Assessing the Heterogeneous Impact of Wars on Trade and Welfare *

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Abstract

This paper studies the economic costs of the Afghanistan and Iraq wars associated with trade disruption. It contributes to the literature in two ways. First, it estimates the impact of war on trade, while accounting for the heterogeneity across war cases and country-pairs of adversaries. Second, it examines the welfare implications of trade disruption when taking into account the importance of heterogeneity. The analysis unveils the presence of sizable differences in the impact of war on trade across war cases and within-country pairs of adversaries. Moreover, for Afghanistan, the welfare implications of allowing for heterogeneity are meaningful: the welfare gain from a counterfactual involving undoing of the 2001 war increases by a factor of six compared to the scenario that does not admit heterogeneous effects.

JEL classification: D74, F10, F14, F51, H56.

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1 Introduction

"The effects of wars on trade should not be neglected and are an important channel through which military conflict affects income and welfare." (Glick and Taylor, 2010)

The recent ending of the Afghanistan war has reignited the debate on the value of the United States' decision to sustain long wars against Afghanistan and Iraq. The costs of war remain central in these discussions, as there is extensive evidence that these wars turned out to be more costly than anticipated.[1] While some studies have meticulously quantified the direct costs of war (e.g., Belasco (2014)), others have uncovered and quantified previously neglected costs related to health care and disability costs for returning troops, loss of life, and macroeconomic effects (e.g., Stiglitz and Bilmes (2008), Stiglitz and Bilmes (2012)). However, for these wars, less is known about the potential costs associated with the trade disruption, which recent studies that examined earlier wars found relevant.[2]

This paper contributes to the literature in two ways. First, it examines the impact of the Iraq and Afghanistan wars on trade accounting for heterogeneity across war cases and country-pairs of trading partners involved in the conflict. Second, it examines the welfare implications of incorporating heterogeneity. The motivation to introduce heterogeneity stems from the several ways in which these wars differ from others: they involved large-scale military invasions, sought regime change, and had very different adversaries in terms of size and military power.[3] Hence, it is possible that focusing on the average partial effect of all wars, as is standard in this literature, might mask variation relevant to quantify welfare effects.[4]

[1] For the Iraq War, Stiglitz and Bilmes (2008) argue that the war costs were grossly miscalculated. In their book, they note that Mitch Daniels and Secretary Rumsfeld projected a war cost between $57 and $69 billion in 2007 dollars. But in 2008, Congress appropriated $845 billion for costs related to military operations, enhanced security in Iraq for U.S. personnel, and aid programs.

[2] Recent studies on wars' trade disruption effects include Glick and Taylor (2010), Martin et al. (2008), Blomberg and Hess (2006). Importantly, these studies do not include in their sample the Afghanistan and Iraq wars.

[3] For instance, in 2003, Iraq's GDP represented about 5 percent of the U.S. military expenditures. Source: own calculations with data from SIPRI & World Bank.

[4] Seitz et al. (2015) is an exception. They obtain the country-pair impact of war on trade costs. There are two main

Using data on interstate wars and bilateral trade flows that include domestic trade flows for the period between 1980-2016, I employ a structural approach to identify the impact of war on trade. The identification exploits time variation in trade within country pairs of adversaries relative to all other country pairs.[5]

Four relevant findings stand out from the empirical analysis. First, compared to the average impact of all wars, which is associated with a 20 percent decline in trade volume, I find that war's impact on trade varies across wars–the Afghanistan war dampened trade among fighting countries by about 90 percent. In contrast, the Iraq war did not have a significant effect on trade. Second, I find that there is heterogeneity across country-pairs fighting the same war. The Iraq war case illustrates this point: whereas the war did not significantly impact trade between Iraq and the U.S., it dampened trade between Iraq and Great Britain and between Iraq and Australia. Third, the pattern of heterogeneity is not unique to these wars–it is also present in the heterogeneous estimates of all other conflicts in the sample. Fourth, the difference between the Afghanistan War and the average effect of all wars is sizable. The magnitude of the effect of the Afghanistan War is closer to the average estimates obtained by Glick and Taylor (2010) using a sample that includes the two World Wars.[6]

With the heterogeneous estimates on the impact of war on trade in hand, I proceed to examine the implications of accounting for heterogeneity for the quantification of the welfare effects. I conduct two counterfactual simulations: the undoing of the Afghanistan war in 2001 and the undoing of the Iraq war in 2003. Each counterfactual delivers percentage changes in exports, wel-

differences between my approach and theirs. First, the present paper uses panel data estimation with high-dimensional fixed effects, while their cross-section approach is a calibration that relies on assuming stochastic trade costs distributed standard uniform. Second, the present paper studies heterogeneity along an additional dimension: war case

[5]I employ the Structural Gravity Model of Trade in a panel data specification with high-dimensional fixed effects. The specification includes exporter-time fixed effects and importer-time fixed effects to control for the multilateral resistances (Olivero and Yotov, 2012). Moreover, these fixed effects also absorb time-varying, country-specific trends. This is important in my setting since it allows me to control for war destructiveness. The specification also includes country-pair fixed effects, which ameliorates endogeneity concerns about unobserved confounding variables that might correlate a country pair's propensity to fight with their level of bilateral trade costs (Baier and Bergstrand, 2007).

[6]Glick and Taylor (2010) estimated a contemporaneous average partial effect of war associated with a decline of -83 percent in trade volume. Their sample spans from 1870 to 1997, including the first and second World Wars.

fare (proxied by real income/expenditure), and the incidence of welfare on consumers (through the CES price index) and producers (through factory-gate prices). The welfare analysis is based on a new quantitative trade model that is representative of a wide class of trade models (Arkolakis et al., 2012), including the CES-Armington version of the Structural Gravity model developed by Anderson and Van Wincoop (2003), which I follow closely. The model endogenizes income and expenditure. But it is important to note that I only study the impact of war on welfare through trade disruption, abstracting from war's destructive effects on production and income.

In the first counterfactual, which describes the undoing of the 2001 Afghanistan War, I find that incorporating heterogeneity on the impact of war on trade generates sizable differences in welfare, but only for one country: Afghanistan. The benchmark scenario (no heterogeneity) yields a 1.58 increase in welfare for Afghanistan from undoing the war, benefiting both consumers and producers. In comparison, allowing the Afghan War to have a distinct impact on trade increases Afghanistan's welfare by about 9 percent from undoing the war.[7] Afghanistan's welfare gain is quantitatively similar when considering heterogeneity across country-pairs fighting this war. In both scenarios undoing the war benefits consumers and producers.

The other belligerents (the U.S. and Great Britain) do not experience significant welfare effects from undoing the Afghan War at any scenario of heterogeneity (i.e., no heterogeneity, war case, country-pair). This pattern is due to the fact that the U.S.-led coalition countries' trade with Afghanistan is low relative to their total trade volume. Hence, even though war lowers trade between them and Afghanistan, their welfare effects are essentially zero. I interpret this finding as evidence that asymmetries in country size matter. Therefore, war's disruptive effect on trade does not imply that war is costly for large countries. At least not in terms of trade disruption.[8]

In the second counterfactual, I simulate the undoing of the Iraq war in 2003. For Iraq, the most dramatic difference is between the average partial effect of all wars: the undoing of the war increases Iraq's welfare by about 1 percent. In contrast, the case that considers a distinct impact of

[7] The welfare gain from undoing the war can be interpreted as a portion of the opportunity cost of the war.
[8] Importantly, I abstract from arming costs.

the Iraq war on trade results in no welfare effect. Moreover, in line with the results from the first simulation, the welfare estimates for U.S.-led coalition countries (Australia, Great Britain, and the U.S.) are close to zero.

