the average of bilateral exports and imports (rather than just exports) as the dependent variable in a gravity model requires some restrictions on the theoretically grounded model, as specified by Anderson and van Wincoop (2003), for example. Specifically, trade barriers should be symmetric across country pairs. This may be less of a problem for a large shock, such as war, which likely affects exports and imports equally.

[14] We use version 1.1 of Barbieri's dataset obtained from the webpage http://pss.la.psu.edu/trd_data.htm. These data actually extend to 1992; we rely on the original source data reported by the DoT for the 1948–97 period. Note that Barbieri reports only combined exports plus imports between countries, not exports and imports separately. This gives another reason for expressing our dependent variable as average trade.

[15] Our results would not be affected by deflating by some other common price measure, such as the price of traded goods, since the difference would be absorbed by the time dummies we include in our estimation.

from three sources. Wherever possible, data from the World Bank's *World Development Indicators* (from the 2000 CD-ROM) are used. When the WDI data are unavailable, missing observations are filled in with comparables from the Penn World Table (PWT) Mark 5.6, Maddison (1995), and (when all else fails) from the IMF's *International Financial Statistics*.[16] For the 1870–1947 period we draw primarily from Maddison (1995; 2001), supplemented by Mitchell (1992, 1993, 1998) and individual country sources. The resulting series are then put into constant 1985 dollars and linked to the 1948–97 series (for details see the Data Appendix.)

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.[17] These data are used to create great-circle distance and the other controls. Whenever appropriate, we make adjustments to 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 (2002), defined as country pairs whose monies are either common or interchangeable at 1:1 par for an extended period of time.[18] For the pre-1948 period, we set CurUGold 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 Meissner (2005) and Obstfeld and Taylor (2003).[19]

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 dataset DYMID1.1, a revised version of the COW dataset MID2.1 compiled by Jones, Bremer, and Singer (1996).[20] This dataset codes the level of hostility reached in a given country's conflict with 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

[16] 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. See the Appendix for details. 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. CPI.
[17] The website is http://www.odci.gov/cia/publications/factbook.
[18] Hard fixes at non 1:1 rates (e.g., Hong Kong, Estonia, Denmark) do not qualify as currency unions under this definition.
[19] On the gold standard and trade see also López-Córdova and Meissner (2003) and Flandreau and Maurel (2005).
[20] The Maoz dataset was taken from the website http://spirit.tau.ac.il/zeevmaoz.

generally involve conflicts with more than 1,000 battle deaths), as well as declarations of war (hostility level 4, and HiAct = 20). The dataset 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*.[21] 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.[22]

Table 1 presents some summary statistics on the number of observations and the frequency of war for the full sample 1870–1997, as well as for the two subsamples 1870–1938 and 1939–97. These statistics are conditional on the availability of data on bilateral trade and GDP, the main constraints for the inclusion of observations in our gravity model estimation. Our full sample contains 251,902 bilateral trade observations involving 172 countries and 11,535 different country pairs. Not surprisingly, the bulk of these observations are in the later sample, as the number of countries proliferated and more data on trade and GDP have become available.

War is a relatively infrequent occurrence in our sample. Conditional on the availability of contemporaneous trade and GDP data, only 75 different country-pairs with 206 country-year observations (since a conflict involving a particular pair may last more than one year) involve war adversaries. However, many countries at war lack contemporaneous trade and/or GDP data while engaged in conflict. When we extend the count by including observations of (up to 10 years of) lagged war, while still conditioning on trade and GDP data availability for these years, the number of country-pairs at war (contemporaneously or in the previous 10 years) in the sample rises to 338. Correspondingly, the number of pair-year observations rises to 2143, amounting to 0.85% (=2143/251902) of the total sample. While the frequency of war observations in the pre-World War II period is somewhat higher (2.97% = 410/13799), wars are still rare events. Still, it is worth noting that even though major conflicts are infrequent, most

[21] The COW data 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., in World War II 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. We have cross-checked our conflict coding with version 3.0 of the COW dataset, which was released after our dataset was assembled; no changes were deemed necessary. Extending the sample beyond 1997 would have little effect since there have been no major wars until the U.S. actions in Afghanistan in 2001 and Iraq in 2003. See the MID codebook at http://cow2.la.psu.edu. The CSP webpage is http://members.aol.com/CSPmgm/cspframe.htm.

[22] We do not consider other forms of conflict, such as civil wars. See, for example, Bayer and Rupert (2004).

countries in the sample have been involved in war at one time or the other. Of the 172 countries, over 60% (104) have been engaged in war sometime during our sample period.

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

We now proceed to show that wars, while relatively infrequent, have had large effects on trade.

A. Benchmark Estimates

We begin by estimating our gravity equation using a country-pair fixed effect (CPFE) panel estimator with a full set of year effects included. Robust standard errors are clustered at the country-pair level to address potential problems of heteroskedasticity and autocorrelation in the error terms.[23]

Results are shown in Table 2, column 1. Pair and year effects are not reported. The War dummy is allowed to enter contemporaneously and with up to ten lags (denoted War1 to War10). The Neutral variable and its lags are initially excluded from the regressor list. Since some traditional gravity variables like distance, shared land borders, or island status, are both time-invariant and pair specific, they are collinear with the pair fixed effects and drop out.[24] 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.[25]

The key variables of interest in this paper are the γ_k estimates of the "trade destruction" impact of war. The CPFE "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

---

[23] All estimation is done with Stata. Clustering at the country pair level allows the variance to differ across pairs and permits an unstructured covariance within the clusters to control for correlation across time. Bertrand, Duflo, and Mullainathan (2004) suggest clustering as the best way to handle autocorrelation in panel differences-in-differences estimation, which can be viewed as a variant of fixed-effect panel estimation; this approach has been followed in other applications of CPFE estimators to the gravity model (see, e.g., Klein and Shambaugh 2006).

[24] Note that because we adjust for changes in territory over time, the land area variable does not drop out.

[25] We follow Rose (2000, 2004) in including (log) per capita GDP as well as GDP as separate control variables. Note the individual effects of these variables are sensitive to the estimator employed, since the two variables are collinear in log terms. The net effect of GDP on trade, given by the sum of these two coefficients, is generally near the theoretically expected value of unity. Dropping GDP per capita would not affect any of the salient results of our analysis concerning the effects of wars.

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 in Table 2, column 1, indicate that the contemporaneous and lagged effects on trade are all negative, with statistically significant effects persisting for 8 years (at the 5% significance level). The effects are also qualitatively large. The contemporaneous effect of war on log trade is –1.78, implying that the level of 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 a war ends, the extent of “trade destruction” declines roughly monotonically over time, and trade returns to its peacetime level about a decade later. Trade is still 42% below the peacetime level five years after the cessation of war and 21% below even after eight years.[26] For lags one to five the coefficients average –.99, implying a 63% destruction of trade ($1–e^{–.99} \approx .63$), while for lags six to ten they average –.19, implying an 18% destruction of trade ($1–e^{–.19} \approx .18$).

What are the consequences of this persistence? Although they have been overlooked hitherto, we think the persistent effects of wars on trade are quantitatively significant. For example, using a 5% discount rate, the present discounted sum of lost trade is about 3.7 times larger when lagged effects for years 1 through 10 are added in as compared to the contemporaneous effect alone.

Why is there such persistence? If the end of conflict allows commercial exchange to resume smoothly and promptly, trade may resume rapidly, but this is not always the case. In fact, in unreported results we find less persistence for lower intensity and shorter conflicts, where most of the effects on trade are contemporaneous. However, for particularly destructive and long-lasting conflicts, such as World Wars I and II—which wreaked havoc on human capital, infrastructure, production capacity, and international cooperation—recovery evidently took much longer. Thus, even with the end of war, trade can remain depressed for several years thereafter, due to the costs and of postwar reconstruction, diplomatic tensions, residual price or quantity controls on trade, and other factors that raise the variable and/or fixed costs of engaging in trade. All of these different channels are captured in our average lagged war effects.[27]

---

[26] Since $1–e^{–.55} \approx .42$ and $1–e^{–.24} \approx .21$.
[27] One other study which does examine both the contemporaneous *and* lagged effects of war is that by Oneal, Russett, and Berbaum (2003). They also find the effects of war to be persistent, but only for one or two years, much

B. Robustness Checks: Different Estimators

To provide sensitivity analysis, the last three columns of Table 2 report the robustness of our results to some alternative estimators.

In Column 2 we present a random effects panel estimator, which assumes that the regression error terms are uncorrelated with the random country-pair specific effects. The coefficients of interest are nearly identical to column 1.

In Columns 3 and 4 we present estimates with individual country dummies rather than pair dummies. This specification most closely conforms to the so-called "theoretical" gravity model which includes multilateral resistance trade terms for each country, since it provides a consistent estimate of "average treatment effects" for border cost variables, like war (Feenstra 2002, 2003).[28] Year dummies are also included in both cases.

For the OLS estimator, shown in Column 3, the coefficients of interest are again similar to Column 1, and the estimated effects of war are, if anything, even larger. Our results are thus not dependent on which choice is made between the two standard ways of including fixed effects in a gravity model.

In Column 4 we address the fact that in panel data for bilateral trade many pair-year cells are typically missing or zero. This raises two questions. First, when does one treat a missing observation as missing or impute zero? Second, how should one address the existence of censoring at zero in estimation?

In answer to the first question, in Column 4, we impute a zero for all pair-years where at least one positive-valued nonmissing trade observation has been recorded in any prior year in our dataset. This augments our sample by an additional 73942 observations.[29] (The results were not sensitive to several alternative ways of imputing, such as imputing all missing data as zeroes, or requiring two prior observations rather than one.)

---

less than we find here. Their smaller estimates are not unexpected, since their sample excludes World Wars I and II and their aftermath, and their definition of war is broader and includes less violent disputes.

[28] Feenstra (2002, 2003) shows that the (exponential of the) direct trade barrier coefficient in a gravity equation corresponds to the geometric average (over countries i and j) of the impact of the barrier (e.g., war) on the bilateral international trade between i and j (relative to intranational trade within these countries). The fixed effect for each country captures the common element in its trade with all other countries, which reflects its average trade barrier referred to as "multilateral trade resistance." It should also be noted that the theoretical gravity model implies that the coefficient of GDPs should be constrained to unity; in our empirical work we find that the magnitudes of the war coefficients are robust to imposing this constraint too.

[29] Including these missing data raises the number of war observations in our dataset for adversaries at war contemporaneously from 206 to 450 and at war with a lag as well as contemporaneously from 2143 to 2925.

In answer to the second question we present results of a Poisson quasi-maximum likelihood estimator, as suggested by Santos Silva and Tenreyro (2006).[30] The coefficients of interest are reported in Column 4; they are very similar to Column 3, and slightly larger than Column 1.

The last column of Table 2 reports the results of an alternative approach to controlling for multilateral resistance effects in gravity models, proposed by Baier and Bergstrand (2006). Their Bonus Vetus OLS ("Good Old OLS") method involves taking a first order log-linear Taylor expansion to approximate the multilateral resistance terms. The method yields theoretically-motivated and observable exogenous multilateral resistance variables that can be introduced into the estimated gravity model specification.[31] In this case, the impact of war on trade is somewhat lower than was seen in Columns 1 and 3; nevertheless the decline in trade is still quite large.[32]

In sum, the results of Table 2 show that the γ estimates are reasonably insensitive to all of these different estimators. The war effects remain: they are consistently large economically, and statistically significant throughout.[33]

C. Robustness Checks: Neutrals and Different Subperiods

We next perturb the model by including the Neutral regressor and its lags, by dividing the sample into two subperiods (1870–1938 and 1939–97), and also by isolating the effects of World War I and World War II from other wars.[34] The results are reported in Table 3, where the benchmark country-pair fixed effect (CPFE) estimator is employed in all cases.

---

[30] To address the problem of missing (censored) observations, we also computed OLS estimates with a Heckman (1976) correction (Heckit), following Linders and de Groot (2006). The results are similar. (The Heckit estimates employ Stata's default MLE option; the first stage equation has the same regressors as the benchmark equation, implying identification is by functional form. The estimate of the correlation of first and second stage error terms was –0.06.)

[31] Under the assumption that the approximation can be taken around an equilibrium with symmetric, but non-zero, trade frictions, involves effectively demeaning the trade cost variables τ as $\ln \tilde{\tau}_{ij} = \ln \tau_{ij} - (1/C)\sum_i^C \ln \tau_{ij} - (1/C)\sum_j^C \ln \tau_{ij} + (1/2C^2)\sum_i^C \sum_j^C \ln \tau_{ij}$, where C is the number of countries.

[32] The contemporaneous coefficient estimate of –1.14, implies a decline in trade of roughly 70 percent, compared to 83 percent in the Column 1 benchmark case.

[33] The theoretically-grounded gravity model implies that the coefficients on the War variables can be used to calculate the ad valorem tariff equivalent of war as $\tau_{war} = e^{\gamma/(1-\sigma)} - 1$, where σ is the elasticity of substitution between domestic and foreign goods (see Anderson and van Wincoop 2004, p. 713, equation 14). Thus, for example, assuming $\sigma = 5$ and setting $\gamma = -2.18$ (the estimated coefficient on the contemporaneous War variable reported in the last column of Table 3) implies $\tau_{war} = e^{-2.18/(1-5)} - 1 = 0.72$, i.e., war is equivalent to a 72% ad valorem tariff.

[34] More precisely, we isolate the effects of all wars occurring over the periods 1914–18 and 1939–45. The modified war variable then picks up World Wars I and II, plus some simultaneous local conflicts, such as Finland-Russia.

The results for the full sample are presented in Column 1. The war effects are very similar to those in Column 1 of Table 2, and are slightly larger. In Columns 2 and 3 we can 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 as compared to the 1939–97 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 much larger than those of other wars. Holding other variables constant, the estimated contemporaneous coefficient for World War I of –3.29 implies a decline in trade of 96%; the corresponding coefficient for World War II of –3.46 implies a similarly high decline in trade of 97%. In the major wars, it would appear that trade between adversaries was almost totally destroyed.[35] Further sensitivity analysis (reported in Appendix Tables A1 and A2) confirms that the effects of other wars are smaller though still very significant, but in the counterfactual analysis that follows we shall focus on the two great wars.

Whilst the War coefficients measuring trade declines among adversaries are essentially unaffected relative to the Table 2 estimates, the negative coefficients on the Neutral variables imply that war also depresses trade between belligerents and neutrals. For the full sample, shown in Table 3, Column 1, trade with neutrals declines by 12% ($\approx 1-e^{-0.13}$) 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. Inspection of the subperiod results reported in the other columns of Table 3 reveals the same basic pattern, though the effects on neutrals for the 1870–1938 period appears to be small and, for the most part, statistically insignificant. Isolating the effects of World War I and II alone shows much larger effects on trade between neutrals and belligerents. The Neutral contemporaneous coefficient for World War I of –0.54 implies a decline in trade of 42%; the same coefficient for World War II of –1.06 implies an even larger decline in trade of 65%.

The results in Table 3 lead to some of the major conclusions of this paper: historically, wars have been very damaging for world trade; major wars have been especially damaging; the damage to trade is felt by neutrals as well as belligerents; and the damage is highly persistent.

[35] Our country-pair, country-specific, and year dummy models represent severe specifications that control for many possible omitted variables. We do not use up degrees of freedom with a full set of time-country interactions. Focusing on various subsamples and isolating the effects of specific wars (e.g. World Wars I and II) should further alleviate concerns associated with omitted variable bias.

The average effects for all wars are shown in Figure 1 based on the "average" coefficients for all wars (from Column 1 of Table 3). 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 5%–12% on average, although this effect is greatly enlarged to 42%–65% in major wars. Furthermore, both of these effects decay slowly and persist for almost ten years.

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 look at the two World Wars as case studies using our model in Section IV. Before doing so, we conduct a final robustness check by addressing possible concerns about the endogeneity of war and trade.

D. Robustness Check: Simultaneity Concerns

The analysis till now has treated the occurrence of wars as events that are exogenous to trade. What if trade and war are endogenously related to each other? That is, trade may depend on war, but the occurrence of wars may depend directly on the trade interdependence between members of a country pair.

There is a vast political science literature that addresses the question of how the likelihood of conflict among nations depends on various measures of economic interdependence, including the level of bilateral trade or trade openness, in addition to various geographic and political regime variables.[36] However, the theoretical and empirical findings suggest that the effects of trade on war are mixed. The "realist" view argues that trade may create conflict by intensifying competition and/or increasing dependence on strategic goods. Indeed, Barbieri (1996a, 1996b, 2002), Beck, Katz, and Tucker (1998), and Barbieri and Peters (2003) find either a positive or negligible effect of trade on the likelihood of conflict. On the other hand, a growing number of studies support the opposing "liberal peace" view that trade interdependence deters

[36] For a survey of the political science literature on links between trade and conflict, see the citations in footnote 3.

conflict and promotes peace by generating economic benefits and raising the costs of conflict. For example, Polachek (1980, 1997), Pollins (1989a, b), Oneal, Oneal, Maoz, and Russet (1996), Oneal and Russett (1997, 1999, 2001), Mansfield and Pevehouse (2000), Gartzke and Li (2003), Oneal, Russett, and Berbaum (2003), all find evidence that trade reduces the incidence of conflicts.