Overall, the findings from the counterfactual indicate that incorporating heterogeneity on the impact of war on trade generates meaningful differences in estimated welfare effects. Moreover, the fact that U.S.-led coalition countries did not experience welfare effects from undoing the wars indicates that the trade disruption channel is only relevant for the smallest countries, which in both cases are the invaded countries.

The rest of the paper is organized as follows. Section 2 introduces the literature review. Section 3 presents background information about the Afghanistan and Iraq wars. Section 4 describes the quantitative framework. Section 5 presents the data. Section 6 discusses the empirical results. Section 7 presents the welfare effects of war due to trade disruption and output destruction. Section 8 concludes.

2 Literature Review

This paper contributes to a burgeoning literature on the relationship between trade and militarized conflict. A few recent studies have studied the impact of conflict on trade. This study is most closely related to Glick and Taylor (2010), who quantify the indirect cost of interstate war due to its disruption of trade. Using the gravity model of trade and data from 1937 to 1997, they estimated the contemporaneous and lasting effects of war on trade. Their results show a strong negative impact of war on trade between belligerents and between belligerents and neutrals. Using these average estimates, they perform a welfare analysis of World Wars I and II, finding that disruption on trade generates a welfare loss of the same order of magnitude as more traditional costs of war, such as loss of human capital. This study differs from Glick and Taylor (2010) in that it incorporates the potential heterogeneous effects of wars on trade between adversaries and assesses their welfare implications.

Two related studies have employed the gravity model of trade to study the effects of conflict on trade. Blomberg and Hess (2006) investigate the effects on trade of terrorism, revolutions and coups, and external wars. They find that all three forms of violence dampen trade. Interestingly, however, they also found that external wars are not statistically significant from zero in some cases. Martin et al. (2008) found that, while militarized interstate disputes significantly decrease bilateral trade between adversaries, such disputes have no significant effect on their multilateral trade.

In terms of its empirical contribution, relative to the gravity papers described above, this paper differs in that it employs the latest developments in the structural estimation of gravity models. Some of these developments include: employing exporter-time and importer-time fixed effects to control for multilateral resistances and time-varying country-specific trends, estimating the gravity equation in multiplicative form using the Poisson Pseudo Maximum Likelihood estimator from Santos Silva and Tenreyro (2006), incorporating country-pair fixed effects (to ameliorate endogeneity concerns due to unobserved factors that might be correlated with trade and the propensity to fight wars), and finally controlling for the effects of globalization.[9]

In the literature on the costs of war, Stiglitz and Bilmes (2008) and Stiglitz and Bilmes (2012) study rigorously the costs of the Afghanistan and Iraq Wars focusing on the United States. These authors quantify previously overlooked costs and classify them as follows: budget items, long-term care for veterans, macroeconomic effects (e.g., the increase in oil price associated with the Iraq war), and the opportunity costs associated with loss of human life and wounded injuries. This paper complements their work in two ways. First, it studies the welfare effects associated with trade disruption; and second, it examines the welfare effects for all belligerents fighting these wars, not only for the U.S.

In the Political Science literature, the effects of war on trade have been explored extensively with mixed results. Among studies that employ time-series event methodologies, Barbieri and Levy (1999) in a paper titled "*Sleeping with the Enemy: The Impact of War on Trade*" study the

[9] I refer the reader to Yotov et al. (2016) for a more detailed summary of the latest development in the empirical gravity literature.

impact of war on trade. They find that war outbreak does not significantly affect contemporaneous trade: from a total of seven country pairs, four of them have a negative but insignificant effect; one country pair reports a negative and significant effect; two country pairs have a positive but insignificant impact. Moreover, they also study whether war outbreak generates a permanent effect on the bilateral trade trend. They find that war outbreak is associated with a positive impact on the long-term trend in five cases. Another study, Anderton and Carter (2001) finds that war reduces trade volume significantly using a sample of fourteen power dyads. My paper differs from these studies in one key respect: it employs a theoretically-based specification that controls for important aspects affecting trade such as: exporter's income, importer's expenditure, multilateral resistances, observed and unobserved country-pair characteristics (for example, some countries due to geographical or historical reasons may tend to have good trade relationships and fight wars), and globalization. Since these studies do not control for these effects, their estimates might suffer from omitted variable bias.

Among the papers that use a gravity-type framework, Keshk et al. (2004), Keshk et al. (2010), and Goenner (2011) find that militarized interstate disputes (MIDs) reduce trade. However, Morrow et al. (1998) and Morrow et al. (1999) find that wars do not affect trade. I complement this literature by studying the heterogeneous impacts of war on trade using the latest developments of the structural gravity literature.

3 Historical Background: Afghanistan and Iraq Wars

In this section, I provide some background information and definitions related to the Afghanistan and Iraq wars. Usually, the conflict literature classifies armed conflict depending on the type of parties involved (state actors, non-state actors, foreign governments). Following the criteria proposed by Gleditsch et al. (2002), both of these wars involved two distinct types of conflicts. Interstate war refers to armed conflict between two governments (states) that results in at least 25 battle-related deaths. This type of conflict describes the first year of the Afghanistan and Iraq wars. The second

type of conflict is internationalized intrastate war. It involves armed conflict between a government (state) fighting against a non-government party (rebel group) that results in 25 battle-related deaths. An important aspect is the involvement of foreign forces with troops providing support. This classification applies to the second period of these wars after the U.S.-led forces toppled the Taliban and Saddam Hussein's regimes. Table 1 below presents the definitions for relevant types of conflict and the criteria used to classify involved parties into primary and secondary belligerents.

Table 1: Conflict Definitions

Interstate war: Armed conflict between two governments that results in at least 25 battle-related deaths in a calendar year.
Internationalized Intrastate war: Armed conflict between a government and a non-government party (rebel group) that results in at least 25 battle-related deaths in a calendar year. There is the involvement of foreign forces with troops.
Primary belligerents in interstate war: Governments that state incompatible positions and suffer 25 battle-related deaths per calendar year
Secondary belligerents in interstate war: Governments that enter a conflict with troops to actively support primary parties. These countries do not need to suffer 25 battle-related deaths.
Primary belligerents in internationalized intrastate war: Only one country whose government or territory is disputed. On the opposing side, the non-state actors (rebel groups). The non-state actors can be an alliance of groups.
Secondary belligerents in intrastate war: A government that provides support to a primary party. These countries do not need to suffer 25 battle-related deaths.

Notes:

(i) *Source: UCDP/PRIO Armed Conflict Dataset Version 21.1.*

3.1 Afghanistan War

Following the terrorist attacks on 9/11, the United States gave an ultimatum to the Afghanistan Government to turn over Osama bin Laden or face American strikes. The Afghan government,

Table 2: Afghanistan War

Years	Conflict Type	Primary Belligerents	Secondary Belligerents
2001	Interstate	*Side A* Afghanistan *Side B*: Great Britain, USA	*Side A*: *Side B*:
2003-2020	Internationalized Intra-state	*Side A*: Afghanistan *Side B*: Hizb-i Islami-yi and Taleban	*Side A*: Great Britain, USA, other NATO countries, Armenia, Australia, Austria, Azerbaijan, Bosnia-Herzegovina, Finland, Georgia, Ireland, Jordan, Malaysia, Mongolia, New Zealand, South Korea, Sweden, Ukraine, United Arab Emirates, *Side B*:
2003-2020	Internationalized Intra-state	*Side A*: Afghanistan *Side B*: Islamic State	*Side A*: Pakistan, USA *Side B*:

Notes:

(i) *Source: UCDP/PRIO Armed Conflict Dataset Version 21.1.*
(ii) The UCDO/PRIO dataset defines Primary belligerents as countries

led by the Taliban, refused to turn over Osama bin Laden. The conflict escalated quickly, and in early October of the same year, the United States and Great Britain launched operation Enduring Freedom.

Afghanistan's Northern Alliance joined the U.S.-coalition troops in the Afghanistan invasion. By December 2001, the U.S.-led coalition took control of the major cities, including the capital Kabul and Kandahar. The Taliban retreated to the Pakistan border, and the formation of a new Afghan government ended the interstate period of the war. This transitional government was presided by a Northern Alliance commander with international support spearheaded by the United Nations.

Despite the rapid fall of the Taliban, the military involvement of international forces continued in Afghanistan. As Table 2 shows, the aftermath of the interstate war morphed into a new con-

flict form: internationalized intra-state conflict, where the local government relied on international security forces to maintain security and fight against a Taliban resurgence and terrorists.

3.2 Iraq War

In January 2002, the U.S. President George W. Bush, in his State of the Union Address, made the following declaration regarding Iraq: "States like this, and its terrorist allies, constitute an axis of evil arming to threaten the peace of the world. By seeking weapons of mass destruction, these regimes pose a grave and growing danger."[10] During the following months, in multiple interviews with the press, top members of the Bush Administration expressed their desire for regime change in Iraq and made a case for the need to pre-emptively deal with the risk it posed.[11]

Escalating the dispute further, in October 2002, the U.S. Congress passed the *Joint Resolution to authorize the use of United States Arm Forces against Iraq*. In November, the United Nations (U.N.) Security Council approved a resolution declaring Iraq in "material breach" of disarmament obligations and offered a last opportunity to comply. Iraq agreed with the resolution, and U.N. inspectors returned to that country. The inspectors briefed the Security Council on its findings during January and February 2003. In March of the same year, the United States, Great Britain, and Spain drafted a new resolution declaring that Iraq failed to comply with the UN resolution. However, they did not gather the support of other UN Security Council members.

On March 17, 2003, President Bush gave an ultimatum to Saddam Hussein and his sons to abandon the country in 48 hours or face military action. They did not comply, and the US-led coalition invaded the country on March 19th. The campaign "Iraqi Freedom" toppled Saddam's regime in less than a month; by May 2003, President Bush declared the end of major combat op-

[10]Source: Bush, George W. 2002, January 29. *President Delivers State of the Union Address*. Retrieved from: https://georgewbush-whitehouse.archives.gov/news/releases/2002/01/20020129-11.html

[11]The senior government officials at the time included Donald Rumsfeld, Secretary of Defense; Dick Cheney, Vice President; Ari Fleischer, White House Press Secretary; Condolezza Rice, National Security Advisor; Colin Powell, Secretary of State. I refer the reader to the documentary Hershey (2008), which shows footage of multiple interviews and discourses in which President Bush and senior government officials made a case for the Iraq war.

Table 3: Iraq War

Years	Conflict Type	Primary Belligerents	Secondary Belligerents
2003	Interstate	*Side A*: Iraq *Side B*: Australia, Great Britain, USA	*Side A*: *Side B*:
2004-2011	Internationalized Intra-state	*Side A*: Iraq *Side B*: al-Mahdi Army, Ansar al-Islam, Islamic State, Reformation and Jihad Front	*Side A*: Albania, Armenia, Australia, Azerbaijan, Bosnia-Herzegovina, Bulgaria, Czech Republic, Denmark, El Salvador, Estonia, Georgia, Great Britain, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Mongolia, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Slovakia, South Korea, USA, Ukraine *Side B*:
2014-2020	Internationalized Intra-state	*Side A*: Iraq *Side B*: Islamic State	*Side A*: Australia, Bahrain, Belgium, Canada, Denmark, France, Great Britain, Jordan, Netherlands, Saudi Arabia, United Arab Emirates, USA *Side B*:

Notes:

(i) *Source: UCDP/PRIO Armed Conflict Dataset Version 21.1.*

erations. The United States took provisional control of the country, pledged support to form a new government to reconstruct the country, and kept a substantial military presence for peacekeeping operations.

Despite the swift victory against Saddam Hussein's regime, the conflict did not end. The security situation in Iraq deteriorated quickly when insurgent groups started to attack the new government and U.S. troops. This new type of conflict, an internationalized intra-state war, lasted from 2004 to 2011. A coalition of countries that include Great Britain, the U.S., and some NATO countries supported the new Iraq government against an insurgence. As Table 3 shows, the U.S.-led coalition withdrew the bulk of its forces from Iraq in 2011. But in 2014, the U.S. recommitted

to Iraq to help fight the Islamic State.

4 Quantitative Framework

4.1 Structural Gravity Model of Trade

This subsection briefly describes the new quantitative trade model employed to estimate the impact of war on trade and to conduct counterfactual simulations to quantify the associated welfare effects. It is representative of a wide class of trade models (Arkolakis et al., 2012), including the Structural Gravity Model of Trade from Anderson and Van Wincoop (2003) in its endowment Armington-CES version, which I follow closely.

The representative consumer has CES preferences over goods differentiated by country of origin:

$$U_j(\cdot) = \left[\sum_i \alpha_i^{\frac{1-\sigma}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where c_{ij} indicates country j's demand for goods produced in country i, the parameter $\alpha_i > 0$ is a CES preference parameter and $\sigma > 1$ is the elasticity of substitution.

Solving the consumer's optimization problem and imposing market-clearing at delivered prices yields the following system of equations:

$$X_{ij,t} = \frac{E_{j,t} Y_{i,t}}{Y_t} \left(\frac{t_{ij,t}}{\Pi_{i,t} P_{j,t}} \right)^{1-\sigma} \tag{2}$$

$$P_{j,t}^{1-\sigma} = \sum_i \left(\frac{t_{ij,t}}{\Pi_{i,t}} \right)^{1-\sigma} \frac{Y_{i,t}}{Y_t} \tag{3}$$

$$\Pi_{i,t}^{1-\sigma} = \sum_j \left(\frac{t_{ij,t}}{P_{j,t}} \right)^{1-\sigma} \frac{E_{j,t}}{Y_t} \tag{4}$$

$$p_{i,t} = \left(\frac{Y_{i,t}}{Y_t} \right)^{\frac{1}{1-\sigma}} \frac{1}{\alpha_i \Pi_{i,t}} \tag{5}$$

$$E_{i,t} = \phi_{i,t} Y_{i,t} = \phi_{i,t} p_{i,t} Q_{i,t}. \tag{6}$$

In equation (2) $X_{ij,t}$ denotes the value of exports from country i to country j at time t. The variable $E_{j,t}$ denotes j's expenditure on goods from all countries, and the term $Y_{i,t}$ denotes sales on i's goods to all countries. Both are divided by Y_t, which is world income. The first term at the right-hand side of equation (2) indicates that the value of bilateral trade between countries i and j is increasing in the product of the sizes of their economies. The second term in parenthesis is the trade friction component. Variable $t_{ij,t} \geq 1$ captures iceberg-type trade costs on goods shipped from country i to country j.