Nonetheless, in our case we have reason to believe that simultaneity is not a serious problem for our gravity model results. Before we present the evidence, we offer some intuition.

Most of the evidence of a significant effect of conflict on trade involves cross-pair variation in the data ("between" estimation), not within pair variation across time ("within" estimation). The former is of no concern to us since we use country-pair fixed effects as our preferred model, a "within" estimator. Whether a given country pair is, on average, more or less likely to engage in war is factored out through fixed effects. Our identification of the effect of war on trade is purely in the time dimension. Since levels of trade between countries are very slowly varying over time (and to a large degree explained by slowly-changing or unchanging covariates such as country size and distance), the use of trade levels to forecast the timing of war is a priori a hopeless cause. Trade measures may tell us something about *which* pairs are more or less likely to go to war; they tell us nothing about *when* those countries will actually go to war.[37]

To establish this result, we proceed by estimating a model of the likelihood that country pairs engage in war in the spirit of the literature. The likelihood of war is specified as a function of bilateral trade dependence, the number of years of peace since the last war (YrsPeace), the major power status of one or more of the pair (MajPower), joint alliance membership (Alliance), as well as of common land borders (Border) and (log) distance:

$$\begin{aligned} War_{ijt} = \alpha_0 + \alpha_1 \ln(Trade_{ij}/Y_i Y_j)_{t-2} + \alpha_2 YrsPeace_{ij,t-2} + \alpha_3 MajPower_{ij} + \alpha_4 Alliance_{ijt-2} \\ + \alpha_5 Border_{ij} + \alpha_6 LnDist_{ij} + \varepsilon_{ijt} \end{aligned}$$

[37] Some papers in the political science literature use simultaneous systems methods to take account of the interdependence between trade and conflict, e.g. Polachek (1980, 1997), Reuveny and Kang (1998), Reuveny (2001), Keshk, Pollins, and Reuveny (2004), and Kim and Rousseau (2005). However, none control for fixed pair effects. As is typical of this literature, these studies utilize different measures of conflict, sample definitions, and explanatory variables, making comparisons difficult. It should be noted that Kesht, Pollins, and Reuveny (2004) and Kim and Rousseau (2005) find conflict affects trade, but do not find evidence that trade interdependence reduces the incidence of conflict. However, these results have been shown to be sensitive to the inclusion of additional explanatory variables, such as distance and relative power.

Countries that trade more bilaterally should—if the liberal argument holds—have a lower likelihood of war because of the opportunity cost associated with the loss of trade gains. The expected effect of major power status is a priori ambiguous. On the one hand, major-power states are more likely to engage in military conflict since they have wide-ranging interests that potentially bring them into conflict with a large number of states. On the other hand, their military capabilities may work to deter actual conflict. The likelihood of conflict should be lower for countries participating in alliances and higher for countries that are adjacent or closer together, since geographic proximity facilitates confrontations over such matters as land borders and enhances the ability to bring military force to bear.[38]

We measure bilateral trade dependence as the log of bilateral trade relative to the product of the pair's GDP levels.[39] MajPower is a dummy variable = 1 if any member of the pair includes the United States, the United Kingdom, Germany, France, Japan, or USSR/Russia. The Alliance variable is a binary dummy based on data from the Correlates of War project, which codes three types of alliances or pacts in order of decreasing level of commitment: 1 = defense, 2 = nonaggression/neutrality, 3 = *entente*. We code Alliance = 1 whenever countries are linked by any of these forms of pacts or alliances.[40] Given the binary nature of conflict observations, the probability of conflict among any particular country pair should also depend on how much time has elapsed since the pair was last in conflict. To control for this temporal relation we include the variable YrsPeace that measures the number of years since the previous war between the pair.[41] Time varying variables are lagged two years to limit simultaneity issues. A full set of year dummies are also used in our specification.

Table 4 presents estimates of the war model using pooled logit and conditional fixed-effect panel logit estimators. Standard errors robust to clustering for common country-pair

---

[38] Of course, distances between potential adversaries can be overcome to a great extent by the ability to project power by naval and air forces.

[39] Martin, Mayer, and Thoenig (forthcoming) suggest that, although countries trading more bilaterally have a lower probability of conflict, countries that are more open to trade overall have a higher probability of war because multilateral trade openness decreases dependence on trade with any given country.

[40] Our data source is the file "AllianceData_July2000.txt" distributed by the Expected Utility Generation and Data Management Program (EUGENE), v 2.013, available from the website: http://eugenesoftware.org. This file extends the original COW data from 1984 to 1992. We have augmented the dataset to include missing members of the Arab League, Council of Independent States, Gulf Cooperation Council, Organization of African Unity, Organization of American States, and Organization of East Caribbean States. We assume that all alliance relationships in effect in 1992 extend through 1997.

[41] For countries in existence in 1870 the years of peace variable begins counting from 1812 or the most recent occurrence of war prior to 1870. Former colonies and other states newly independent after 1870 "inherit" the war memory of their parent colonizers.

observations are provided throughout. The pooled logit results reported in the Column 1 indicate that the likelihood of conflicts increases when country pairs are contiguous, decreases when an alliance relation exists or a major power is involved, and decreases the longer the period of peace between any pair of countries (the coefficients for YrsPeace are divided by 100 to improve readability of results); these effects are all statistically significant, typically at better than 1 percent, for the full sample and the more recent subperiod. Most importantly, Table 4 indicates that trade dependence significantly decreases the risk of war at better than 1% for the full sample. This suggests that there may indeed be some reverse causality between the extent of bilateral trade relations and the possibility of war.

However, the results in Column 2 with country-pair fixed effects (CPFE) show exactly what is driving the pooled results, and they reveal a markedly different picture of the effects of trade on war. (Note that fixed effects exclude all country-pairs where there are no wars during the sample—there is no within-unit variation in the regressand—and this reduces the sample size accordingly.) The CPFE estimator indicates *no effect* of trade on war.[42] It is also worth noting that the years of peace variable is positive with the fixed effect estimator, implying that the longer the period of time since a particular country pair have engaged in war, the *higher* the likelihood of a future war between them. These results cast doubt about the extent to which trade interdependence affects variations in the likelihood of conflict for any given individual country pair. That is, the explanatory power of trade in our war equations is entirely attributable to fitting variations across country pairs (between effects) rather than explaining variations across time for individual pairs (within effects).[43]

The remaining columns of Table 4 report the results of including other explanatory variables commonly employed in the political science literature to explain the likelihood of conflict. These include the level of democratization (PolityL) and relative power capabilities

---

[42] These results hold for 1870–38 and 1939–97 subperiod regressions as well.

[43] This is confirmed in "between effects" estimates by (i) pooled logit war regressions in which the trade dependence ratio for each country pair is replaced by the corresponding intra-pair mean (without time averaging the other explanatory variables) and (ii) an OLS cross-section regression of the average frequency of war across pairs on the intra-pair mean of the trade dependence ratio as well as the time averages of all other explanatory variables. In these regressions the differences in trade across pairs exert a significant, negative effect on the likelihood of conflict. Zorn (2001) also distinguishes between-pair effects and within-pair effects in pooled and draws similar conclusions for a sample of "politically relevant" pairs over the period 1950–85 (and in fact finds that the over-time effect of trade on conflict is significantly positive). Oneal and Russet (2005) claim that trade significantly reduces conflict both across country pairs and across time in a larger dataset spanning 1885–2001. However, the latter effect is significant in their analysis only at a 10% level (using an appropriate two-tailed test).

(RelCap). The "democratic peace" proposition hypothesizes that countries sharing similar democratic values are less likely to engage in war (e.g., Oneal and Russet, 1997, 1999, 2001; Oneal, Russet, and Berbaum, 2003). Our measure of democracy is drawn from the Polity IV dataset (Jaggers and Gurr 1995, updated by Marshall and Jaggers, 2000) which codes democracy levels and autocracy for individual countries on a 0–10 point scale. A political regime score for each country is constructed from its democracy score minus its autocracy score plus 10, giving a variable that ranges from –10 for the most autocratic regime to +10 for the most democratic regime. Following Russet and Oneal (2001), we define our democratization measure, PolityL, as the lowest democracy score among a country pair (the "weakest link") and hypothesize that the probability of war declines as this variable rises.

Realists argue that a preponderance of power deters military action (e.g., Russet and Oneal 2001) Our measure, RelCap, is defined as the absolute value of the log difference between country indices of military capability for based on industry, population, and military forces, as constructed by Singer and Small (1993).[44] Note that limited data availability for these variables severely restricts the sample size usable for estimation, particularly with fixed effects.

As shown in Table 4, greater democratization and a larger preponderance of power each lower the likelihood of conflict (though this effect is only significant in the former case with fixed effects and in the latter case without fixed effects). Most importantly, our earlier conclusion about the effects of trade on the incidence of conflict is unaltered by the inclusion of these additional variables: trade reduces the likelihood of wars in pooled regressions, but not when fixed effects are included.

The estimated war equation provides helpful insights as we turn back to our original problem of estimating a trade equation. We conclude this discussion by reporting in Table 5 the results of a panel instrumental variable gravity regression, where we now instrument for contemporaneous war with those variables found to be useful in explaining the likelihood of war in Table 4: the number of years since peace, major power status, alliance relationships, and distance (in addition to all of the regressors previously seen in the gravity estimates).[45]

---

[44]We downloaded version p4v2000 of the Polity IV dataset for Political Regime Characteristic and Transitions, 1800–1999 from the website www.bsos.umd.edu/cidcm/inscr/polity at the Center for International Development and Conflict Management, University of Maryland. Our data source for the military capability indices was the file "Cap93.csv" from the EUGENE program. These data extend only to 1993.

[45] We only instrument for contemporaneous war, not its lags. Note that the first stage of this procedure involves estimation of a linear probability, rather than a probit, equation for war, with fixed effects. Not surprisingly in view

For comparison, in Column 1 of Table 5 we report the corresponding fixed effect (CPFE) results when not instrumenting for war.[46] Year dummies are included but are not reported in both estimations. Without loss of generality, neutral effects are excluded. The coefficient on war is slightly higher (in absolute value) in the results from the instrumental variable procedure (2.02 versus 1.80), but all other coefficients are virtually unchanged. Thus controlling for simultaneity has a qualitatively insignificant effect on our analysis. A Hausman test confirms that the differences are also statistically insignificant; the hypothesis of a systematic difference between the two sets of results in Table 5 can be rejected at better than 1 percent.[47]

In sum, our estimates of war equations imply that the level of trade interdependence may help to answer the question of *which* countries engage in conflict, rather than *when* countries engage in conflict. Trade does not explain much of the time series variation in war for individual country pairs when CPFE estimation is used. Thus simultaneity does not appear to be a serious problem for our trade equations, and hence for our estimates of the effects of war on trade.

IV. 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.

A. Counterfactual Methodology

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 that in the year

---

of the results in Table 4, the explanatory power of these first stage regressions is poor; R-squared values are less than .10. Other regressions (not shown) show that the result in Table 5 is robust to the inclusion of PolityL and RelCap as additional instruments. Indeed, the war coefficient is even larger when these instruments are added.

46 These results are slightly different from those in Column 1 of Table 2 because the sample has been constrained by the availability of instruments.

47 Our IV estimates do not address possible bias due to selection on observables, i.e., where the decision to go to war is determined by particular variables that also influence trade. As an example of positive bias, if "bad" government institutions (say, autocracy) increase the likelihood of war while also dampening commercial trade ties, the estimated effect of war on trade may be biased up in absolute value. As an example of negative bias, a common border should bias this effect down in absolute value since it typically raises the likelihood of war, while also enhancing trade. The border effect is dealt with here by including the observable control in the trade "outcome" equation (see Heckman and Hotz 1989). A different way to address this issue, outside the scope of this paper, would be to a employ a non-parametric technique with propensity scoring in order to construct and compare the trade levels of matched samples of grouped observations with similar characteristics, where the "treatment" group contains countries at war and the "control" group those at peace (see Rubin and Thomas 1992).

before the outbreak of war (1913 for WWI, 1938 for WWII), which we denote here as year 0.[48] That is, we set $\text{Trade}_{ijt}^{normal} = \text{Trade}_{ij0}$ for all t>0 in the interval encompassing the contemporaneous years of war and the 10-year aftermath period over which our empirical analysis has suggested lagged effects of war may exist.

With these imputed "normal" trade levels in the absence of war, we then employ the gravity model to compute the comparative statics effects of war barriers in two ways. In the first approach we use our gravity model war coefficients from Table 3 (Columns 4 and 5) 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 over 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.[49] Because we do not take account of possible effects on multilateral resistance terms with this method, we refer to this as a "partial equilibrium" (PE) approach. In a second new approach, we take into account the possibility that war may endogenously affect the level of multilateral resistance and hence the overall adjustment of trade. Accordingly, we refer to this second method as a "general equilibrium" (GE) approach.

Specifically, in our partial equilibrium approach we calculate the fractional wartime reduction in trade for each pair as:[50]

$$\frac{\Delta \text{Trade}_{ijt}^{war}}{\text{Trade}_{ij0}} = e^{\left[\sum_k \gamma_k \text{War}_{ij,t-k} + \sum_k \lambda_k \text{Neutral}_{ij,t-k}\right]}$$

---

[48] We have tried other approaches to check 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 1914–27 and 1939–54 for all country pairs, and use that as the 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.

[49] 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 where 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. 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.

[50] For multi-year wars the contemporaneous effects of war for belligerents and neutrals — γ_0, λ_0 — apply for years t=1, …t*, where t* is the last year of the war; the lagged effects kick in for the aftermath years t*+1, … t*+10.

where Δ is the difference operator relative to the base year equilibrium (i.e., $\Delta \mathrm{Trade}_{ijt}^{war} = \mathrm{Trade}_{ijt}^{war} - \mathrm{Trade}_{ij0}$). The impact of war on world trade in each year can then be computed as a weighted sum:

$$\frac{\Delta \mathrm{Trade}_{t}^{war}}{\mathrm{Trade}_{0}} = \frac{\sum_{(i,j)} \left(e^{\left[\sum_k \gamma_k \mathrm{War}_{ij,t-k} + \sum_k \lambda_k \mathrm{Neutral}_{ij,t-k} \right]} \right) \left(\mathrm{Trade}_{ij0} \right)}{\sum_{(i,j)} \left(\mathrm{Trade}_{ij0} \right)}$$

where $\mathrm{Trade}_t = \sum_{(i,j)} \mathrm{Trade}_{ijt}$ denotes total world trade in year t.

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 (the BB country pairs):

$$\frac{\Delta \mathrm{Trade}_{t}^{war}}{\mathrm{Trade}_{0}} = \frac{\sum_{(i,j)} \left(e^{\left[\sum_k \gamma_k \mathrm{War}_{ij,t-k} \right]} \right) \left(\mathrm{Trade}_{ij0} \right)}{\sum_{(i,j)} \left(\mathrm{Trade}_{ij0} \right)}.$$

And, second, the reduction in world trade due to the impact of war on belligerent-neutral trade (among BN pairs):

$$\frac{\Delta \mathrm{Trade}_{t}^{war}}{\mathrm{Trade}_{0}} = \frac{\sum_{(i,j)} \left(e^{\left[\sum_k \lambda_k \mathrm{Neutral}_{ij,t-k} \right]} \right) \left(\mathrm{Trade}_{ij0} \right)}{\sum_{(i,j)} \left(\mathrm{Trade}_{ij0} \right)}.$$

In our general equilibrium approach, we still use the same gravity model parameter coefficient estimates, but when calculating the wartime trade level relative to the base year equilibrium, we allow the multilateral resistance terms P to change in response to the existence of trade barriers associated with war. To do this we employ the following compact form of the gravity equation based on the specification of Anderson and van Wincoop (2003)

$$\text{Trade}_{ijt} = \left(\frac{Y_{it}Y_{jt}}{Y_t}\right)\left(\frac{\tau_{ijt}}{P_{it}P_{jt}}\right)^{1-\sigma} \quad i,j = 1\ldots C, \ (i \neq j)$$

$$\left(P_{it}\right)^{1-\sigma} = \sum_j \theta_{jt}\left(\frac{\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} \qquad i = 1\ldots C$$

where σ is the elasticity of substitution, $\theta_j = Y_j/Y$, $Y = \sum_j Y_j$ are income shares, τ_{ij} denotes all bilateral trade barriers between countries i and j, and P_i denotes the average (unobserved) trade barriers or multilateral resistance faced by country i.[51]

We first determine the "no war" trade equilibrium of the model in our benchmark years, 1913 or 1938. More specifically, given observations in year 0 (=1913 or 1938) of output Y_{i0}, and hence world output shares θ_{i0}, as well as of bilateral trade levels Trade_{ij0}, we can solve for the equilibrium set of trade barriers τ_{ij} and multilateral resistance terms P_i in the base year that satisfy the system. We denote these equilibrium values as τ^o_{ij0}, P^o_{i0}, where the superscript "o" denotes the "no war" equilibrium.[52] Calibration of the elasticity parameter σ is also required.

Next we perturb the τ^o_{ij0} using our gravity model estimates of the trade barrier effects of war. More specifically, we define the perturbed trade barriers for a given year t as

$$\tilde{\tau}^{war}_{ijt} = \tau^o_{ij0} \cdot e^{\left[\sum_k (\gamma_k/(1-\sigma))\text{War}_{ij,t-k} + \sum_k (\lambda_k/(1-\sigma))\text{Neutral}_{ij,t-k}\right]}$$

[51] Note that the theoretical trade equation imposes coefficient values of unity on the trade elasticity of income changes and $1-\sigma$ on the trade elasticity to both the bilateral and multilateral trade barriers.

[52] In other words, we solve the set of equations $\text{Trade}_{ij0} = \left(Y_{i0} \cdot Y_{j0} / Y_0\right)\left(\tau^o_{ijt} / \left(P^o_{it} \cdot P^o_{jt}\right)\right)^{1-\sigma}$, $i, j \in C \times C \ (i \neq j)$ and $\left(P^o_{i0}\right)^{1-\sigma} = \sum_j \theta_{j0}\left(\tau^o_{ij0} / P^o_{j0}\right)^{1-\sigma}$, $i = 1\ldots C$ for the set of unknowns $\left\{\tau^o_{ijt}\right\}$, $\left\{P^o_{it}\right\}$. For a complete panel of trade and GDP data for C countries, there are C unknown P_i and C(C-1)/2 unknown τ_{ij} (since trade barriers are symmetric, i.e. $\tau_{ij} = \tau_{ji}$ and it is presumed that there are no internal trade barriers, i.e. $\tau_{ii} = 1$), implying a total of C(C-1)/2 + C unknown variables. Given C/(C-1)/2 bilateral trade equations and C equations for the multilateral resistance effects, the total number of equations and unknowns are equal. In actuality, the trade matrix is unbalanced because of missing observations for many trade pairs, implying the actual number of unknowns and equations is less. For every missing Trade_{ij} we reduce the number of τ_{ij} unknowns by 1 and the number of bilateral trade equations by 1, so that there are still an equal number of equations and unknowns. For 1913 there are 55 countries with GDP and at least one bilateral trade observations, and a total of 392 observations. For 1938 the system consists of data for 66 countries with 750 total observations. The numerical solutions were performed with Matlab's equation solver.

where the war and neutral effect coefficients γ_k, λ_k are obtained from our gravity model estimates.[53] We impose an assumption that all other variables in the trade cost function as well as output are constant across equilibria in this exercise, so as to isolate the direct impact of war on trade all else equal.[54] Thus we use the same set of $\{Y_{i0}\}$ and $\{\theta_{i0}\}$ as in the base year 0 along with the now exogenously given $\tilde{\tau}^{war}_{ijt}$ to solve our system for the unknown values of trade and resistance for the war equilibrium in each year t >0.

We denote these counterfactual levels as $\mathrm{Trade}^{war}_{ijt}, P^{war}_{it}$.[55] The resulting calculations allow us to compute the counterfactual trade losses for each year t relative to the base year equilibrium levels, Trade^{o}_{ijt}. As in the partial equilibrium exercise, we can also sum up to compute the aggregate trade loss across all pairs, or subsets of pairs, at each point in time.[56]

B. World War I and II Trade Losses

Figures 2 and 3 present the results of these partial equilibrium and general equilibrium exercises for World War I and World War II, respectively, with the impact on *total world trade* shown. The general equilibrium results use a calibrated value of $\sigma = 5$, as in Anderson and van Wincoop (2003). Our calculations are based on coefficients estimated from the average effects of all wars in the sample, reported in last two columns of Table 3, which reflect the estimated effects of World War I and II alone. These are the correct parameters to use if the great wars were more destructive of trade than other wars, a hypothesis for which we have found support.[57]

---

[53] Note that the coefficients from the gravity estimates are divided by $1-\sigma$ because the latter enters as an exponent of τ_{ij} in the bilateral trade equations. Since $\gamma_k < 0, \lambda_k < 0, 1-\sigma < 0$, trade barriers rise when the war (and/or neutral) dummies are "on", i.e. when $War_{jj,t-k} = 1$.

[54] Anderson and van Wincoop (2003) also take account of the valuation effects of changes in P_i on income shares, but they find this effect to be small in their comparative statics when eliminating all trade barriers. Since we find that the difference between partial and general equilibrium effects of war is relatively small, we assume that this additional effect is second order in our model and can be neglected.

[55] Here we solve the set of equations $\mathrm{Trade}^{war}_{ijt} = \left(Y_{i0} \cdot Y_{j0} / Y_0\right)\left(\tilde{\tau}^{war}_{ijt} / \left(P^{war}_{it} \cdot P^{war}_{jt}\right)\right)^{1-\sigma}$ for $i, j \in C \times C, (i \neq j)$ and $\left(P^{war}_{it}\right)^{1-\sigma} = \sum_j \theta_{j0} \left(\tilde{\tau}^{war}_{ijt} / P^{war}_{jt}\right)^{1-\sigma}$, $i = 1 \ldots C$ for the unknowns $\left\{\mathrm{Trade}^{war}_{ijt}\right\}, \left\{P^{war}_{it}\right\}$.

[56] The partial equilibrium exercise essentially is equivalent to perturbing the trade barriers relative to period 0, but holding the resistance terms P_i constant.

[57] The very destructive impacts of the great wars is apparent in columns 4 and 5 of Table 5, but the decline in trade would have been only a little smaller had we used the more conservative coefficients in the first column of Table 5, based on all wars.

Panel (a) shows the total destructive impact on world trade of war from the war-related trade frictions captured by our γ_k and λ_k coefficients. We can also examine an approximate decomposition of these impacts, as noted above. Panel (b) shows the impact of war on world trade (for *all* pairs) resulting from just the war-related trade frictions γ_k between BB (belligerent-belligerent) country pairs. Panel (c) shows the impact of war on world trade (for *all* pairs) resulting from the war-related trade frictions λ_k between BN (belligerent-neutral and) pairs. In the case of the general equilibrium calculations, these decompositions include the impact of changing multilateral resistance felt by all country pairs, including not just the BB and BN pairs, but also the belligerent-ally (BA) and neutral-neutral (NN) pairs. As expected, the general equilibrium decline of trade is always lower than when considering partial equilibrium effects alone.

In Figures 2 and 3, a ratio less than unity implies that trade in the presence of war is less than the (imputed) trade in the absence of war.[58] We may note that 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). Referring to the general equilibrium effects, Figures 2 and 3 show that:

- In the case of WWI, war among adversaries reduced world trade by roughly 14% in 1914-15 and almost 18% in 1916–18; the effects then dampen monotonically. The impact on neutrals reduced world trade by an additional 10%–15% 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, as more countries entered the war. The impact on neutrals accounts for a fall off in trade of an additional 35%–40% during 1939–41; this effect then decays as the United States 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 50% loss of trade over a 5-year to 7-year wartime period, followed by 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.

[58] 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.

V. Tallying the Costs of War

Although we find evidence suggestive of large economic losses via lost trade, we cannot easily attach a welfare measure to these losses. Moreover, 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 this 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).[59]

A. The Costs of World War I

Table 6 presents rough calculations of the costs of World War I on this basis, using the best estimates for dead and wounded, proxy real wage levels 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 all dead are assumed to be of working age.[60]

As the table reports, at war's end there were 8.6 million dead and 5.4 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

[59] We can also compare the results of our calculations with other costs of war, such as government spending necessary to engage in war as well as the value of property losses, although the data are fragmentary. See below.

[60] 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.

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 New Zealand lost 37 thousand (of 1.1 million) by the dead-equivalent measure; 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 world GDP of 3.4%. It is important to note that this cost was a significant burden for the world as well as for the 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.[61] 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 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. From the discussion in Section IV, there is reason to believe that the trade-related costs of war are substantial. As discussed earlier, Figure 2a shows the predicted size of "lost trade" during and after the war relative to a counterfactual "no war" scenario where trade levels are assumed to persist at their 1913 benchmark levels. Total trade falls by approximately 30% during each of the 5 wartime years relative to the benchmark. Figure 2b, attributes roughly half of the decline to war-related trade frictions arising from BB (belligerent-belligerent) country pairs; Figure 2c, attributes the remainder to the effects of the BN (belligerent-neutral) country pairs. In each case, the model

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

suggests that trade then recovered gradually over 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, for both our partial and general equilibrium exercises. 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 (e.g, as in Frankel and Rose 2002). In our notation, their basic cross-country regression model of the level of output per capita (Y/N) takes the form:

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

where X is a vector of other control variables and $\widetilde{Trade}/Y$ is the exogenous component of the country's trade share, which is constructed from an underlying first-stage gravity model using distance and other geographic variables as exogenous explanatory regressors.[62] This two-stage or instrumental variable (IV) approach allows the authors to control for the endogeneity of trade in these regressions, for 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 relationship. Frankel and Romer (1999, Table 3, column 2) give an IV estimate of $\delta = 1.97$ for the trade share. We made this calibration choice because the value of 1.97 is the authors' preferred central estimate; but we should note that the above expressions show that national or global costs are simply linear in the coefficient δ, so we can quickly and easily obtain revised cost estimates under plausible alternative assumptions about the coefficient δ, and we shall discuss such perturbations below.

The Frankel-Romer (FR) specification is ideally suited for our purposes since, at least with respect to the model used 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 declines in

[62] 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.

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 avoiding the question as to whether 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 focus on the trade channel allows us to finesse the issue, which is just as well given the scarce data on real output during wars.[63]

We proceed 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 prior to the start of war, here 1913. We can estimate the fractional loss of income in country i at time t > 0 using a linear approximation implied by the Frankel-Romer estimated equation:

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

Here, as we defined it above, $\Delta \mathrm{Trade}_{ijt}^{war}$ is the estimated change in trade for the pair at time t under wartime conditions relative to Trade_{ij0}, which is the assumed "normal" peacetime trade level in all years (1913 for World War I). As we have discussed, the simulation also keeps GDP levels at their peacetime constant level (Y_{i0}) to isolate the trade-destruction channel.

Denoting the set of all countries in the world as C, we next sum these GDP losses over pairs (i,j) for various (possibly time-varying) subsets of country pairs $V_t \subseteq C \times C$ and calculate their present value cost

$$\left(\frac{\Delta Y}{Y}\right)_{\{V_t\}} = \sum_t \sum_{(i,j)\in V_t} 2\delta\beta^t(1-\beta)\left(\frac{\Delta \mathrm{Trade}_{ijt}^{war}}{\mathrm{Trade}_{ij0}}\right)\left(\frac{\mathrm{Trade}_{ij0}}{Y_{i0}}\right)$$

by cumulating the discounted flow costs over the interval including the contemporaneous and lagged years of war, where β is the discount factor.

[63] This is not to say such effects are negligible. The magnitude of endogenous GDP shocks is the subject of considerable controversy in a parallel literature; recent research suggests they might also be quite large (Hess 2003).

In practice, we implement this cost calculation for various definitions of V_t, to capture the breakdown of all costs across five mutually disjoint country-pair subsets:

i. costs to belligerents from lost trade with belligerent adversaries (ij = BB pairs);
ii. costs to belligerents from lost trade with allies (ij = BA pairs);
iii. costs to belligerents from lost trade with neutral (ij = BN pairs);
iv. costs to neutrals from lost trade with belligerents (ij = NB pairs);
v. costs to neutrals from lost trade with neutrals (ij = NN pairs);

Some observations are required on this cost decomposition. Here ij = BA means a pair where i and j are in a war as belligerents, but they are on the same (i.e. "A" for allied) side. We note that in the partial equilibrium exercises, subsets (ii) and (v) are both zero, by assumption (we did estimate ally effects separately but, in results not reported, we found them to be small and not very statistically significant). However, in a general equilibrium calculation, all five costs can be nonzero due to changing multilateral resistance.

The base year (1913 or 1938) levels of trade and GDP used in these calculations presume that the composition of the five country-pair subsets is fixed, with the status of a country as a belligerent determined by whether it was ever at war during the conflict period (1914–18 or 1939–45). If all belligerent countries are involved in war for the entire conflict period (and do not switch sides) the country-pair subsets would stay fixed over time, since no country ever switches status between being neutral and belligerent (or vice versa). In actuality, some countries become belligerents later in the conflict period (e.g. the United States entered WWI in 1917 and WWII in 1941), while other countries ceased being belligerents before the overall conflict ends (e.g. Russia exited WWI in 1917). This does not affect the calculation of total world trade losses, but it *does* affect the decomposition of losses into the various subsets (BB, BN, BA, NB, NN); hence year-by-year adjustments must be made to deal with these changing composition effects of countries entering or leaving a war over time. As an example, the U.S. was neutral with respect to Germany during the years 1914–16, but an adversary of Germany during the years 1917–18. With a fixed composition, all changes in bilateral trade changes between the U.S. and Germany would be allocated to the BB pair set; in our adjustments we allocate the trade changes for the years 1914–16 to the BN and NB subsets. Similar adjustments are made for all countries which change status (between belligerent and neutral) during the conflict period.[64]

Table 7 reports the results of this exercise, applied to World War I, for both partial and general equilibrium approaches. Trade losses are shown on a present discounted basis relative to total *world* trade in 1913; GDP losses are shown on a present discounted basis relative to the total GDP for the country group (see column label) in 1913. Trade impacts are based on the gravity model in Table 3, column 4. GDP impacts are based on the Frankel-Romer regression estimate of the impact of trade on GDP level. Present value costs are computed using an annual discount factor of $\beta = 0.95$.[65]

In WWI the belligerent nations accounted for about half of world population, three-quarters of world GDP, and 80% of world trade. According to our general equilibrium estimation method, both belligerents *and* neutrals suffered large economic impacts. To be conservative, we focus our discussion on the general equilibrium results (partial equilibrium results are slightly larger, as expected).

[64] More specifically, to account for changing composition effects on trade we first generate year-by-year trade change results assuming *both* war and neutral trade barriers exist (i.e. the belligerent-belligerent and belligerent-neutral war dummies are “on”). We then allocate these trade changes across the fixed composition of the five country-pair subsets (BB, BA, BN, NB, and NN) based on whether countries were ever at war (where it should be noted that changes in BA and NN trade occur only because of general equilibrium effects on multilateral resistance). Second, we generate trade loss results assuming neutral trade barriers *alone* are in effect (i.e. only belligerent-neutral war dummies are “on”). In the absence of any composition effects from the beginning of the war, there should be no effect of these neutral barriers on trade for BB and BA pairs (aside from general equilibrium effects). Hence, any trade changes in a given year found for BB or BA pairs in this second calculation necessarily reflect trade effects for pairs in which one or both countries were neutral at that time, though they were belligerents before or after. As discussed in the text, for example, the U.S. was neutral with respect to Germany and the U.K. during 1914–16, and an adversary of Germany and an ally of the U.K. during 1917–18. Thus the trade change in response to neutral-belligerent war barriers during 1914–16 for the U.S. and Germany ($\Delta \mathrm{Trade}^{\mathrm{neutral}}_{\mathrm{US\text{-}GE}}$) and the U.S. and U.K. ($\Delta \mathrm{Trade}^{\mathrm{neutral}}_{\mathrm{US\text{-}UK}}$) capture BN/NB pair effects, while the trade change during 1917–18 for the U.S. and U.K. capture a BA pair effect. We use the results from this second round of calculations (with only neutral barriers in place) to adjust the trade loss changes for our fixed composition when both war and neutral barriers are in place. Thus, for example, in the case of U.S. and Germany for 1914–16, we subtract the neutral-barrier change ($\Delta \mathrm{Trade}^{\mathrm{neutral}}_{\mathrm{US\text{-}GE}}$) from the trade changes for the BB set and add it to the change for the BN/NB sets. In the case of U.S. and U.K. trade, we add the neutral barrier change ($\Delta \mathrm{Trade}^{\mathrm{neutral}}_{\mathrm{US\text{-}UK}}$) to the BN and NB sets for 1914–16 and to the BA set for 1917–18.

[65] We scale the trade losses by world trade, and not country groups, since the calculations for some country groups—e.g., BN and NN—are very sensitive to the country group trade totals used in the denominator. It was not clear how to measure group totals in the base year when some countries (like the U.S.) switched from neutral to belligerent/ally over time in the two world wars. To avoid this problem, we use total world trade in the base year in the denominator. This has the added advantage of permitting the summing of effects across different groups without any need for weighted sums. However, we scale GDP losses relative to group totals because the human costs are normally computed this way, i.e., relative to country group GDP.

Table 7 shows that lost trade was greatest among belligerents, as expected, leading to a permanent flow loss of 2.60% of their GDP (cell d). The decline in trade involving neutrals caused a further income loss of 0.89% of GDP (cell g). There was of course some "trade diversion" in general equilibrium, as would be expected. The presence of war barriers between BB and BN pairs also lowers multilateral resistance between BA and NN pairs in general equilibrium. But these effects turn out to be rather small. Belligerents losses on BB and BN trade were offset by a very small gain on BA trade of just –0.12% (cell j). The total flow loss to belligerents was 3.37% relative to the belligerents' own GDP (cell m).