The terms $\Pi_{i,t}$ and $P_{j,t}$ in equations (4) and (3) denote the outward and inward multilateral resistances, which are aggregate trade cost indexes for producers and consumers, respectively.

Equation (5) is derived from the world market clearing conditions of the goods market at delivered prices:

$$\begin{aligned} & Y_{i,t} = \textstyle\sum_j X_{ij,t} \quad \forall i. \\ \Leftrightarrow \quad & Y_{i,t} = \textstyle\sum_j (\alpha_i p_{i,t} t_{ij} / P_{j,t})^{1-\sigma} E_{j,t} \quad \forall i. \\ \Leftrightarrow \quad & Y_{i,t} = (\alpha_i p_{i,t})^{1-\sigma} \textstyle\sum_j (t_{ij} / P_{j,t})^{1-\sigma} E_{j,t} \quad \forall i. \end{aligned} \tag{7}$$

In equation (7), $p_{i,t}$ is the exporter's factory gate price, and α_i is the preference parameter noted earlier. Equation (5) can be obtained by dividing both sides of (7) by world income Y_t, substituting the expression in (4), and solving for $p_{i,t}$.

Turning to equation (6), this equation reflects two important features of the model. First, the model assumes exogenous trade imbalances. Hence, for country i, the parameter $\phi_{i,t} > 1$ indicates a trade deficit at time t, and $0 < \phi_{i,t} < 1$ indicate a trade surplus. Second, the model treats income ($Y_{i,t}$) as a function of producer prices ($p_{i,t}$), which are endogenous.

In my setting, conflict enters the model only through the trade costs variable.[12] Specifically, following (Baier et al., 2019), I assume that trade costs take a generic functional form:

$$\ln t_{ij,t}^{1-\sigma} = Z_{ij}\Psi + \beta_1 WAR\_BIL_{ij,t}, \tag{8}$$

[12] In the Appendix A.2, I demonstrate how the Structural Gravity Model can be used to study the destructive effects of war on income.

where Z_{ij} is a vector of time-invariant variables affecting trade costs, and the conflict indicator variable $WAR\_BIL_{ij,t}$ captures the presence or absence of war. Thus, the effect of war on trade costs is captured by the parameter β_1.

The quantitative model described above has three important limitations. It assumes that peace is a reversion to the status quo and not the result of some form of a negotiated settlement, which would have an effect on peace payoffs. Moreover, it abstracts from the possibility of arming. Some studies that address this issue include Skaperdas and Syropoulos (2001), who analyze a factor-price channel; Garfinkel et al. (2020a), who study a terms-of-trade channel; and Garfinkel et al. (2020b), who examine an income channel.

4.2 From Theory to Empirics: Average Partial Effect of War

This subsection derives an equation to estimate the potentially heterogeneous effects of war on trade. First, I describe the specification that estimates the average partial effect of all wars. Next, I describe the method I employ to estimate heterogeneity at two different levels: war case, and symmetric country-pair, which I will define in the remainder of this section.

The baseline estimating equation is obtained by re-writing equation (2) in exponential form, substituting the trade costs function in (8), and adding an error term:[13]

$$X_{ij,t} = exp[\gamma_{i,t} + \delta_{j,t} + \mu_{ij} + \beta_1 WAR\_BIL_{ij,t} + \beta_2 WAR\_MULTI\_BRDR_{ij,t} + CTRL_{ij,t}\boldsymbol{\beta}] + \epsilon_{ij,t}. \quad (9)$$

As noted earlier, $X_{ij,t}$ denotes bilateral trade flows at time t. The exporter-time fixed effects, denoted by $\gamma_{i,t}$, control for the outward multilateral resistance, country i's output share, and any other time-varying exporter-specific factor affecting bilateral trade. Similarly, the importer-time fixed effects denoted by $\delta_{j,t}$ absorb the inward multilateral resistance, the importer's expenditure,

[13] The full system of equations (2)-(6) will be employed in the next section to quantify welfare effects

and any other time-varying importer-specific variable affecting trade.[14] The term μ_{ij} is a country-pair fixed effects that absorbs time-invariant bilateral determinants of trade costs, along with other unobservable time-invariant factors.

The two coefficients of primary interest in this paper are those that capture the average partial effect of war on bilateral trade and multilateral trade. The coefficient of $WAR\_BIL_{ij,t}$, which is an indicator variable, captures the average partial effect of war on trade between belligerents. The coefficient of $WAR\_MULTI\_BRDR_{ij,t}$ captures the effect of war on international trade relative to internal trade between a belligerent and all other countries except its war adversary. This variable is calculated as the interaction term between two indicator variables: $WAR\_MULTI_{ij,t}$ that captures trade between a belligerent and all countries except its war adversary, and $BRDR_{ij,t}$, which is an indicator variable that takes the value of one when the trade flow is "international" and zero when it is "intra-national."

Lastly, the vector $CTRL_{ij,t}$ includes standard gravity control variables such as the binary indicator $GATT\_WTO_{ij,t}$, which takes the value of 1 if both countries i and j are members of the GATT/WTO at time t, and takes the value of zero otherwise; the binary indicator variable $RTA_{ij,t}$ for whether countries i and j have a regional trade agreement at time t. Also, following Bergstrand et al. (2015) I incorporate a timer-varying border dummy to control for globalization. Specifically, $BRDR_{ij,t}$ are yearly binary indicator variables for whether trade flows are international: it takes the value of 1 if the trade flows are international ($X_{i\neq j,t}$) and the value of 0 if the trade flows are intra-national ($X_{ii,t}$).

To estimate this equation, I follow the recommendation of Santos Silva and Tenreyro (2006) to estimate it in multiplicative form using the Poisson Pseudo Maximum Likelihood (PPML) estimator.[15] This approach enables me to deal with heteroskedasticity in trade data and allows me to take into account the presence of zeros in the data.

[14] Introducing exporter-time and importer-time allows me to control for changes in income and expenditure, which allows me to control for the destructiveness of war.

[15] I estimate the regressions in STATA using the PPMLHDFE command developed by Correia et al. (2020)

4.3 Heterogenous Effects of War on Trade

This subsection describes the specifications that incorporate yhe heterogeneous effects of war on trade. The methodology to estimate heterogeneous effects is based on the work of Baier et al. (2019).

I begin by introducing a specification that incorporates heterogeneity across war cases. The cases of interest are denoted by the index $W \in \{ALL\_OTHER, AFGHAN, IRAQ\}$, where ALL_OTHER indicates all interstate wars during 1980-2016 excluding the Afghanistan and Iraq wars. The specification takes the form:

$$X_{ij,t} = exp[\gamma_{i,t} + \delta_{j,t} + \mu_{ij} + \sum_{W} \beta_{1,W} WAR\_BIL^{W}_{ij,t} + \beta_2 WAR\_MULTI\_BRDR_{ij,t} + CTRL_{ij,t}\boldsymbol{\beta}] + \epsilon_{ij,t}, \quad (10)$$

were, the coefficient $\beta_{1,W}$ captures a different average partial effect for each war case.