Neutrals suffered greatly due to the collapse of trade with belligerents, but this was a *large* share of their own trade, explaining the substantial flow cost for them of 7.22% of their GDP (cell e). The offset due to trade diversion between neutrals was paltry, a flow gain of only 0.43% of GDP (cell h). The net cost to neutrals was thus a massive 6.79% on a flow basis relative to the neutrals' own GDP (cell n).

Summing up over all countries, the estimated cost to the world as a whole was 4.35% of world GDP on a permanent flow basis (cell o).[66]

On first sight it may seem odd that the small estimated impacts on neutrals seen in Figure 1 can generate such relatively large losses for neutrals compared to belligerents, but this follows from two facts. First, not every pair of belligerents was an adversarial pair. Second, many belligerents were large countries (in GDP terms) 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.

One possible concern is whether the results would be robust if we used the FR model to estimate the effect of lost trade on GDP *growth rates*, rather than GDP *levels* as above. We found

[66] The weighted sum of belligerent and neutral GDP losses is computed using Maddison 1913 GDP weights, as reported at the top of the table. The belligerents' weight is 71% ($1945.840/$2726.065) and the weight of the neutrals is 29%. In our counterfactuals the implicit weight on belligerent GDP is higher, at 89%, since we have GDP data for many fewer neutrals countries than are included in Maddison's world total (which includes many guesstimates). We prefer to use the Maddison weights here because they probably more accurately reflect the true weights of each country group. Use of his 71% weight is also desirable because it is conservative for our purposes and imparts a downward bias to our bottom line estimate; shifting to an 89% weight on belligerents would increase our estimated world losses as it would put a greater weight on the larger percentage losses suffered by belligerents.

that our method was robust. As a test, we used the "all war" coefficients is Table 3, column 1, and computed the implied costs of a hypothetical war two ways: first, using the above FR estimate of $\delta = 1.97$ for the impact of trade/GDP ratios on output levels; second, using the FR estimate of $\delta = 1.31$ for the impact of trade/GDP ratios on output growth rates (Frankel and Romer 1999, Table 4, column 10). Figure 4 assumes, for simplicity, a peacetime growth rate of 2% per annum, a discount rate of 5%, a trade share of 10% of GDP divided equally among allies, adversaries, and neutrals, and an initial income level of 1 in period 1 (shown as 100%). The losses are computed using the partial equilibrium method. Using the example of a five-year war (comparable to a major war like WWI) we find that the FR model in levels delivers a transitory loss to output that is fully reversed after 10 years of peace. The model in growth rates delivers a much smaller loss, but one that is permanent. It so happens that both trajectories deliver a loss of output of about 2.5% in present discounted value. Thus, by coincidence, the exact form of the FR model does not appear to matter for our welfare cost estimates.

Compared to the human costs, also shown in Table 7, the economic costs of lost trade 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—considerably smaller than the 4.35% attributed to lost trade. Under these assumptions and metrics, the striking conclusion is that the costs of lost trade due to WWI were somewhat higher than the horrible costs of lost human capital.

B. The Costs of World War II

We should not expect the same conclusion for World War II, which was a very different type of war. World War I and previous wars were confined essentially to battle zones, 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 (particularly 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 people into the armed services (Nesterov 1990). We should therefore expect all of its attendant direct costs to have been that much higher.

On the other hand, there is reason to question the magnitude of the indirect costs through damage to world trade. After all, there was much less trade at the beginning of World War II. 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 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 2, Table 6, and Table 7 for World War II. The results are shown in Figure 3 and in Tables 8 and 9. As noted earlier, Figure 3 is qualitatively very similar to Figure 2, although the trade losses are noticeably larger in World War II. Losses mount up a little more slowly in 1939–41 for adversaries, as the belligerency slowly spreads to include the European Lowland countries and Italy in 1940 and the United States and Japan at the very end of 1941. Figure 3b shows that during the war about 10%–20% of world trade was destroyed by the belligerent-belligerent (BB) pairs; but Figure 3c shows that a further 25%–40% was destroyed by belligerent-neutral (BN) pairs, which provides a graphic illustration of the importance of the negative externality effect. Total trade destruction in Figure 3a was about 40%–50% overall in the wartime years, with some evening out due to the change from neutral to belligerent status by some major trading nations, notably the United States. Trade then recovers over the subsequent decade after 1945.

Table 8 shows human costs, and now includes estimates of civilian casualties in the baseline figures, since World War II involved so many killed and injured noncombatants. We should interpret these figures cautiously, as the labor content of the civilian casualties was probably less than that of military casualties, implying our methodology will exaggerate somewhat 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 A3 supplies the details). Without imputation, the figure falls to 46.2 million (penultimate row, Table 8), and military casualties amount to about half the total, 34.7 million (final row).

Losses for individual countries, 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 (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, compared to Japan's 4.4 million). Occupied France lost 3.3%, Belgium 2.4%, and Netherlands 5.5%, but Denmark only 0.2% and Norway 0.8%. Britain's loss was 1.7%, less than New Zealand on a proportional basis. The United States 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 6, 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.

Using the same approach as in Table 7, Table 9 compares human costs to trade costs for World War II. Trade losses are shown relative to total *world* trade in 1938; GDP losses are relative to total GDP for the country group (see column label) in 1938. Trade impacts are now based on the gravity model in Table 3, column 5. Computing human loss relative to world GDP, not just belligerents' GDP, leaves a bottom line figure of 5.43% 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%. Trade costs appear at the foot of the table and are much smaller, as expected. Adversaries cost each other 1.45% of GDP (cell d) and also paid a further 1.11% due to trade lost with neutrals (cell g). A small gain due to trade diversion with allies of 0.03% (cell j) leaves a total loss to the belligerents of 2.53% of their own GDP (cell m). Neutrals suffered a loss in trade that we value at 11.80% of their own GDP on a flow basis (cell n), a very large loss. Again, as in World War I, neutrals were heavily hit because the countries that went to war were large, the neutrals were small and open, and belligerents accounted for a large share of neutrals' trade. Computing the weighted sum of these figures, we find an overall loss of 4.16% of world GDP for the permanent flow costs of World War II, a similar magnitude to the human costs.

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 9 versus 2.43% in Table 7) simply because it was bigger, longer, and deadlier. With respect to the costs of trade destruction, World War II was comparable to World War I (4.16% in Table 9 versus 4.35% in Table 7). There are some offsetting effects at work here. On the one hand, more nations and a greater share of the world's GDP were caught up in World War II, and the estimated coefficients in Table 3 suggest that the trade destruction was greater. On the other hand, overall world trade in the base year of 1938 (relative to GDP) had shrunk to about half its 1913 level.

C. What About Other Costs of War?

Of course, the value of lost human life is not the only cost of war. Total costs, though difficult to calculate, must also take account of the destruction of physical capital, excess military spending, looting, and many other types of loss. Yet even for wars that have been as meticulously studied as World Wars I and II, such estimates are still very rough and subject to considerable disagreement in the literature. Nonetheless, we now compare our trade related costs to the available figures, subject to this caveat, and we will argue that the trade-related costs still look quite large, and clearly so for World War I.

One of the most comprehensive studies of the total costs of World War I remains that of Bogart (1920), although it has been subject to recent criticism from Broadberry and Harrison (2005). The latter object to Bogart's calculation of human costs and prefer to use a "replacement cost" approach to figuring human capital losses. However, this tends to produce a small figure for human costs (much smaller than ours above) since the latter authors do not capture lost utility but only child rearing costs; the true cost is probably also underestimated since the gestation period for human capital (about 18 years) is much longer than that needed to build or purchase and install a piece of physical capital, and an appropriate discount factor should be added. Since we have already computed our own human costs above, using a broader utility type measure, we avoid these problems. We capture the lost "consumer surplus" that would have been achieved by the casualties. We also avoid the potential objection that we have biased the result in our favor (of finding a relatively high trade-related cost) by using a human capital measure that looks "too small." Instead we focus on Bogart's other measures of war costs. Granted, these too attract objections from Broadberry and Harrison (2005), mainly due to a failure to correct for wartime inflation, since Bogart computes nominal rather than real sums. But for our purposes, this gives the right bias—if Bogart's costs are too high and our trade costs still look significant in comparison, then they would look even bigger compared to inflation-adjusted costs.

According to Bogart, what he calls the "direct" costs of World War I (excess government spending necessary to wage war) were $186 billion in 1913 prices (Broadberry and Harrison 2005, Table 8). Excluding lost human capital, he found the "indirect" costs (property losses, etc.) were $84 billion. These are cumulative flows, or stock measures. For comparison we found the trade-related costs of World War I were 4.35% of world GDP on a flow basis, which equates to a stock value of $177 billion in 1913 prices. Our estimates of human costs were similarly $99 billion.[67] Adding these four figures we obtain a grand total of $546 billion, of which trade-related costs made up 32%. Thus, including the impact of lost trade would augment standard measures of the total costs of World War I by almost 50%—a significant correction, we think.

It would be desirable to be able to replicate these calculations with at least the same (albeit limited) degree of confidence for World War II, but for the second war the extant figures appear even more fragile and subject to wider suspicion. Broadberry and Harrison (2005, Table 13) report an attempt by Nesterov (1990) to apply an approach similar to Bogart. He estimated direct losses at $1,433 billion in 1938 prices, and indirect losses (including not only property but also lost human capital, not tabulated separately) at $2,567 billion, for a total of $4,000 billion (a surprisingly round number). In these same units, we would calculate the stock value of the trade-related costs of World War II at just $361 billion in 1938 prices, so that trade costs add less than 10% to the war's estimated total cost.[68] These provisional calculations caution that although our measures of trade costs are similar in the two wars, there are probably many other significant costs to be reckoned with in the massive conflagration of 1939–45.

D. Sensitivity Analysis

Our results suggest that the trade-related costs of war are of the same order of magnitude as the "traditional" costs of war measured in terms of human capital lost through deaths and injury. Is this finding robust? We think the link from war to trade is consistently large and of the magnitude shown, given our extensive robustness checks. The link from trade losses to GDP losses depends on our use of the Frankel and Romer (1999, Table 3) IV estimate of δ of 1.97 (s.e. = 0.99), the baseline coefficient we used to convert lost trade to lost income.

---

[67] World GDP of $2,726 billion in 1990 was deflated to 1913 dollars using a US CPI of 10/133.8; the resulting flow costs for trade and human losses were multiplied by 20 to convert a flow to a stock assuming a 5% discount rate.
[68] Based on 1.54% of world GDP in 1938, using a U.S. CPI correction of 14/133.8 and again multiplying by 20 to convert the flow to a stock assuming a 5% discount rate.

A wide range of values of the FR coefficient δ appear in the literature, and alternative values would alter our conclusion in a simple, proportional way, given that our costs are proportional to δ. For example, if we switch from the FR full sample of 150 countries to a subsample of 98 countries with potentially more robust data (see FR, Table 3, column 4), then the IV estimate is less precise, but it is also much larger, rising by 50% to 2.96 (s.e. = 1.49). An alternative to the 1985 FR cross-section analysis is the historical study by Irwin and Terviö (2002), which found similar δ coefficient magnitudes, although with low precision given smaller historical samples: IV estimates for 7 cross sections between 1913 and 1954 (Irwin and Terviö 2002, Table 4) gave an average estimate of 3.03.

Thus, we can be reassured that, for the historical periods we consider, similar trade-income coefficients have been detected. Still, to augment and qualify our bottom line results, we propose two conservative alternatives to our baseline results where we assume a smaller value for δ in the lower end of the consensus range from the literature, say, either $\delta = 1$ or $\delta = 0.5$.[69] The flow costs of World War One (baseline estimate 4.35%) would then be revised down to 1.1%–2.2% of world GDP, compared to the human cost estimate of 2.43%. The flow costs of World War Two (baseline estimate 4.16%) would be 1%–2% of world GDP, compared to the human cost of 5.43%. Even then, the costs remain large: 40%–80% of the then-shocking human costs of World War I or 20%–40% of the even-more-shocking human costs of World War II.

VI. 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 show that these costs can be large—of the same order of magnitude as more traditional measures of the costs of conflict, such as loss of life.

[69] If one is willing to ignore endogeneity, the OLS coefficients are typically smaller in this literature. However, Frankel and Romer (1999) reported that there is very little difference between their OLS and IV estimates, and that OLS coefficients do not overstate the impact of trade on income. Also, as noted by Rodriguez and Rodrik (2002) and confirmed in Irwin and Terviö (2002), the IV coefficients can be sensitive to the inclusion of latitude. In response, additional specification checks conducted by Rose showed that latitude and other geography controls have no deleterious impact on the size or significance of the trade coefficient in the GDP equation estimations in Frankel and Rose (2002), where the basic IV estimates of δ range between 1.59 and 1.96, with an OLS estimate of 0.79. See http://faculty.haas.berkeley.edu/arose/Rodrik.pdf. The basic estimates may be upward biased by omitted variables; smaller coefficients than these do appear in Frankel and Rose (2002) but only when other, probably endogenous and collinear controls, such as the investment ratio, are included as regressors in the income equation resulting in a probable downward bias (see their pp. 447–48). On these grounds we argue that the "conservative consensus" estimate of δ would be in the 0.5 to 1.0 range.

War is hell: the human toll suffered by belligerents as a result of war was immense; but, on narrow economic grounds, the losses due to trade were also of a significant magnitude and are not as widely appreciated. 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.

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 two world wars certainly offer a disturbing counterpoint to this vision: they affected an extremely large fraction of world trade and engulfed some of the most open trading nations on earth. Perhaps other mechanisms are needed to avert war, such as multinational institutions. An economic rationale for such institutions might be gleaned from this paper, given the emphasis we place on the important and neglected role of external effects. The large negative trade externalities imposed on neutrals by wars ought to have encouraged neutral countries to try to set limits to the belligerent tendencies of others. After the great wars, multilateral institutions (the League of Nations, the United Nations) held out such a promise, even if they were not entirely successful. Perhaps this was the only way to save neutrals from the large negative spillovers generated by the belligerents—as well as to save belligerents from themselves.

References

Adam, Christopher, and David Cobham. 2007. Modelling Multilateral Trade Resistance in a Gravity Model with Exchange Rate Regimes. Working paper, University of Oxford.

Anderson, James E., and Eric van Wincoop. 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review* 93(1): 170–92.

Anderson, James E., and Eric van Wincoop. 2004. Trade Costs. *Journal of Economic Literature* 42(3):691–751.

Anderton, Charles, and John Carter. 2001. The Impact of War on Trade: An Interrupted Time-Series Study. *Journal of Peace Research* 38 (4): 445–57.

Baier, Scott, and Jeffrey Bergstrand. 2006. *Bonus Vetus* OLS: A Simple Approach for Addressing the "Border Puzzle" and Other Gravity-Equation Issues. Working paper, Clemson University and University of Notre Dame, March.

Barbieri, Katherine. 1996a. Economic Interdependence and Militarized Interstate Conflict, 1870–1985. Ph.D. dissertation, SUNY Binghampton.

Barbieri, Katherine. 1996b. Economic Interdependence: A Path to Peace or a Source of Interstate Conflict? *Journal of Peace Research* 33(1):29–49.

Barbieri, Katherine. 2002. *The Liberal Illusion: Does Trade Promote Peace?* Ann Arbor, Mich.: University of Michigan Press.

Barbieri, Katherine, and Jack Levy. 1999. Sleeping with the Enemy: The Impact of War on Trade. *Journal of Peace Research* 36:463–79.

Barbieri, Katherine, and Gerald Schneider. 1999. Globalization and Peace: Assessing New Directions in the Study of Trade and Conflict. *Journal of Peace Research* 36 (4):387–404.

Bayer, Resat, and Matthew Rupert. 2004. Effects of Civil Wars on International Trade, 1950–92. *Journal of Peace Research* 41(6):699–713.
Bergstrand, Jeffrey H. 1989. The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade. *Review of Economics and Statistics* 71(1):143–53.
Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. How Much Should We Trust Differences-in-Differences Estimates? *Quarterly Journal of Economics* 119 (1):249–75.
Bogart, Ernest L. 1919. *Direct and Indirect Costs of the Great World War*. New York: Oxford University Press.
Blomberg, S. Brock, and Gregory Hess. 2004. How Much Does Violence Tax Trade? *Review of Economics and Statistics* 88(4):599–612.
Broadberry, Steven N., and Mark Harrison. 2005. The Economics of World War I: An Overview. In *The Economics of World War I*. Cambridge: Cambridge University Press.
Broadberry, Steven N, and Peter Howlett. 1998. The United Kingdom: "Victory at All Costs." In Mark Harrison, ed., *The Economics of World War II: Six Great Powers in International Comparison*. Cambridge: Cambridge University Press.
CIA World Factbook. http://www.odci.gov/cia/publications/factbook/index.html. August 14, 2000.
Eaton, Jonathan, and Samuel Kortum. 2002. Technology, Geography, and Trade. *Econometrica* 70(5):1741–79.
Estevadeordal, Antoni, Brian Frantz, and Alan M. Taylor. 2003. The Rise and Fall of World Trade, 1870–1939. *Quarterly Journal of Economics* 118 (May):359–407.
Feenstra, Robert C. 2002. Border Effects and the Gravity Equation: Consistent Methods for Estimation. *Scottish Journal of Political Economy* 49:491–506.
Feenstra, Robert C. 2004. *Advanced International Trade: Theory and Evidence*. Princeton, N. J.: Princeton University Press.
Ferguson, Niall. 1999. *The Pity of War*. New York: Basic Books.
Flandreau, Marc, and Mathilde Maurel. 2005. Monetary Union, Trade Integration, and Business Cycles in 19th Century Europe. *Open Economies Review* 16(2):135–52.
Frankel, Jeffrey A., and David Romer. 1999. Does Trade Cause Growth? *American Economic Review* 89 (3):379–99.
Frankel, Jeffrey A., and Andrew K. Rose. 2002. An Estimate of the Effect of Common Currencies on Trade and Income. *Quarterly Journal of Economics* 117:437–66.
Frankel, Jeffrey, Ernesto Stein, and Shang Jin Wei. 1996. Regional Trading Arrangements: Natural or Supernatural? *American Economic Review* 86 (May):52–56.
Gartzke, Erik, and Quan Li. 2003. Measure for Measure: Concept Operationalization and the Trade Interdependence-Conflict Debate. *Journal of Peace Research* 40(5):553–571.
Glick, Reuven, and Andrew K. Rose. 2002. Does a Currency Union Affect Trade? The Time Series Evidence. *European Economic Review* 46 (June):1125–51.
Goldin, Claudia, and Frank Lewis. 1975. The Economic Cost of the American Civil War: Estimates and Implications. *Journal of Economic History* 35 (June):299–326.
Gowa, Joanne. 1994. *Allies, Adversaries, and International Trade*. Princeton, N.J.: Princeton University Press.
Gowa, Joanne, and Edward D. Mansfield. 1993. Power Politics and International Trade. *American Political Science Review* 87(2):408–20.
Green, Donald, Soo Yeon Kim, and David Yoon. 2001. Dirty Pool. *International Organization* 55(2):441–68.
Heckman, James J. 1976. The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models. *Annals of Economic and Social Measurement* 5(4):475–92.

Heckman, James J., and V. Joseph Hotz. 1989. Choosing Among Alternative Nonexperimental Methods for Estimating the Impact of Social Programs: The Case of Manpower Training. *Journal of the American Statistical Association* 84(408):862–74.
Irwin, Douglas A., and Marko Terviö. 2002. Does Trade Raise Income? Evidence from the Twentieth Century. *Journal of International Economics* 58 (October):1–18.
Jaggers, Keith, and Ted R. Gurr. 1995. Tracking Democracy's Third Wave with the Polity III Data. *Journal of Peace Research* 32 (November):469–82.
Jones, Daniel, Stuart Bremer, and J. David Singer. 1996. Militarized Interstate Disputes: 1816–1992. *Conflict Management and Peace Science* 15:163–213.
Keshk, Omar, Brian Pollins, and Rafael Reuveny. 2004. Trade Still Follows the Flag: The Primacy of Politics in a Simultaneous Model of Interdependence and Armed Conflict. *Journal of Politics* 66(4):1155–79.
Kim, Hyung Min, and David L. Rousseau, 2005. The Classical Liberals Were Half Right (or Half Wrong): New Tests of the "Liberal Peace," 1960–88. *Journal of Peace Research* 42(5):523–43.
Klein, Michael W., and Jay C. Shambaugh. 2006. Fixed Exchange Rates and Trade. *Journal of International Economics* 70 (December):359–83.
Lemke, Douglas, and William Reed. 2001. The Relevance of Politically Relevant Dyads. *Journal of Conflict Resolution* 45(February):126–43.
Linders, Gert-Jan M., and Henri L.F. de Groot, 2006. Estimation of the Gravity Equation in the Presence of Zero Flows. Tinbergen Institute Discussion Papers 06-072/3.
López-Córdova, J. Ernesto, and Christopher M. Meissner. 2003. Exchange-Rate Regimes and International Trade: Evidence from the Classical Gold Standard Era. *American Economic Review* 93(1):344–53.
Maddison, Angus. 1995. *Monitoring the World Economy, 1820–1992.* Paris: OECD.
Maddison, Angus. 2001. *The World Economy: A Millennial Perspective.* Paris: OECD.
Mankiw, N. Gregory, David Romer, and David N. Weil. 1992. A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics* 107:407–37.
Mansfield, Edward D., and Rachel Bronson. 1997. Alliances, Preferential Trading Arrangements, and International Trade. *American Political Science Review* 91(1):94–107.
Mansfield, Edward D., and J. C. Pevehouse. 2000. Trade Blocs, Trade Flows, and International Conflict. *International Organization* 54:775–808.
Mansfield, Edward D., and Brian M. Pollins. 2001. The Study of Interdependence and Conflict: Recent Advances, Open Questions, and Directions for Future Research. *Journal of Conflict Resolution* 45(6):834–59.
Mansfield, Edward D., and Brian M. Pollins, eds. 2003. *Economic Interdependence and International Conflict: New Perspectives on an Enduring Debate.* Ann Arbor, Mich.: University of Michigan Press
Marshall, Monty G., and Keith Jaggers. 2000. Polity IV Project: Political Regime Characteristics and Transitions, 1800–1999, Dataset Users Manual. Center for International Development and Conflict Management (CIDCM), University of Maryland, College Park, Md.
Martin, Philippe, Thierry Mayer, and Mathias Thoenig. Forthcoming. Make Trade not War? *Review of Economics Studies*.
Meissner, Christopher M. 2005. A New World Order: Explaining the International Diffusion of the Gold Standard, 1870–1913. *Journal of International Economics* 66:385–406
Mitchell, Brian. 1992. *International Historical Statistics: Europe, 1750–1988.* New York: Stockton Press.
Mitchell, Brian. 1993. *International Historical Statistics: The Americas, 1750–1988.* New York: Stockton Press.
Mitchell, Brian R. 1998. *International Historical Statistics: Africa, Asia & Oceania, 1750–1988.* New York: Stockton Press.

Morrow, James, Randolph Siverson, and Tressa Taberes. 1998. The Political Determinants of International Trade: The Major Powers, 1907–1990. *American Political Science Review* 92 (September):649–61.

Morrow, James, Randolph Siverson, and Tressa Tabares. 1999. Correction to: "The Political Determinants of International Trade." *American Political Science Review* 93(4):931–33.

Nesterov, L. 1990. Tsena voiny [The Price of War]. *Vestnik statistiki* 5:3–7.

Obstfeld, Maurice, and Alan M. Taylor. 2003. Sovereign Risk, Credibility, and the Gold Standard: 1870–1913 versus 1925–31. *Economic Journal* 113 (April):1–35.

Oneal, John R., Frances H. Oneal, Zeev Maoz, and Bruce Russett. 1996. The Liberal Peace: Interdependence, Democracy, and International Conflict, 1950–86. *Journal of Peace Research* 33(1):11–28.

Oneal, John R., and Bruce Russett. 1997. The Classical Liberals were Right: Democracy, Interdependence and Conflict, 1950–1985. *International Studies Quarterly* 41:267–94.

Oneal, John R., and Bruce Russett. 1999. Assessing the Liberal Peace with Alternative Specifications: Trade Still Reduces Conflict. *Journal of Peace Research* 36:423–42.

Oneal, John R., and Bruce Russett. 2001. Clear and Clean: The Fixed Effects of the Liberal Peace. *International Organization* 55(2):469–85.

Oneal, John R., and Bruce Russett. 2005. Rule of Three, Let it Be? When More Really Is Better. *Conflict Management and Peace Science* 22:293–310.

Oneal, John R., Bruce Russett, and Michael Berbaum. 2003. Causes of Peace: Democracy, Interdependence, and International Organizations, 1885–1992. *International Studies Quarterly* 47(3):371–94.

Polachek, Solomon. 1980. Conflict and Trade. *Journal of Conflict Resolution*, 24:55–78.

Polachek, S. W. 1997. Why Democracies Cooperation More and Fight Less: The Relationship between International Trade and Cooperation. *Review of International Economics* 5:295–309

Pollins, Brian. 1989a. Conflict, Cooperation, and Commerce: The Effect of International Political Interactions on Bilateral Trade Flows. *American Journal of Political Science* 33:737–61.

Pollins, Brian. 1989b. Does Trade Still Follow the Flag? *American Political Science Review* 83:465–80.

Reuveny, Rafael. 2000. The Trade and Conflict Debate: A Survey of Theory, Evidence and Future Research. *Peace Economics, Peace Science and Public Policy* 6:23–49.

Reuveny, Rafael. 2001. Bilateral Import, Export, and Conflict/Cooperation Simultaneity. *International Studies Quarterly* 45(1): 131–158.

Reuveny, Rafael, and Heejoon Kang. 1998. Bilateral Trade and Political Conflict/Cooperation: Do Goods Matter? *Journal of Peace Research* 35(5):581–602.

Rodriguez, Francisco, and Dani Rodrik. 2001. Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence. In Ben Bernanke and Kenneth S. Rogoff, eds., *NBER Macroeconomics Annual 2000*. Cambridge, Mass.: MIT Press.

Rose, Andrew K. 2000. One Money, One Market: The Effect of Common Currencies on Trade. *Economic Policy* 15 (April):7–33.

Rose, Andrew K. 2004. Do We Really Know That the WTO Increases Trade? *American Economic Review* 94(1).

Rubin, Donald B., and Neal Thomas, 1992. Characterizing the Effect of Matching Using Linear Propensity Score Methods with Normal Distributions. *Biometrika* 79(4):797–809.

Russet, Bruce, and John Oneal. 2001. *Triangulating Peace: Democracy, Interdependence, and International Organizations.* New York: W. W. Norton.

Santos Silva, J.M.C., and Silvana Tenreyro. 2006. The Log of Gravity. *Review of Economics and Statistics* 88(4):641–658.

Schneider, Gerald, Katherine Barbieri, and Nils Petter Gleditsch, eds. 2003. *Globalization and Armed Conflict*. New York: Rowman & Littlefield.

Singer, J. David, and Melvin Small. 1993. National Material Capabilities Data, 1816–1985. Inter-University Consortium For Political And Social Research.

Taylor, Alan M., and Jeffrey G. Williamson. 1997. Convergence in the Age of Mass Migration. *European Review of Economic History* 1 (April):27–63.

Thursby, Jerry, and Marie Thursby. 1987. Bilateral Trade Flows, the Linder Hypothesis, and Exchange Risk. *Review of Economics and Statistics* 69(August):488–95.

Urlanis, B. 1971. *Wars and Population.* Moscow: Progress.

Zorn, Christopher. 2001. Estimating Between and Within Cluster Covariate effects, with an Application to Models of International Disputes. *International Interactions* 27(4):433–45.

Table 1: Sample Characteristics

	1870–1997	1870–1938	1939–97
Total			
Number of pair-year observations	251902	13799	238103
Number of country pairs	11535	739	11476
Number of countries	172	50	171
War, contemporaneous			
Number of pair-year observations	206	59	147
Number of country pairs	75	25	64
Number of countries	48	19	44
War, contemporaneous and lagged			
Number of pair-year observations	2143	410	1733
Number of country pairs	338	72	296
Number of countries	104	29	96

Note: “Total” refers to pair-year observations with data on bilateral trade and GDP (per capita). “War, contemporaneous” refers to pair-year observations with contemporaneous data on bilateral trade and GDP and also currently at war (War=1). “War, contemporaneous and lagged” refers to pair-year observations with data on trade and GDP at war currently or in the preceding 10 years (War=1 or War*n* =1 for *n* =1,…,10).

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

	Country Pair FE		Random Effects		Country FE		Poisson		Bonus Vetus	
War	-1.78		-1.78		-2.06		-1.72		-1.14	
	(0.22)	***	(0.22)	***	(0.23)	***	(0.24)	***	(0.32)	***
War1	-1.28		-1.24		-1.59		-0.72		-1.23	
	(0.27)	***	(0.26)	***	(0.30)	***	(0.22)	***	(0.35)	***
War2	-1.32		-1.28		-1.53		-0.70		-1.23	
	(0.22)	***	(0.22)	***	(0.25)	***	(0.18)	***	(0.30)	***
War3	-1.12		-1.09		-1.26		-0.51		-0.79	
	(0.15)	***	(0.15)	***	(0.17)	***	(0.17)	***	(0.24)	***
War4	-0.70		-0.68		-0.81		-0.68		-0.44	
	(0.13)	***	(0.13)	***	(0.17)	***	(0.14)	***	(0.22)	***
War5	-0.55		-0.51		-0.47		-0.55		-0.32	
	(0.09)	***	(0.09)	***	(0.12)	***	(0.11)	***	(0.16)	***
War6	-0.37		-0.33		-0.38		-0.45		-0.24	
	(0.08)	***	(0.08)	***	(0.09)	***	(0.10)	***	(0.12)	***
War7	-0.22		-0.20		-0.26		-0.42		-0.11	
	(0.07)	***	(0.07)	***	(0.08)	***	(0.09)	***	(0.10)	***
War8	-0.24		-0.21		-0.24		-0.36		-0.11	
	(0.08)	***	(0.08)	***	(0.08)	***	(0.08)	***	(0.10)	***
War9	-0.11		-0.09		-0.14		-0.35		-0.10	
	(0.06)	*	(0.06)		(0.08)	*	(0.08)	*	(0.09)	*
War10	-0.03		-0.01		-0.05		-0.32		-0.04	
	(0.06)		(0.06)		(0.07)		(0.08)		(0.09)	
Log Distance	---†		-1.38		-1.20		-0.84		-1.16	
			(0.03)	***	(0.03)	***	(0.04)	***	(0.03)	
Log Product Real GDPs	0.36		0.72		-0.19		0.13		-0.14	
	(0.04)	***	(0.02)	***	(0.06)	***	(0.10)	***	(0.06)	***
Log Product Real GDP/capita	0.64		0.43		1.09		0.92		1.06	
	(0.04)	***	(0.03)	***	(0.06)	***	(0.10)	***	(0.06)	***
Common Language	---†		0.33		0.44		0.14		0.52	
			(0.06)	***	(0.04)	***	(0.08)	***	(0.04)	
Common Land Border	---†		0.42		0.10		0.35		0.16	
			(0.14)	***	(0.11)		(0.10)		(0.11)	
Number Landlocked	---†		-0.35		-0.47		-5.06		0.82	
			(0.04)	***	††		(1.00)	**	(0.15)	
Number Islands	---†		0.08		-1.33		-3.83		0.95	
			(0.05)		††		(1.11)	***	(0.14)	
Log Product Land Areas	0.24		0.03		0.15		0.14		0.33	
	(0.08)	***	(0.02)		(0.12)		(0.12)		(0.01)	***
Current Colony	0.62		0.56		1.06		1.23		0.59	
	(0.16)	***	(0.16)	***	(0.22)	***	(0.35)	***	(0.28)	***
Ever Colony	---†		2.22		1.09		0.61		0.96	
			(0.13)	***	(0.13)	***	(0.14)	***	(0.12)	
Currency Union	0.21		0.17		0.92		0.27		1.11	
	(0.06)	***	(0.06)	***	(0.09)	***	(0.10)	***	(0.11)	***
R-squared	0.45		0.62		0.70		N/A		0.70	
Number of Observations	251902		251902		251902		325844		251902	
Number of Country Pairs	11535		11535		11535		11649		11535	
Pair Dummies	Yes		Yes		No		No		No	
Country Dummies	No		No		Yes		Yes		Yes	
Avg.Effect, War–War5	*-1.12*		*-1.09*		*-1.29*		*-0.81*		*-0.86*	