Second, I proceed to account for the heterogeneity across country-pairs fighting in the Afghan and Iraq wars. The bilateral war coefficient on this specification assumes a symmetric effect between exporter and importer. Let the index q denote the set of country-pairs fighting a war case (indexed by W).[16] The estimating equation is given by:

$$X_{ij,t} = exp[\gamma_{i,t} + \delta_{j,t} + \mu_{ij} + \sum_{W} \sum_{q \in W} \beta_{1,W:q} WAR\_BIL^{W:q}_{ij,t} + \beta_2 WAR\_MULTI\_BRDR_{ij,t} + CTRL_{ij,t}\boldsymbol{\beta}] + \epsilon_{ij,t}, \quad (11)$$

[16] For the Afghan War the index q takes the values: Afghanistan-U.S. and Afghanistan-Great Britain. For the Iraq War the index q takes the values Iraq-Australia, Iraq-Great Britain, Iraq-U.S.

where $\beta_{1,W:q}$ captures a distinct and symmetric average partial effect for each country-pair (indexed by q) fighting a war case (indexed by W).

5 Data

The study employs an unbalanced panel database with 199 countries spanning the period from 1980 to 2016. The country-sample comes from the Correlates of War system of countries. The full list of countries is provided in the Data Appendix A.1.

Data on wars come from the UCDP/PRIO Armed Conflict Dataset Version 21.1. developed by Gleditsch et al. (2002). This dataset defines war as an interstate militarized dispute with more than 25 annual battle deaths.

The trade data comes from the Structural Gravity Dataset of Manufacturing Sector: 1980:2016; developed by Larch et al. (2019).[17] I follow the recommendation of Yotov et al. (2016) to perform gravity estimation with both intra-national and international trade flows.

For estimation purposes, I replaced missing trade data with zeros. In the Appendix A.3, I include a sensitivity analysis showing that the treatment of zeros does not drive the results.[18] To quantify welfare effects, I extrapolated missing production values for Afghanistan in 2001 and Iraq in 2003 using GDP evolution.[19] Importantly, I did not use extrapolated values to estimate the impact of war on trade.

Table 8 reports summary statistics on trade data among adversaries fighting the Afghanistan and Iraq wars. The key takeaway from this table is that for U.S.-led coalition countries, trade with Afghanistan and Iraq represents a very small portion of their total trade volume.

[17] The dataset is publicly available in the website https://www.wto.org/english/res_e/reser_e/structural_gravity_e.htm

[18] Appendix A.3 presents results without replacing missing trade values with zeros. Overall the results are qualitatively identical and quantitatively similar.

[19] I also obtained results extrapolating the income and expenditures time series using the evolution of exports, as in Baier et al. (2019). I obtained qualitatively similar results

Table 4: Adversaries' Trade as Percentage of Country's Trade Volume

Side A	Side B	Trade = Imports + Exports	Trade as % of A's Trade Volume	Trade as % of B's Trade Volume
Afghanistan War, 2001				
AFG	GBR	5524824	1.24	0
AFG	USA	5164469	1.11	0
Iraq War, 2003				
IRQ	AUS	391958	0.01	0
IRQ	GBR	85657336	2.08	0.01
IRQ	USA	271174912	6.89	0

Notes:

(i) This table shows summary trade statistics for countries involved in the Afghanistan and Iraq wars.
(ii) Trade data comes from the Structural Gravity Dataset of Manufacturing Sector: 1980:2016; developed by Larch et al. (2019).

I also control for GATT/WTO membership and the presence of Regional Trade Agreements. The data to construct both variables come from the WTO.

6 Empirical Results

6.1 Baseline: Average Partial Effect of All Wars

I begin by estimating the baseline specification described in equation (9) in order to provide a benchmark to compare the heterogeneous effects.

The benchmark is the average partial effect of all wars on bilateral trade. This effect is negative and highly significant. It implies a trade volume effect of about -21 percent ($(e^{-0.238} - 1) \times 100$). In this and all subsequent specifications, I control for the impact of war on multilateral trade (WAR_MULTI_BRDR). This effect turns out statistically insignificant, echoing the findings of Martin et al. (2008).

6.2 Heterogeneous Effects on Trade: Afghanistan and Iraq Wars

Table 5 presents regressions of trade on war at different levels of heterogeneity. Column (1) reports the baseline estimates of the average partial effect of all wars on bilateral trade for comparison purposes. As mentioned at the beginning of the section, this estimate implies a trade volume effect of about -21 percent ($(exp(-0.238) - 1) \times 100$).

Column (2) of Table 5 isolates the impact on trade of the Afghanistan and Iraq wars from all other wars. This specification leads to a large, highly significant negative effect of the Afghanistan War on trade between adversaries. The coefficient interpretation is in levels since both variables are mutually exclusive. It implies a trade volume effect of -90.2 percent ($(exp(-2.329) - 1) \times 100$), which is larger than the trade volume effect of all other wars (-21 percent). In contrast, the coefficient on the Iraq war variable is small, negative, and statistically insignificant. As expected, the average impact of all other wars is slightly smaller than the average partial effect of all wars reported in column (1).

Lastly, in column (3), I incorporate heterogeneity on the impact of war on trade among adversaries fighting the Afghanistan and Iraq Wars. To do this, I estimate equation (11), which delivers symmetric effects by country-pair. For the Afghanistan War, this specification results in a sizable and highly significant negative impact on trade between Afghanistan and the U.S: their trade volume declines by -94.8 percent ($(exp(-2.959) - 1) \times 100$). The impact on trade between Afghanistan and Great Britain is also negative and highly significant, but lower in magnitude: bilateral trade decreases approximately by half (-54.2 percent $= ((exp(-0.783) - 1) \times 100$). For the Iraq War, the impact of war on trade between Iraq and the U.S. is positive but insignificant, similar to the results in the previous column. Yet, the war has a large, negative, and highly significant effect on trade between Iraq and Australia and Iraq and Great Britain, of about -90 percent ($(exp(-2.381) - 1) \times 100$) and -37 percent ($(exp(-0.469) - 1) \times 100$), respectively. Hence, even though there is heterogeneity across country-pairs, these negative effects are not large enough to lead to a negative impact of the Iraq war on trade. The positive and insignificant effect on trade

Table 5: Impact of War on Trade

VARIABLES	(1) WAR_AVG	(2) WAR_CASE	(3) SYMM
GATT_WTO	0.305***	0.305***	0.305***
	(0.0499)	(0.0499)	(0.0499)
RTA	0.178***	0.178***	0.178***
	(0.0437)	(0.0437)	(0.0437)
WAR_BIL	-0.238**		
	(0.0969)		
WAR_BIL_ALL_OTHER		-0.230**	-0.230**
		(0.0971)	(0.0971)
WAR_MULTI_BRDR	0.00643	0.00643	0.00643
	(0.0227)	(0.0227)	(0.0227)
WAR_CASE_AFGHAN		-2.329***	
		(0.626)	
AFG_GBR			-0.783***
			(0.183)
AFG_USA			-2.959***
			(0.182)
WAR_CASE_IRAQ		-0.0166	
		(0.250)	
IRQ_AUS			-2.381***
			(0.170)
IRQ_GBR			-0.469***
			(0.170)
IRQ_USA			0.190
			(0.170)
Observations	1,045,558	1,045,558	1,045,558
Country-pair FE	✓	✓	✓
Importer-time FE	✓	✓	✓
Exporter-time FE	✓	✓	✓
Border-time FE	✓	✓	✓

Notes:

(i) This table presents estimates on the impact of war on trade incorporating heterogeneity indicated in the column headers. Column 1 highlights the no heterogeneity scenario where all wars have the same average partial effect. Column 2 indicates the presence of heterogeneity across war cases, where the Afghan and Iraq wars have a distinct impact on trade. Column 3 indicates the presence of heterogeneity across country-pairs fighting the Afghan and Iraq Wars.

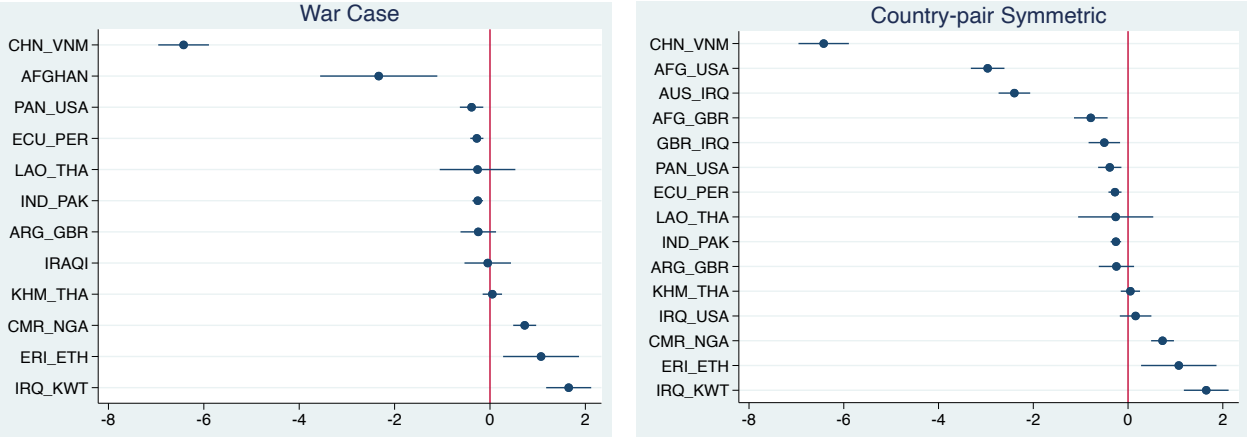
(ii) Robust standard errors in parentheses are clustered by country-pair. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

between Iraq and the U.S. dominates.[20]

[20]The fact that the U.S. took provisional control of Iraq in May 2003 after overthrowing Saddam Hussein's government might explain the increase in trade between the U.S. and Iraq in 2003.

6.3 Heterogeneity across War Cases: 1980-2016

Figure 1: Heterogeneity of the Impact of War on Trade



(a) Across war cases

(b) Across country-pairs of adversaries

Notes:

(i) These figures present heterogeneous estimates of the impact of war on trade for all wars in the sample spanning the period from 1980 to 2016. Panel (a) isolates the impact of war on trade for each war case. Panel (b) isolates the impact of war on trade for each country pair fighting a war.

(ii) The trade volume effect implied by an estimate $\hat{\beta}$ (reported in the horizontal axis) is as follows: $(\exp(\hat{\beta}) - 1) \times 100$. For example, a coefficient $\hat{\beta} = -2$ translates to a trade volume effect of -86.47 percent $= (\exp(-2) - 1) \times 100$.

(iii) Some countries involved in wars do not appear in the figures because they did not trade for the whole period of the war.

Having studied the heterogeneous impact of the Afghanistan and Iraq wars on trade, I now examine the heterogeneous effects of all war cases during 1980-2016. Similar to the previous specification, I include controls for GATT/WTO membership, RTAs, and Multilateral trade. I also include the same set of fixed effects.

To ease the interpretation, Figure 1 summarizes the estimates of heterogeneous effects across war cases (Panel a) and across country pairs of adversaries (Panel b). Two interesting findings stand out. First, in a similar pattern across both scenarios, the magnitude of the coefficient is quite heterogeneous, ranging from -6.5 to 1.87. Second, war increases trade flows for some war cases and country pairs. A possible explanation is that war depressed internal trade relative to international trade, and since internal trade is part of the reference group, the estimates turn out

positive.

6.4 Endogeneity Concerns

This subsection addresses potential endogeneity concerns between trade and war. The first concern is omitted variable bias. Specifically, if a country pair's propensity to fight wars is systematically correlated with their trade costs level, then the estimated war coefficient is likely to be biased. To alleviate this issue, I include country-pair fixed effects in my specification. As Baier and Bergstrand (2007) argue, including country-pair fixed effects controls for time-invariant unobserved heterogeneity, which enables me to identify the average treatment effect. This approach is standard in the empirical trade literature. Moreover, my specification includes exporter-time and importer-time fixed effects. Therefore it controls for time-varying country-specific factors that might increase a country's propensity to attack another country.

The other potential endogeneity issue is reverse causality between trade and conflict. My argument follows the one in Glick and Taylor (2010). Specifically, as in their study, I start by distinguishing between two types of identification in the relationship between trade and the probability of war.

The first type is cross-sectional variation, which most studies in Political Science use to establish a relationship between trade and war (Glick and Taylor, 2010). These studies find the empirical regularity that country pairs with a higher level of trade tend to fight less on average. I argue that this is not a threat to my specification since I include country-pair fixed effects that control for a country pair's propensity to trade more or fight more.

The second type of identification is within-pair variation. If there is evidence that time variation on trade within country pairs affects the probability of war, then reverse-causality would threaten my identification. However, as noted by Glick and Taylor (2010), it is improbable that year-over-year changes in trade level affect the probability of war contemporaneously.[21] Using my

[21] Glick and Taylor (2010) argue that changes in trade might affect the probability of war in the long run. But it is highly unlikely that such a relationship exists in yearly data. Also, they find no evidence that trade affects the

Table 6: Impact of Trade Costs on the Probability of War (1980-2010)

VARIABLES	(1) OLS	(2) XTLOGIT
$TRADE\_COSTS_{ij,t}$	-8.96e-05	2.015
	(0.000183)	(2.474)
$RIVALRY$	0.0379	16.89
	(0.0325)	(1,277)
Observations	424,541	594
Country-pair FE	✓	✓
Year FE	✓	✓

Notes:

(i) This table presents estimates on the impact of trade costs on the probability of war. The trade costs ($TRADE\_COSTS_{ij,t}$) were estimated using the Structural Gravity Model, and the rivalry (*RIVALRY*) variable is an indicator capturing strategical rivalries that comes from Thompson and Dreyer (2012).
(ii) Column (1) estimates a linear probability model and column (2) estimates a Fixed-Effects Logit.
(iii) Robust standard errors in parentheses are clustered by country-pair. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

dataset, I regress an indicator variable for war on bilateral $TRADE\_COSTS_{ij,t}$ estimated using the Structural Gravity Model and a *RIVALRY* indicator measure to control for the level of hostility between two countries. Table 6 reports the results. Column (1) shows the linear probability model estimates, and Column (2) shows the logit results estimated using XTLOGIT. In both columns, the trade costs coefficient is not statistically significant. I interpret this finding as evidence that mitigates the concerns for the presence of reverse causality in my estimates.

7 Quantifying the Welfare Effects of War through Trade Disruption

In this section, I conduct two counterfactual exercises to quantify the welfare effects of war through trade disruption: the undoing of the Afghanistan War in 2001 and the undoing of the Iraq

probability of war using a sample from 1870 to 1997.

war in 2003. The general equilibrium analysis is based on the system of equations (2)-(6) from the structural Gravity Model of Trade previously described in Section 4.1.