† variable dropped due to collinearity with country pair fixed effects. †† standard error too large to be reported.
Year dummies and constant not reported. Robust standard errors clustered at the country pair level in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 3: 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		-3.29		-3.46	
	(0.22)	***	(0.28)	***	(0.24)	***	(0.27)	***	(0.35)	***
War1	-1.33		-1.41		-1.37		-2.33		-1.41	
	(0.27)	***	(0.44)	***	(0.26)	***	(0.48)	***	(0.50)	***
War2	-1.35		-0.86		-1.58		-1.45		-2.14	
	(0.22)	***	(0.30)	***	(0.25)	***	(0.34)	***	(0.45)	***
War3	-1.15		-0.47		-1.31		-0.73		-1.46	
	(0.15)	***	(0.17)	***	(0.17)	***	(0.18)	***	(0.22)	***
War4	-0.74		-0.38		-0.80		-0.79		-1.08	
	(0.13)	***	(0.23)		(0.15)	***	(0.30)	***	(0.19)	***
War5	-0.57		-0.11		-0.65		-0.27		-0.75	
	(0.09)	***	(0.13)		(0.10)	***	(0.18)		(0.12)	***
War6	-0.39		-0.09		-0.44		-0.23		-0.51	
	(0.08)	***	(0.14)		(0.09)	***	(0.19)		(0.10)	***
War7	-0.24		0.00		-0.26		-0.07		-0.35	
	(0.07)	***	(0.11)		(0.08)	***	(0.14)		(0.09)	***
War8	-0.24		0.02		-0.28		-0.03		-0.35	
	(0.08)	***	(0.10)		(0.09)	***	(0.12)		(0.08)	***
War9	-0.11		0.10		-0.15		0.00		-0.26	
	(0.06)	*	(0.08)		(0.07)	*	(0.10)		(0.08)	***
War10	-0.03		0.12		-0.07		0.05		-0.12	
	(0.06)		(0.09)		(0.07)		(0.11)		(0.07)	*
Neutral	-0.13		-0.04		-0.12		-0.54		-1.06	
	(0.02)	***	(0.05)		(0.02)	***	(0.19)	***	(0.20)	***
Neutral1	-0.07		-0.02		-0.07		-0.36		-0.58	
	(0.02)	***	(0.05)		(0.02)	***	(0.23)		(0.28)	**
Neutral2	-0.04		0.07		-0.04		-0.25		-0.57	
	(0.02)	*	(0.05)		(0.02)	*	(0.10)	**	(0.23)	**
Neutral3	-0.05		0.00		-0.04		-0.15		-0.18	
	(0.02)	**	(0.06)		(0.02)	*	(0.09)		(0.10)	*
Neutral4	-0.09		-0.08		-0.08		-0.23		-0.16	
	(0.02)	***	(0.05)		(0.02)	***	(0.10)	**	(0.09)	*
Neutral5	-0.07		-0.03		-0.07		-0.13		-0.25	
	(0.02)	***	(0.05)		(0.02)	***	(0.09)		(0.07)	***
Neutral6	-0.09		-0.08		-0.09		-0.18		-0.27	
	(0.02)	***	(0.05)		(0.02)	***	(0.09)	**	(0.06)	***
Neutral7	-0.04		-0.08		-0.04		-0.12		-0.24	
	(0.02)	**	(0.05)		(0.02)	*	(0.08)		(0.06)	***
Neutral8	0.01		-0.09		0.02		-0.07		-0.14	
	(0.02)		(0.05)	*	(0.02)		(0.07)		(0.06)	**
Neutral9	0.02		-0.09		0.03		-0.12		-0.04	
	(0.02)		(0.04)	**	(0.02)		(0.07)	*	(0.05)	
Neutral10	0.02		-0.01		0.02		0.01		-0.08	
	(0.02)		(0.04)		(0.02)		(0.08)		(0.05)	
Average Effect, War–War5	*-1.17*		*-0.89*		*-1.27*		*-1.48*		*-1.72*	
Average Effect, Neu–Neu5	*-0.07*		*-0.02*		*-0.07*		*-0.28*		*-0.47*	
R-squared	0.46		0.31		0.16		0.31		0.13	
Number of Observations	251902		13799		238103		13799		238103	
Number of Country Pairs	11535		739		11476		739		11476	

Notes: 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. Robust standard errors clustered at the country-pair level are in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 4: Estimates of Likelihood of War, 1870-1997

	Logit	Panel Logit, Fixed Effect	Logit	Panel Logit, Fixed Effect	Logit	Panel Logit, Fixed Effect
$\ln(Trade_{ij}/Y_iY_j)_{t-2}$	-0.40 ***	0.05	-0.40 ***	0.16	-0.27 ***	0.03
	(0.02)	(0.09)	(0.03)	(0.11)	(0.04)	(0.10)
$YrsPeace_{t-2}$	-0.01 ***	0.11 ***	-0.01 ***	0.12 ***	-0.01 ***	0.09 ***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
MajPower	-1.06 ***	---†	-1.07 ***	---†	0.73 ***	---†
	(0.17)		(0.18)		(0.26)	
$Alliance_{t-2}$	-0.71 **	-0.69	-1.01 ***	-2.05 ***	-0.83 **	-0.60
	(0.29)	(0.43)	(0.30)	(0.58)	(0.33)	(0.43)
Border	0.89 ***	---†	0.91 **	---†	1.02 **	---†
	(0.34)		(0.38)		(0.43)	
Log Distance	0.01	---†	-0.02	---†	-0.31 **	---†
	(0.09)		(0.10)		(0.15)	
$PolityL_{t-2}$			-0.01	-0.40 ***		
			(0.01)	(0.07)		
$RelCap_{t-2}$					-0.35 ***	-0.42
					(0.08)	(0.28)
Pseudo R-squared	0.51		0.54		0.45	
Log Likelihood	-4335.49	-309.19	-3827.82	-205.19	-1937.27	-254.50
Number of Observations	187844	14522	149482	12126	148500	6730
Number of Country Pairs	9942	329	7812	275	8646	115

† variable dropped in fixed effects regression.

Notes: Year dummies and constant not reported. Estimates for YrsPeace divided by 100. Standard errors in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 5: Trade Effects of War, 1870-1997: Treating War as Endogenous

	Actual War		Instrumented War	
War	-1.80	***	-2.01	***
	(0.09)		(0.67)	
War1	-1.29	***	-1.30	***
	(0.16)		(0.17)	
War2	-1.32	***	-1.33	***
	(0.15)		(0.15)	
War3	-1.12	***	-1.13	***
	(0.13)		(0.13)	
War4	-0.71	***	-0.72	***
	(0.12)		(0.12)	
War5	-0.55	***	-0.56	***
	(0.10)		(0.10)	
War6	-0.37	***	-0.37	***
	(0.09)		(0.09)	
War7	-0.22	***	-0.23	***
	(0.08)		(0.08)	
War8	-0.24	***	-0.24	***
	(0.08)		(0.08)	
War9	-0.11		-0.12	
	(0.08)		(0.08)	
War10	-0.03		-0.03	
	(0.07)		(0.07)	
Log Distance	---†		---†	
Log Product Real GDP	0.36	***	0.36	***
	(0.01)		(0.01)	
Log Product Real GDP/capita	0.64	***	0.64	***
	(0.01)		(0.01)	
Common Language	---†		---†	
Common Land Border	---†		---†	
Number Landlocked	---†		---†	
Number Islands	---†		---†	
Log Product Land Areas	0.25	***	0.25	***
	(0.03)		(0.03)	
Current Colony	0.62	***	0.62	***
	(0.07)		(0.07)	
Ever Colony	---†		---†	
Currency Union	0.20	***	0.20	***
	(0.03)		(0.03)	
Average Effect, War–War5	*-1.13*		*-1.17*	
R-squared	0.45		0.39	
Number of Observations	251736		251736	
Number of Country Pairs	11535		11535	
Year Dummies	Yes		Yes	
Pair Dummies	Yes		Yes	
Country Dummies	No		No	

† Variable dropped due to collinearity with country pair fixed effects.
Notes: First column reports pooled panel estimates with fixed effects; second column reports pooled panel estimates with fixed effects while instrument out War. Instrumental variables are YrsPeace, MajPower, and Alliance, as well as variables in the gravity regression. Year dummies and constant not reported Standard errors in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Table 6: Human Costs of World War I

	Dead	Wounded	Dead equivalent	1913 Pop. (mil.)	Maddison (1990$) Cost ($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: Notes: Dead equivalent are estimated as 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 gives $2,781.5. GDP is then computed based on a total population in 1910 of 51.356 million from Mitchell (1992). Variant estimates of the death counts were considered for several countries, as follows. We found that the above Bogart-Ferguson casualty data closely match most the death counts for almost all countries in other studies, e.g., Broadberry and Harrison (2005), and the consensus is usually close to the figures presented in the original U.S. War Department study of 1924. This is not surprising since Urlanis (1971) is an important original source for these studies. However, most sources show wide disagreement with Urlanis in the case of four countries (see: e.g., http://users.erols.com/mwhite28/warstat1.htm), where Urlanis has very high estimates of death. 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, from 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; high: 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 7: 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	$2,726,065
1913 trade (1985$ million) with allies	$44,997	—	$44,997
1913 trade (1985$ million) with belligerents	$19,671	$16,403	$36,074
1913 trade (1985$ million) with neutrals	$16,403	$3,509	$19,912
1913 trade (1985$ million) total	$81,071	$19,912	$100,983
	Losses of Belligerents	Losses of Neutrals	Losses of World
Human costs	(a)	(b)	(c)
Population loss, dead equivalent	1.90%	—	0.92%
GDP loss, permanent flow	3.41%	—	2.43%
Trade costs with Belligerents	(d)	(e)	(f)
Trade loss, permanent flow, partial equilibrium	6.17%	2.60%	8.76%
Trade loss, permanent flow, general equilibrium	6.19%	2.13%	8.32%
GDP loss, permanent flow, partial equilibrium	2.59%	8.80%	4.37%
GDP loss, permanent flow, general equilibrium	2.60%	7.22%	3.92%
Trade costs with Neutrals	(g)	(h)	(i)
Trade loss, permanent flow, partial equilibrium	2.60%	—	2.60%
Trade loss, permanent flow, general equilibrium	2.13%	-0.13%	2.00%
GDP loss, permanent flow, partial equilibrium	1.09%	—	0.78%
GDP loss, permanent flow, general equilibrium	0.89%	-0.43%	0.52%
Trade costs with Allies	(j)	(k)	(l)
Trade loss, permanent flow, partial equilibrium	—	—	—
Trade loss, permanent flow, general equilibrium	-0.29%	—	-0.29%
GDP loss, permanent flow, partial equilibrium	—	—	—
GDP loss, permanent flow, general equilibrium	-0.12%	—	-0.09%
Trade costs, total	(m)	(n)	(o)
Trade loss, permanent flow, partial equilibrium	8.76%	2.60%	11.36%
Trade loss, permanent flow, general equilibrium	8.03%	2.00%	10.03%
GDP loss, permanent flow, partial equilibrium	3.68%	8.80%	5.14%
GDP loss, permanent flow, general equilibrium	3.37%	6.79%	4.35%

Notes: Trade losses are relative to total *world* trade in 1913; GDP losses are relative to the total GDP for the country group (see column label) in 1913. Trade impacts are based on the gravity model in Table 3, column 4. GDP impacts are based on the Frankel-Romer regression estimate of the impact of trade on GDP level. The discount factor is 0.95. The definition of belligerents in the weighting data 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). Partial equilibrium results hold adjustment of multilateral resistance barriers constant; general equilibrium results allow endogenous adjustment of trade flows and multilateral resistance barriers. These effects are adjusted to reflect changes in the composition of which countries were belligerent, adversarial, allied, or neutral during the period.
Sources: Weighting data on population and GDP from Maddison (1995). Trade data are from the authors' data; see text.
(a) based on Table 6 and its underlying calculations;
(b) zeroes assumed;
(c) based on a weighted average of (a) and (b);
(d) see text and Table 3, Column 4; GDP costs depend on trade losses and elasticity of income to trade share;
(e) see text and Table 3, Column 4; GDP costs depend on trade losses and elasticity of income to trade share;
(f) based on a weighted average of (d) and (e) using belligerent and neutral shares of world trade and GDP, respectively;
(g) trade loss as (d);
(h) zeroes assumed in partial equilibrium;
(i) based on a weighted average of (g) and (h) using belligerent and neutral shares of world trade and GDP, respectively;
(j) zeroes assumed in partial equilibrium;
(k) zeros assumed;
(l) based on a weighed average of (j) and (k) using belligerent and neutral shares of world trade and GDP, respectively;
(m) based on a sum of (d), (g), (j);
(n) based on a sum of (e) and (h);
(o) based on a sum of (f), (i), (l).

Table 8: Human Costs of World War II

	Dead	Wounded	Dead equivalent	1938 Pop. (mil.)	Maddison (1990$) Cost ($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%
United States*	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%*

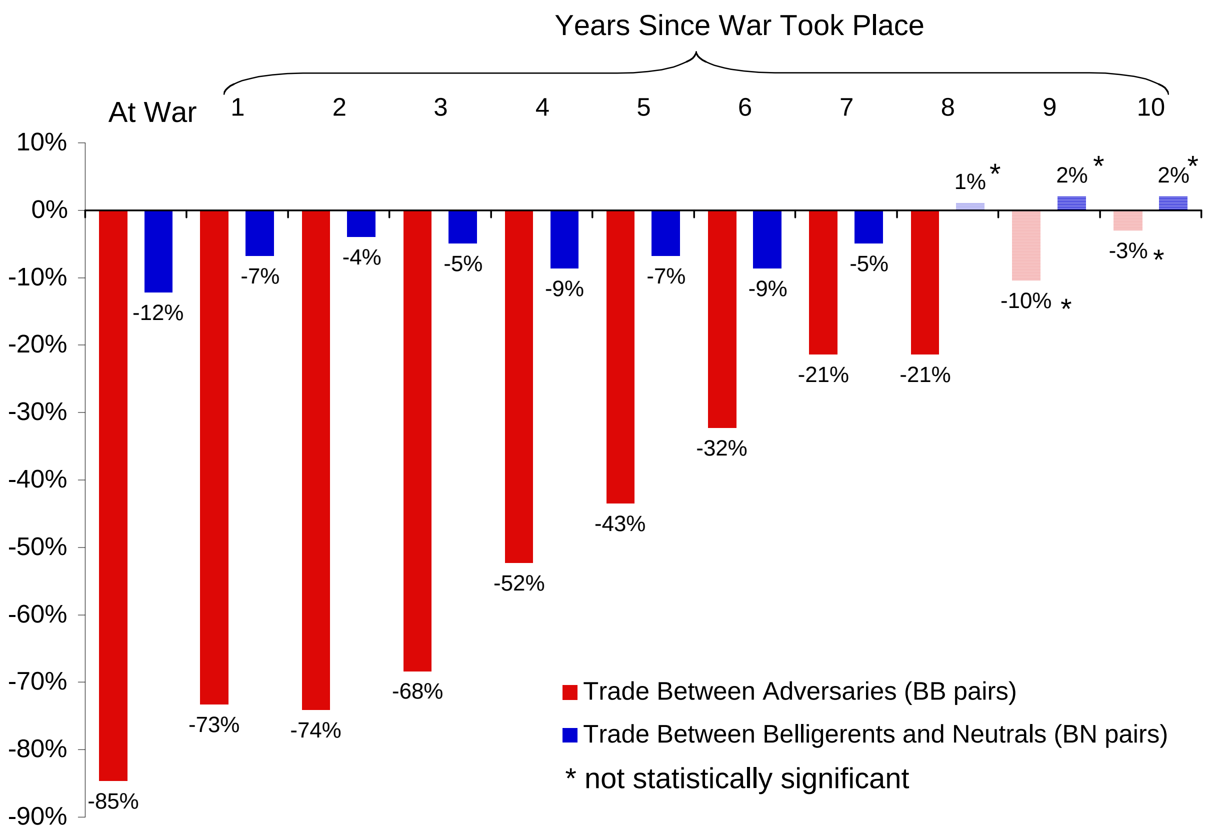
Sources: See text and notes. Dead and wounded include both military and civilian casualties; some missing data are imputed except for rows marked *. See Appendix Table A3 for details and sources. Incomes and populations are from Maddison (2004), adjusted to 1938 borders using Maddison (1995, 2001); Czechoslovakia data are 1937 values and South Africa data are interpolated using 1913 and 1950 values.
Notes: Dead equivalent are estimated as 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 9: Economic Costs of World War II: Human versus Trade

	Belligerent Countries	Neutral Countries	World
Weighting data			
1913 population (million)	1,760	489	2,249
1938 GDP (1990$ million)	$3,413,265	$731,461	$4,144,726
1938 trade (1985$ million) with allies	$37,519	—	$37,519
1938 trade (1985$ million) with belligerents	$18,042	$8,434	$26,476
1938 trade (1985$ million) with neutrals	$8,434	$2,563	$10,997
1938 trade (1985$ million) total	$63,994	$10,997	$74,991
	Losses of Belligerents	Losses of Neutrals	Losses of World
Human costs	(a)	(b)	(c)
Population loss, dead equivalent	4.52%	—	3.54%
GDP loss, permanent flow	6.59%	—	5.43%
Trade costs with Belligerents	(d)	(e)	(f)
Trade loss, permanent flow, partial equilibrium	6.98%	5.71%	12.69%
Trade loss, permanent flow, general equilibrium	7.02%	5.40%	12.42%
GDP loss, permanent flow, partial equilibrium	1.61%	11.65%	3.38%
GDP loss, permanent flow, general equilibrium	1.45%	11.89%	3.29%
Trade costs with Neutrals	(g)	(h)	(i)
Trade loss, permanent flow, partial equilibrium	5.71%	—	5.71%
Trade loss, permanent flow, general equilibrium	5.40%	-0.04%	5.36%
GDP loss, permanent flow, partial equilibrium	1.09%	—	0.90%
GDP loss, permanent flow, general equilibrium	1.11%	-0.09%	0.90%
Trade costs with Allies	(j)	(k)	(l)
Trade loss, permanent flow, partial equilibrium	—	—	
Trade loss, permanent flow, general equilibrium	-0.16%	—	-0.16%
GDP loss, permanent flow, partial equilibrium	—	—	—
GDP loss, permanent flow, general equilibrium	-0.03%	—	-0.03%
Trade costs, total	(m)	(n)	(o)
Trade loss, permanent flow, partial equilibrium	12.69%	5.71%	18.41%
Trade loss, permanent flow, general equilibrium	12.25%	5.36%	17.61%
GDP loss, permanent flow, partial equilibrium	2.71%	11.65%	4.28%
GDP loss, permanent flow, general equilibrium	2.53%	11.80%	4.16%

Notes: Trade losses are relative to total *world* trade in 1938; GDP losses are relative to the total GDP for the country group (see column label) in 1938. Trade impacts are based on the gravity model in Table 3, column 5. GDP impacts are based on the Frankel-Romer regression estimate of the impact of trade on GDP level. The discount factor is 0.95. The definition of belligerents in the weighting data is those countries ever involved in WWII 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). Partial equilibrium results hold adjustment of multilateral resistance barriers constant; general equilibrium results allow endogenous adjustment of trade flows and multilateral resistance barriers. These effects are adjusted to reflect changes in the composition of which countries were belligerent, adversarial, allied, or neutral during the period.
Sources: Weighting data on population and GDP from Maddison (1995). Trade data are from the authors' data; see text.
(a) based on Table 8 and its underlying calculations;
(b) zeroes assumed;
(c) based on a weighted average of (a) and (b);
(d) see text and Table 3, Column 5; GDP costs depend on trade losses and elasticity of income to trade share;
(e) see text and Table 3, Column 5; GDP costs depend on trade losses and elasticity of income to trade share;
(f) based on a weighted average of (d) and (e) using belligerent and neutral shares of world trade and GDP, respectively;
(g) trade loss as (d);
(h) zeroes assumed in partial equilibrium;
(i) based on a weighted average of (g) and (h) using belligerent and neutral shares of world trade and GDP, respectively;
(j) zeroes assumed in partial equilibrium;
(k) zeros assumed;
(l) based on a weighed average of (j) and (k) using belligerent and neutral shares of world trade and GDP, respectively;
(m) based on a sum of (d), (g), (j);
(n) based on a sum of (e) and (h);
(o) based on a sum of (f), (i), (l).

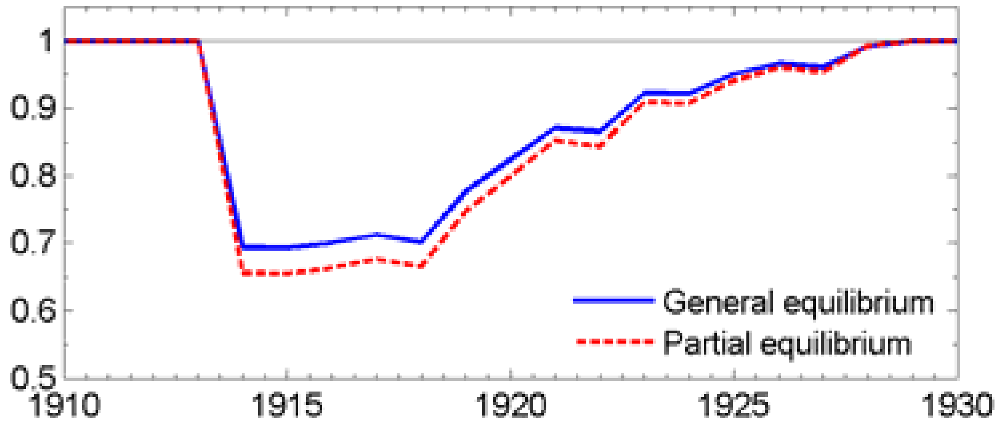
Figure 1
Impact of War on Trade for a Given Country Pair
Contemporaneous Impact and Lags 1 through 10



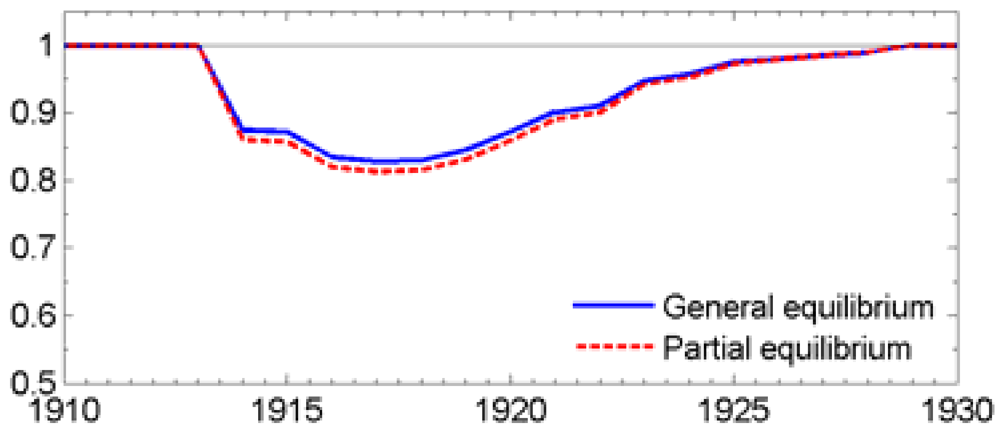
Source: Table 3, column 1.

Figure 2
Impact of World War I on Total World Trade
Predicted Aggregate Wartime Trade Relative to Counterfactual Peacetime Level (1913)

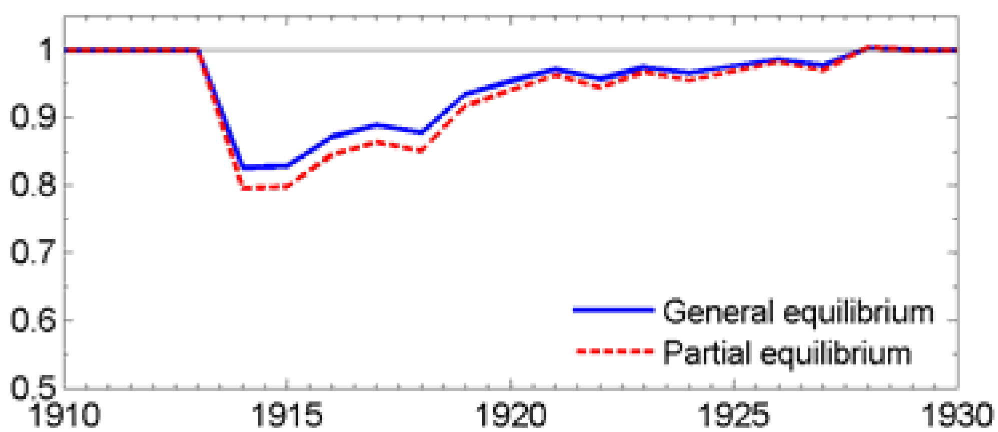
(a) Total due to both Belligerent-Belligerent and Belligerent-Neutral War Barriers



(b) Due to Belligerent-Belligerent War Barriers



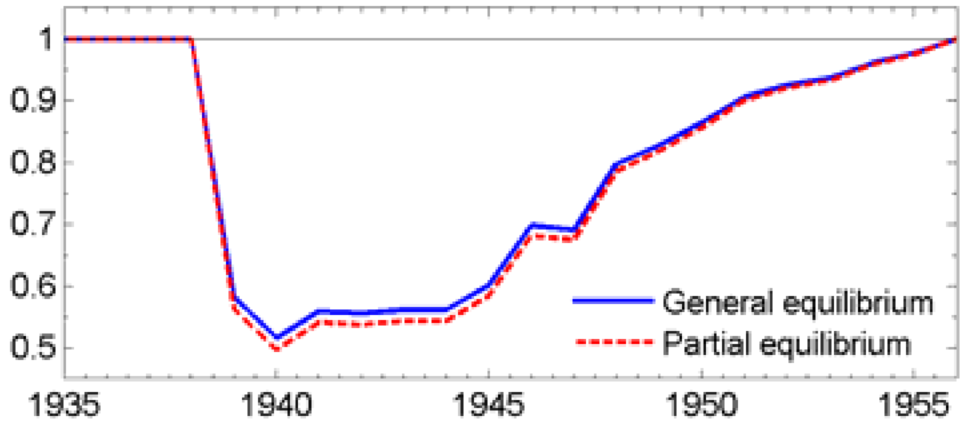
(c) Due to Belligerent-Neutral War Barriers



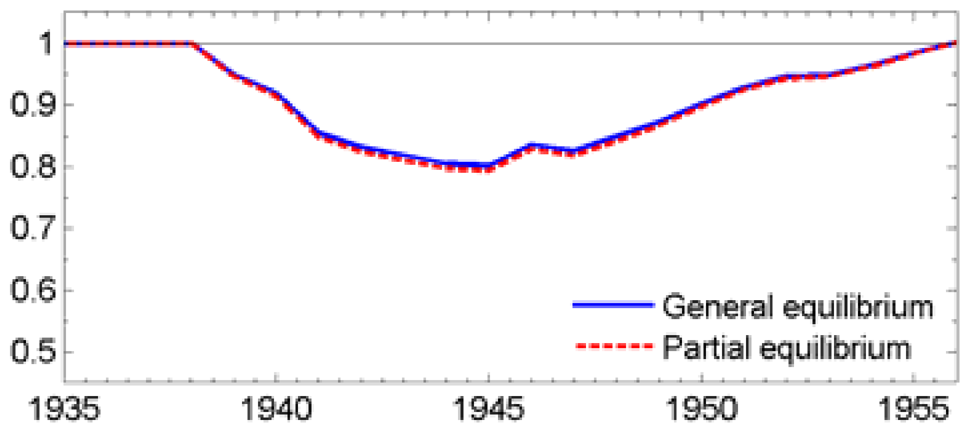
Notes and Sources: Authors' calculations. See text.

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

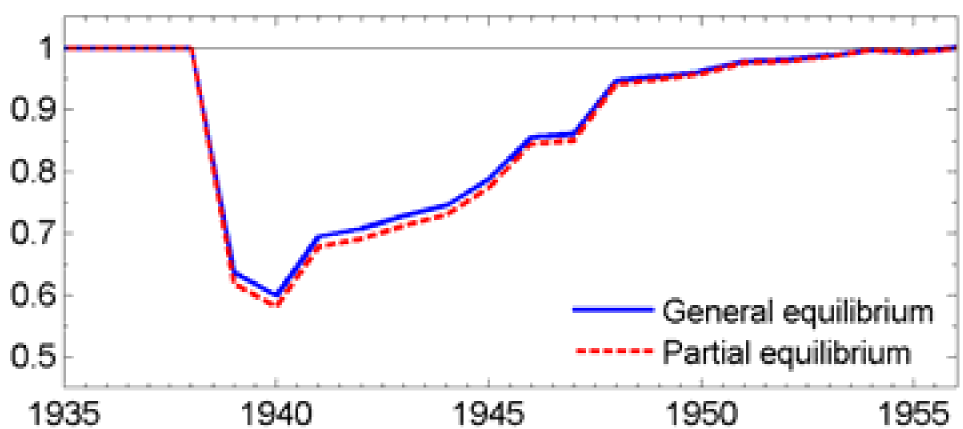
(a) Due to both Belligerent-Belligerent and Belligerent-Neutral War Barriers



(b) Due to Belligerent-Belligerent War Barriers

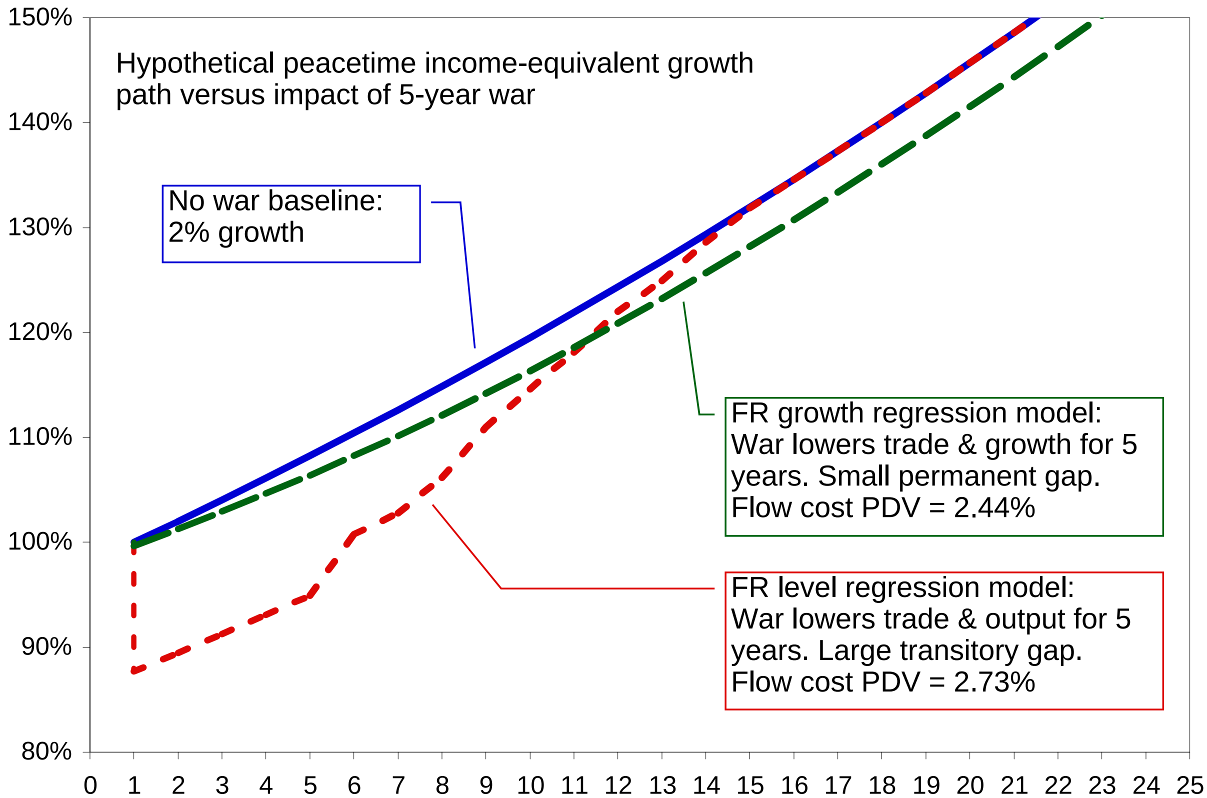


(c) Due to Belligerent-Neutral War Barriers



Notes and Sources: Authors' calculations. See text.

Figure 4
Impact of War on Trade and Growth Trajectory
Comparison of Predicted Present Discounted Value of Losses
Using the Frankel-Romer Model in Levels versus Growth Rates



Note: Based on partial equilibrium loss calculation and coefficients from Table 3, column 1.

APPENDIX MATERIALS NOT NECESSARILY FOR PUBLICATION

Appendix Table A1: Trade Effects of Different Wars, 1870–1997, CPFE estimates

The table reports 66 coefficients for status-lag-type interaction terms from a single CPFE regression: for status as war or neutral, for lags zero to ten years, and for three types of war (WWI, WWII, and other).

	WWI		WWII		Other Wars	
War	-3.46		-3.06		-0.91	
	(0.29)	***	(0.37)	***	(0.23)	***
War1	-2.58		-1.00		-1.32	
	(0.47)	***	(0.60)	*	(0.27)	***
War2	-1.63		-1.91		-0.97	
	(0.38)	***	(0.48)	***	(0.28)	***
War3	-0.98		-1.32		-1.09	
	(0.21)	***	(0.23)	***	(0.27)	***
War4	-1.00		-1.00		-0.42	
	(0.33)	***	(0.19)	***	(0.23)	*
War5	-0.37		-0.72		-0.52	
	(0.22)	*	(0.12)	***	(0.22)	**
War6	-0.33		-0.48		-0.43	
	(0.24)		(0.10)	***	(0.20)	**
War7	-0.23		-0.34		-0.24	
	(0.16)		(0.09)	***	(0.19)	
War8	-0.10		-0.35		-0.19	
	(0.14)		(0.08)	***	(0.22)	
War9	0.06		-0.25		0.04	
	(0.12)		(0.08)	***	(0.15)	
War10	0.20		-0.11		-0.01	
	(0.15)		(0.07)		(0.14)	
Neutral	-0.52		-0.96		-0.11	
	(0.19)	***	(0.19)	***	(0.02)	***
Neutral1	-0.36		-0.47		-0.06	
	(0.21)	*	(0.29)	*	(0.02)	***
Neutral2	-0.14		-0.45		-0.03	
	(0.11)		(0.23)	**	(0.02)	
Neutral3	-0.05		-0.15		-0.04	
	(0.10)		(0.10)		(0.02)	*
Neutral4	-0.15		-0.14		-0.08	
	(0.11)		(0.09)		(0.02)	***
Neutral5	-0.05		-0.27		-0.05	
	(0.10)		(0.07)	***	(0.02)	**
Neutral6	-0.15		-0.31		-0.07	
	(0.10)		(0.06)	***	(0.02)	***
Neutral7	-0.11		-0.25		-0.03	
	(0.10)		(0.06)	***	(0.02)	
Neutral8	0.01		-0.12		0.02	
	(0.09)		(0.06)		(0.02)	
Neutral9	-0.10		-0.02		0.03	
	(0.10)		(0.05)		(0.02)	
Neutral10	0.04		-0.06		0.03	
	(0.11)		(0.05)		(0.02)	
Average Effect, War–War5	*-1.67*		*-1.50*		*-0.87*	
Average Effect, Neu–Neu5	*-0.21*		*-0.41*		*-0.06*	
R-squared			0.46			
Number of Observations			251902			
Number of Country Pairs			11535			

Notes: Controls not reported: distance, output, output per capita, language, land border, landlocked, islands, land area, current colony, ever colony, currency union, year dummies, country-pair fixed effects, and constant. Robust standard errors clustered by country pairs reported in parentheses. Significance at 1%, 5%, and 10% indicated by ***, **, and *, respectively.