Using the nomenclature in Head and Mayer (2014), this analysis is General Equilibrium Trade Impact (GETI) because it endogenizes income (Y) and expenditure (E) through the dependence on producer prices (p). The chain of effects begins with the direct impact of war on bilateral trade costs, which in turn have first-order effects on the CES price index (P) and the outward multilateral resistance (Π) of the belligerent countries, and second-order effects on the price indexes $\{P, \Pi\}$ of the non-belligerent countries. In turn, all these effects have an impact on producer prices (p) via equation (5), and through these prices, direct general equilibrium effects on income Y and expenditure E.[22] Since the system represents a general equilibrium, changes in income and expenditure, in turn, have direct effects on trade and indirect effects on the value of the CES price index and outward multilateral resistance.

My counterfactual analysis involves three steps. To avoid repetition, I illustrate the procedure only for the Afghanistan War when the war has a distinct impact on trade from other wars. In essence, I conduct six counterfactual exercises: two wars (Afghanistan and Iraq) and for each war three heterogeneity scenarios (average, war case, country-pair).

In the first step, I recover the trade costs matrix for the baseline (BLN) and counterfactual (CFL) scenarios. To construct the baseline trade costs, I employ:

$$\left[t_{ij,t}^{1-\sigma}\right]^{BLN} = \exp\left[\hat{\mu}_{ij,t} + CTRL_{ij,t}\hat{\boldsymbol{\beta}} + \hat{\beta}_1(WAR\_CASE\_AFGHAN = 1)\right], \qquad (12)$$

where $\hat{\boldsymbol{\beta}}$ denotes the estimated vector of control variables ($GATT\_WTO_{ij,t}$ and $RTA_{ij,t}$), the term $\hat{\beta}_1$ indicates the estimated coefficient for the war indicator variable (WAR_CASE_AFGHAN), and $\hat{\mu}_{ij,t}$ are the estimates of country-pair fixed effects. All the estimates come from the empirical analysis performed in Section 6.

Next, I proceed to estimate the trade costs matrix for the counterfactual scenario; the undoing

[22] Since I abstract from the destructive effect of war on the endowments, war affects income only through the terms of trade channel.

of the Afghanistan War, which involves setting the Afghanistan War indicator variable equal to zero in 2001 in the following equation:

$$\left[t_{ij,t}^{1-\sigma}\right]^{CFL} = \exp\left[\hat{\mu}_{ij,t} + CTRL_{ij,t}\hat{\boldsymbol{\beta}} + \hat{\beta}_1(WAR\_CASE\_AFGHAN = 0)\right] \tag{13}$$

where $\left[t_{ij,t}^{1-\sigma}\right]^{CFL}$ denotes counterfactual bilateral trade costs in power transform form. According to this equation, the changes in trade costs from undoing the war are determined by the impact of war on trade estimated in Section 6.

When it is not possible to obtain estimates of pair fixed effects, either because trade flows are missing or pair fixed effects cannot be separately identified, it is not possible to estimate bilateral trade costs using equation (12). To address this issue, I implement the two-stage procedure proposed by Anderson and Yotov (2016), which yields predicted bilateral trade costs and can be used to fill up missing trade costs values. The first stage of this procedure recovers estimates of pair fixed effects from the regressions that estimate the impact of war on trade. In the second stage, these country-pair fixed effects are regressed on gravity variables and country fixed effects. The predicted country-pair fixed effects from this regression are then used to generate trade costs according to equation (12). These are the values used to replace the missing trade costs.

In the second step, with the full trade cost matrices in hand, I proceed to solve for each scenario (baseline and counterfactual) the system of equations (2)-(6) involving $\{Y_{i,t},\ E_{j,t},\ X_{ij,t},\ \phi_{i,t},\ t_{ij}^{1-\sigma},\ \sigma,\ \alpha_i,\ P_{j,t}^{1-\sigma},\ \Pi_{i,t}^{1-\sigma},\ p_{i,t}\}$. The values for incomes, expenditures, bilateral trade flows, and the trade imbalance terms $(Y_{i,t},\ E_{j,t},\ X_{ij,t},\ \phi_{i,t})$ are either directly obtained or calculated from the data. The trade cost terms $(t_{ij,t}^{1-\sigma})$ are recovered from gravity estimates as described in step one above. The value of the elasticity of substitution is assumed to be five ($\sigma = 5$), similar to Anderson and Van Wincoop (2003) and in line with the mean value of estimates in the trade literature reported by Head and Mayer (2014). Then, using these data and parameters, I proceed to solve for the preference parameter from CES preferences, CES price index, outward multilateral resistance, and producer prices (i.e., for $\alpha_i,\ P_{j,t}^{1-\sigma},\ \Pi_{i,t}^{1-\sigma},\ p_{i,t}$).

Because the system is homogeneous of degree zero, a normalization of prices is needed. Without loss of generality, I select Germany as the reference country, effectively setting its CES price index equal to one.[23] After solving the system, each experiment reports the following country-specific indexes: total exports (X_i), welfare defined as real expenditure/real income (W_i), the CES price index capturing changes in consumer prices (P_i), and the factory-gate price capturing changes in producer prices (p_i). Two important caveats in this analysis are the assumption of a fixed trade imbalance: $\phi_{i,t}$, which is kept at the baseline level during the counterfactual; and the choice of Germany as a reference country, which implies that its CES price index is unaffected by the undoing of the wars.

Lastly, in step three, I calculate General Equilibrium indexes for each variable of interest (total exports, welfare, consumer prices, and producer prices) using the formula:

$$\%\Delta IND = \left(\frac{\widehat{IND}^{CFL} - \widehat{IND}^{BLN}}{\widehat{IND}^{BLN}} \right) \times 100, \tag{14}$$

where CFL denotes the counterfactual (no-war) scenario and BLN denotes the baseline (war) scenario.

7.1 Welfare Effects: Afghanistan War

Table 7 presents the counterfactual results of undoing the Afghanistan war in the year 2001. Panels (A) - (D) show the results for different heterogeneity scenarios on the impact of war on trade for three belligerent countries: Afghanistan, Great Britain, and the U.S.; and the three most affected neutral countries: Azerbaijan, Tajikistan, and Pakistan. The columns present the general equilibrium indexes. Column (1) reports the percentage change in a country's total exports; column (2) shows the percentage change in a country's welfare, which is proxied by real income; columns (3) and (4) report the changes in consumer and producer prices, respectively.

[23] By construction Germany's CES price index will be unaffected by the undoing of the wars on the counterfactual exercises.

Table 7: The Effects of Undoing the Afghan War on Belligerent's Trade and Welfare

	(1)	(2)	(3)	(4)
	Full Endowment GE			
Country	$\%\Delta \sum_{j \neq i} X_{ij}$	$\%\Delta W$	$\%\Delta P$	$\%\Delta p$
Panel A. Average War				
AFG	0.94	1.58	-0.76	0.81
GBR	0.00	0.00	0.00	0.00
USA	0.00	0.00	0.00	0.00
AZE	0.00	0.00	0.00	0.00
TJK	0.01	0.00	0.00	0.00
PAK	0.44	0.07	-0.04	0.03
Panel B. Afghan War Case				
AFG	7.79	9.14	-4.95	3.74
GBR	0.00	0.00	0.00	0.00
USA	0.00	0.00	0.00	0.00
AZE	0.08	-0.02	-0.01	-0.02
TJK	0.08	-0.01	-0.01	-0.03
PAK	0.14	-0.02	-0.02	-0.04
Panel C. Symmetric Bilateral Effects				
AFG	7.86	9.18	-4.94	3.78
GBR	0.00	0.00	0.00	0.00
USA	0.00	0.00	0.00	0.00
AZE	0.08	-0.02	-0.01	-0.02
TJK	0.08	-0.01	-0.01	-0.03
PAK	0.14	-0.02	-0.02	-0.04

Notes:

(i) This table reports the effects of undoing the trade disruption effects of the Afghan War in 2001.