Appendix Table A2: Trade Effects of Different Wars, 1870–1997, Heckit estimates

The table reports 66 coefficients for status-lag-type interaction terms from a Heckman OLS regression: for status as war or neutral, for lags zero to ten years, and for three types of war (WWI, WWII and other).

	WWI		WWII		Other Wars	
War	-3.78		-3.40		-1.09	
	(0.38)	***	(0.43)	***	(0.22)	***
War1	-3.32		-1.59		-1.45	
	(0.50)	***	(0.62)	***	(0.35)	***
War2	-2.11		-2.39		-1.07	
	(0.37)	***	(0.46)	***	(0.40)	***
War3	-1.47		-1.31		-1.19	
	(0.28)	***	(0.23)	***	(0.32)	***
War4	-1.42		-0.94		-0.52	
	(0.40)	***	(0.21)	***	(0.31)	*
War5	-0.62		-0.45		-0.57	
	(0.31)	**	(0.14)	***	(0.31)	*
War6	-0.64		-0.31		-0.55	
	(0.32)	**	(0.11)	***	(0.22)	**
War7	-0.64		-0.18		-0.41	
	(0.25)	**	(0.10)	*	(0.19)	**
War8	-0.55		-0.19		-0.26	
	(0.23)	**	(0.10)	**	(0.21)	
War9	-0.08		-0.13		-0.18	
	(0.21)		(0.09)		(0.17)	
War10	0.06		0.02		-0.22	
	(0.22)		(0.09)		(0.15)	
Neutral	-0.48		-0.93		-0.15	
	(0.24)	**	(0.25)	***	(0.03)	***
Neutral1	-0.31		-1.16		-0.05	
	(0.26)		(0.34)	***	(0.03)	**
Neutral2	-0.12		-1.08		-0.03	
	(0.19)		(0.29)	***	(0.03)	
Neutral3	-0.04		-0.01		-0.02	
	(0.17)		(0.12)		(0.02)	
Neutral4	-0.10		-0.03		-0.07	
	(0.18)		(0.10)		(0.03)	***
Neutral5	-0.06		-0.07		-0.03	
	(0.17)		(0.08)		(0.02)	
Neutral6	-0.16		-0.12		-0.06	
	(0.17)		(0.08)		(0.03)	**
Neutral7	-0.11		-0.11		-0.05	
	(0.17)		(0.08)		(0.03)	**
Neutral8	0.00		-0.03		0.01	
	(0.17)		(0.07)		(0.03)	
Neutral9	-0.06		0.07		0.03	
	(0.17)		(0.07)		(0.02)	
Neutral10	0.09		0.02		0.01	
	(0.16)		(0.06)		(0.02)	
Average Effect, War–War5	*-2.12*		*-1.68*		*-0.98*	
Average Effect, Neu–Neu5	*-0.19*		*-0.55*		*-0.06*	
Number of Observations			325844 total 251902 uncensored			
Number of Country Pairs			11649			

Notes: See Appendix Table A1. Country-specific fixed effects used instead of country-pair effects. The Heckit estimates use Stata's default MLE option and the first stage equation has the same regressors (with identification by functional form). The estimate of the correlation of first and second stage error terms was –0.06.

Appendix Table A3: 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
United States	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 Chinese 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.

Data Appendix

This appendix provides a more detailed description of the source and construction of the data for trade, real GDP, GDP per capita, and land area. Details for all other variables are contained in the text.

Bilateral Trade

As discussed in the text, trade data for the period 1948-1997 were constructed from the IMF's *Direction of Trade* (DoT). These data are essentially the same as in Glick and Rose (2002); the dataset is obtainable from http://faculty.haas.berkeley.edu/arose/RecRes.htm#Software. The average value of bilateral trade between each pair of countries is created by averaging all of the possible trade values potentially available (exports from i to j, exports from j to i, imports into i from j, imports into j from i). Observations where all four figures have a zero or missing value are dropped from the sample in our benchmark regressions. The text describes how we impute missing values for the purpose of robustness checks of our results.

The primary source of trade data for 1870-1947 is Barbieri (1996a); her International Trade Dataset Version 1.1 can be obtained from http://pss/la.psu.edu/trd_data.htm. Since her data measure bilateral trade as the sum of exports and imports between each country pair (imports into i into j and into j from i) exports), these figures are divided by two to create an average value of trade. When Barbieri data are unavailable, bilateral export and import data from Mitchell (1992, 1993, 1998) for selected countries with their main trading partners are used. As with the DoT trade data used for the 1948-97 period, bilateral trade for each country pair is constructed from the Mitchell data by averaging all of the possible trade values potentially available. Remaining data gaps are filled where possible from López-Córdova and Meissner (2003).

The Barbieri trade data are expressed in millions of current U.S. dollars. López-Córdova and Meissner's trade are expressed in real 1990 U.S. dollars and were converted into nominal dollar terms using the U.S. consumer price index. The Mitchell data, which are expressed in current local currency terms, were converted into current dollar with the official exchange rate series from Global Financial Data (GFD), with exceptions noted below.

Argentina: Official rate from Mitchell (1993) is used through 1910. Data from 1911 on comes from Gerardo della Paolera, Alan M. Taylor and Carlos G. Bózzoli, "Historical Statistics," in della Paolera and Taylor, eds., *A New Economic History of Argentina* (Cambridge: Cambridge University Press, 2003).

Bulgaria: French Franc rate is used while Bulgaria was in the Latin Monetary Union (1880-1898, 1906-1911). An average of the 1898 and 1906 exchange rates is used for the intervening years. The 1911 rate is used for 1912 and 1913. The official Bulgarian Lev rate from GFD is used from 1920 onward.

Chile: For all years, the data comes from Juan Braun et al., "Economía Chilena 1810-1995: Estadísticas Históricas," Documento de Trabajo no. 187, Pontificia Universidad Católica de Chile, Instituto de Economía (Enero), Santiago (January 2000).

China: Trade figures for 1905-1932 in Mitchell (1998) converted from Haikwan tael into dollars using exchange rate from GFD. Figures for 1933-1938 converted into yuan at exchange rate of 1 tael = 0.72 yuan, and the yuan/dollar exchange rate from GFD then used for conversion into dollars.

Colombia: Exchange rate implicit from gold content from GFD used while Colombia was on gold standard (1871-1885, 1907-1913). For the years 1886 through 1906, we used the average of the 1885 and 1907 exchange rates; for the years 1914-1918 we used the average of the 1913 and 1919 exchange rates. The peso exchange rate from GFD was used from 1919 on.

Ghana: U.K. Pound exchange rate is used.

Greece: French Franc rate from GFD is used while Greece was in the Latin Monetary Union (1870-1876). Exchange rate figures for 1880-89 come from Michael Bordo. Figures for 1901-1945 are from GFD; the DOT rate for 1948 is used for 1946 and 1947.

Romania: French Franc rate from GFD was used while Romania was in the Latin Monetary Union (until 1914).

Serbia: French Franc rate from GFD used

Uruguay: Data for 1885-. comes from GFD; the exchange rate for the years 1874-1884 is set equal to the 1885 rate.

Lastly, exchange rate data from the DoT for 1948 is used for 1946 and 1947 for the following countries: Belgium, Brazil, Canada, Czechoslovakia, Egypt, South Africa, Switzerland, Turkey.

Occasionally missing Barbieri observations are left unfilled even when data from Mitchell or López-Córdova and Meissner are available, because the data do not align well. Furthermore, in a limited number of instances the Barbieri observations were replaced ("overwritten") with data from Mitchell or López-Córdova and Meissner, due to apparent inconsistencies in Barbieri's figures. A list of these instances is available upon request. After data from the various sources for the 1870-1947 period were merged, the pre-1948 dataset is converted into 1985 dollars using the U.S. CPI index and then spliced together with the 1948-1997 data.

GDP and GDP per capita

As discussed in the text, real GDP and GDP per capita data (in constant 1985 dollars) for the 1948–97 period are obtained from the World Bank's *World Development Indicators*, the Penn World Table (PWT) Mark 5.6, Maddison (1995; 2001), and from the IMF's *International Financial Statistics*. These data are essentially the same as in Glick and Rose (2002), with the general exception that we use Maddison data to fill in observations for 1948 and 1949.

For the 1870–1947 period the data primarily come from Maddison (1995; 2001) and are supplemented by information from Mitchell (1992, 1993, 1998) and individual country sources, as described below. In general, real GDP data in national currency units from the supplementary sources are converted first into the real 1990 dollar terms reported by Maddison using the ratio of figures for overlapping year(s). GDP per capita is then calculated using population series implicit in the supplementary source's GDP and GDP per capita data. After adjusting for border changes (see below) and using the U.S. CPI to put into 1985 dollar terms, the 1870-1947 series are then linked to the 1948-1997 series using the average ratio of overlapping observations for 1948-1952 (the availability of Maddison data beyond 1948 allows this overlap).

Further details of the use of supplementary data sources is provided below:

Argentina: Figures for 1875-1899 are taken from Gerardo della Paolera, Alan M. Taylor, and Carlos G. Bózzoli, "Historical Statistics", in della Paolera and Taylor, eds., *A New Economic History of Argentina* (Cambridge: Cambridge University Press, 2003).

Austria-Hungary*:* GDP and GDP per capital figures for 1870-1913 come from Max-Stephan Schulze, "Patterns of Growth and Stagnation in the Late Nineteenth-Century Hapsburg Economy," *European Review of Economic History* 4:3 (2000). Maddison provides GDP data for Austria and Hungary separately for 1913 within their 1990 borders. These data points were scaled up by the ratio of each country's population within 1913 borders to its population within 1990 borders and then added together to give a Madison-based GDP estimate for Austria-Hungary in 1913. The Schulz GDP series was then rescaled by its ratio in 1913 to this Maddison figure. GDP for 1914-1917 were imputed from the (real) GDP figures for Austria within its 1990 borders in Maddison, scaled up by the ratio of Austria Hungary's GDP to Austria's GDP in 1913. Real GDP per capita was computed using the population series implicit in Schulze's data for 1870-1913; for 1914-1917, we rescaled Maddison's population data for Austria (within its 1990 border) by the ratio of Schulze's population figure in 1913 to Maddison's figure for Austria within its 1913 border

Brazil: Figures for 1880-1899 come from Michael Bordo and Hugh Rockoff, "The Gold Standard as a 'Good Housekeeping Seal of Approval,'" NBER Working Paper no. 5340 (November 1996).

Chile: Figures for 1870-1899 are taken from Juan Braun et al., "Economía Chilena 1810-1995: Estadísticas Históricas," Documento de Trabajo no. 187, Pontificia Universidad Católica de Chile, Instituto de Economía (Enero), Santiago (January 2000).

Cuba: Figures for 1903-1949 come from Mitchell (1993), where data on GDP (pp. 750, 755) and population (p. 58) are presented. Since the Cuban peso is pegged one to one to the U.S. dollar, the U.S. price deflator is used to convert Mitchell's peso series into 1990 dollars.

Ecuador: Figures for 1939-1954 come from Mitchell (1993), which provides data for GDP (p. 765) and population (p. 58).

Egypt: GDP data for 1886-1945 are taken from Tarik M. Yousef, "Egypt's Growth Record Under Economic Liberalism, 1885-1950: A Reassessment Using New GDP Estimates," *Review of Income and Wealth* 48: 561-579 (December 2002). GDP per capita is calculated using Yousef's GDP series and population data from Mitchell (1998, p. 47).

Greece: GDP figures for 1927 and 1928 come from Michael Bordo. GDP per capita is calculated using Maddison's population series.

Hungary: GDP data for 1942 and 1943 come from Mitchell (1992, p. 894). Population data is from Maddison.

India: Population and GDP per capita data for 1873-1899 are taken from Moni Mukherjee, *National Income of India, Trends and Structure* (Calcutta: Statistical Publishing Society, 1969). The implicit GDP series is computed from these data, converted into real 1990 dollars in the standard manner, and then divided by population to generate real GDP per capita.

Mexico: Figures for 1895-1899 come from Mitchell (1993, p. 749).

Paraguay: GDP and population data for 1938-1954 come from Mitchell (1993, pp. 767, 63-64, respectively).

Phillippines: GDP figures for 1946-1949 are taken from Mitchell (1998, p. 1012); population data are from Maddison.

Portugal: Figures for 1880-1914 come from Bordo and Rockoff (1996).

Soviet Union: The average of GDP for 1940 and 1945 from Maddison is used to fill in observations for 1941-1944; the average of per capita GDP for 1940 and 1946 from Maddison is used to fill in 1941-1945.

Spain: Figures for 1870-1954 come from Leandro Prados de la Escosura, *El progreso económico de España: 1850-2000* (Madrid: Fundación BBVA, 2002).

Uruguay: Figures for 1870-1954 are taken from Luis Bértola et al., *El PBI de Uruguay 1870-1936 y otras estimaciones* (Montevideo: 1999). GDP and GDP per capita data are given in index level form, with 1913 = 100. To convert into real 1990 dollars, the index series is multiplied by Maddison's GDP value in 1913. Likewise, the implicit population index series from Bértola et al is computed and converted into actual population terms using Maddison's 1913 population value. These population figures are then used to calculate GDP per capita.

Maddison (1995) reports GDP and GDP per capita series based on 1990 borders. We adjust these data to take account of the effects of historical changes in borders on economic activity, under the assumption (typically employed by Maddison) that such effects are proportionate to differences in population. Maddison's Appendix H provides population figures for selected countries in 1913 and 1939 for the borders existing at the time as well as for their 1990 borders. We adjust his GDP series based on 1990 borders by using the ratio of population within the 1913 and 1939 borders to the population within 1990 borders. (These adjustments are made only if the population difference was more than 3 percent.) Adjustments based on the 1913 ratios were applied over the 1870-1917 period for Austria-Hungary, Bulgaria, Denmark, France, Germany, Greece, Italy, Romania, Russia, Serbia/Yugoslavia, and the United Kingdom. Adjustments based on the 1939 ratios were applied to the 1918-1944 period for Bulgaria, Czechoslovakia, Germany, Italy, Poland, Romania, Russia/Soviet Union, and Serbia/Yugoslavia. Adjustments were also made for border changes affecting Korea in 1945, India in 1948, and Pakistan in 1972.

GDP per capita figures generally are assumed unaffected by these border adjustments, with the exception of Germany and Italy, for whom Maddison reports separate per capita figures for 1913, 1939, and 1990 borders.

APPENDIX MATERIALS NOT NECESSARILY FOR PUBLICATION

In conducting our general equilibrium counterfactuals we impute GDP levels in 1913 and 1938 for selected additional countries with bilateral trade data for those years in order to maximize the number of observations in our calculations. Specifically, we imputed 1913 GDP levels for the following countries by calculating the ratio of Maddison GDP data for that country and a reference group in the nearest year with data for both, and then using this ratio to scale down the reference group's GDP (in 1985 dollars) in 1913: Algeria (1913, Ind4), Bolivia (1945, LA8), Dominican Republic (1950, LA8), Ecuador (1939, LA8), El Salvador (1920, LA8), Guatemala (1920, LA8), Haiti (1945, LA8), Honduras (1920, LA8), Iran (1913, Ind4), Malaysia (1913, Asn4), Nicaragua (1920, LA8), Paraguay (1939, LA8),Romania (1913, Ind4), where the year and reference group (Asn4 = China, Indonesia, Japan, Thailand; Ind4 = France, Germany, U.K., U.S.; LA8 = Argentina, Brazil, Chile, Colombia, Peru, Uruguay, Venezuela) are indicated in parentheses. Correspondingly we imputed 1938 GDP data for the following countries: Algeria (1913, Ind4), Bolivia (1945, LA8), Costa Rica (1938, LA8), Dominican Republic (1950, LA8), El Salvador (1938, LA8), Ghana (1913, Ind4), Guatemala (1938, LA8), Haiti (1945, LA8), Honduras (1938, LA8), Iran (1913, Ind4), Iraq (1913, Ind4), Malaysia (1938, Asn4), Nicaragua (1938, LA8), Panama (1945, LA8), South Africa (1913, Ind4).

Land Area

Land area figures were taken from the *World Factbook* (Washington, D.C.: Central Intelligence Agency, 2000). For the period 1870-1917 land area data for Albania, Austria-Hungary, Belgium, Denmark, Finland, France, Germany, Greece, Korea, the Netherlands, Norway, Romania, Russia/USSR, Sweden, and Turkey were obtained from the online replica of the *Encyclopedia Britannica, 11th edition* (Cambridge: University Press, 1911). Figures for the 1918-1944 period for Albania, Austria, Belgium, Czechoslovakia, Denmark, Estonia, Finland, France, Greece, Hungary, Korea, Latvia, Lithuania, the Netherlands, Norway, Poland, Romania, Sweden, Turkey, USSR (Russia), Germany, and Yugoslavia are taken from the *New World Looseleaf Atlas* (New York: Hammond, 6th edition, no date, circa 1920s).