(ii) The first three countries listed in each panel are the Afghan war belligerents. The last three countries listed in each panel are the neutral countries that experienced the biggest welfare change because of General Equilibrium effects.

(iii) Column (1) indicates the percentage change in a country's total exports. Column (2) reports the welfare effects, which can be interpreted as a portion of the opportunity costs of conflict since this measures how much a country's real GDP would increase by undoing the Afghan War. Columns (3) and (4) decompose the incidence of welfare on consumers and producers, respectively.

Panel A shows the scenario where the Afghanistan war has the same impact on trade as all wars during the 1980-2016 period. Column 1 reports the change in the country's total exports. Notice that Afghanistan is the only belligerent country with an increase in total exports (0.94 percent). Since the model is general equilibrium, trade costs from undoing the war also affect neutral countries: Pakistan is the country that benefited the most, as it experienced a welfare increase of 0.44 percent. This is expected since Pakistan and Afghanistan are neighbor countries and had good trade and political relationships when the Afghanistan War escalated in 2001.

Column (2) displays the change in welfare, which is the key variable of interest in this analysis. As this column shows, the war's undoing increases Afghanistan's welfare by about 1.6 percent. Both consumers and producers benefit, but producers gain relatively more (columns 3 and 4). Interestingly, the U.S.-led coalition countries (Great Britain and the U.S.) are essentially unaffected by the war. A possible explanation is that the bilateral trade with Afghanistan is relatively low compared to their total trade volume for these countries. Hence, even if war increases bilateral trade costs between them and Afghanistan, the impact on their exports and welfare is close to zero. Among the neutral countries, Pakistan's welfare increases by $.07$ percent. In this case, consumers benefit more than producers (columns 3 and 4).

Next, in Panel B, I allow the Afghanistan war case to have a distinct impact on trade. Under this scenario, Afghanistan's exports rise to about 7.79 percent from undoing the war (column 1). Also, in line with the above panel, Pakistan's exports increase, although by a lower magnitude. Column 2 reports the welfare effects: Afghanistan's welfare gain from undoing the war rises to about 9 percent. The increase in welfare reflects the higher impact of war on trade obtained from isolating the Afghanistan War case from all other wars, shown in column 2 of Table 5. Interestingly, even though the Afghan war considerably lowered the U.S.-led coalition countries' trade with Afghanistan, their welfare effect is close to zero. The explanation is the same as in the previous panel: for U.S.-led coalition countries, the trade volume with Afghanistan is very small relative to their total trade volume. Even though undoing the Afghanistan war increased exports, the welfare

effect is marginally negative for neutral countries. Regarding welfare's incidence on consumers and producers (columns 3 and 4), for Afghanistan, consumers benefit more than producers. On the other hand, the neutral countries' consumers benefit from undoing the Afghanistan war, while producers suffer marginal losses.

Finally, in Panel C, I allow the Afghanistan war to have a distinct impact on the trade for each country pair of adversaries. The resulting effects on exports, welfare, and prices are qualitatively and quantitatively similar to the previous panel.

7.2 Welfare Effects: Iraq War

Turning to the counterfactual involving the undoing of the Iraq War in 2003, Table 8 reports the results for the key indexes of interest.

Panel A in Table 8 presents the scenario that assumes that the Iraq War has the same impact on trade as all other wars in the sample. The results on exports, which are reported in column 1, indicate that Iraq's exports increase by about 1.67 percent. However, the undoing of the war does not affect exports from the U.S-led coalition countries; a similar pattern was found in the Afghanistan War case. Also, since the analysis is general equilibrium, changes in trade costs among belligerents affect neutral countries through changes in the CES price index and producer prices. In this case, Kuwait and Georgia were the most affected countries; both experienced a small decline in their exports. Column (2) reports the welfare effects, which are the key variables of interest. In line with the previous column, only Iraq welfare among the belligerent countries improves by about 1.23 percent. The U.S. coalition countries were not affected. Similarly, the welfare effect on neutral countries was very low: Kuwait's welfare decreased by $.01$ percent and Georgia's welfare was practically zero. Columns (3) and (4) report the changes in consumer and producer prices. Iraq's consumers benefited more than producers: consumer prices declined by $.67$ percent, while producer prices increased by $.55$ percent. For Kuwait, a neutral country, producer prices declined while there was no change in consumer prices.

Turning to the case that isolates the impact of the Iraq wars, because the Iraq war did not have a significant impact on trade (Table 5), Panel B shows no welfare effects.

Lastly, in Panel C, I quantify the welfare effect from undoing the war when allowing for heterogeneous effects across country-pairs of adversaries. The results show a pattern that is qualitatively similar to Panel A. Iraq's export increased, the U.S.-led coalition countries did not change, and among the neutral countries, total exports from Kuwait and Georgia declined slightly (Column 1). Iraq is the only belligerent country that benefited from undoing the war (Column 2), and for Iraq, the price change benefited more consumers than producers.

Overall, three interesting insights result from the preceding analysis. First, for Afghanistan, allowing for heterogeneity on the impact of war on trade generates a sizable difference in the welfare effect of war relative to the average partial effect for all wars. In contrast, the results across the different cases of heterogeneity are qualitatively similar and of about the same magnitude.

Second, for Iraq, allowing for heterogeneity at the directional country pair does not generate a meaningful difference in welfare effect relative to the average case. However, there is an important insight from examining heterogeneity: the value added of the analysis is not from comparing magnitudes relative to the average case, but instead, it comes from an improved understanding of the sources of those welfare effects. For example, both the average case and the directional-country pair cases generate welfare effects of about the same magnitude. However, it is interesting that the trade with the U.S. played no role in the welfare effect, based on the insignificant impact of the war on trade between Iraq and the U.S — see column 3 in Table 5.

Table 8: The Effects of Undoing the Iraq War on Belligerent's Trade and Welfare

	(1)	(2)	(3)	(4)
	Full Endowment GE			
Country	$\%\Delta \sum_{j \neq i} X_{ij}$	$\%\Delta W$	$\%\Delta P$	$\%\Delta p$
Panel A. Average War				
IRQ	1.67	1.23	-0.67	0.55
AUS	0.01	0.00	0.00	0.00
GBR	0.01	0.00	0.00	0.00
USA	0.01	0.00	0.00	0.00
KWT	-0.04	-0.01	0.00	-0.01
GEO	-0.01	0.00	0.00	0.00
Panel B. Iraq War Case				
IRQ	0.00	0.00	0.00	0.00
AUS	0.00	0.00	0.00	0.00
GBR	0.00	0.00	0.00	0.00
USA	0.00	0.00	0.00	0.00
KWT	0.00	0.00	0.00	0.00
GEO	0.00	0.00	0.00	0.00
Panel C. Symmetric Bilateral				
IRQ	1.15	0.87	-0.51	0.36
AUS	0.06	0.00	0.00	0.01
GBR	0.02	0.00	0.00	0.00
USA	0.00	0.00	0.00	0.00
KWT	-0.03	0.00	0.00	0.00
GEO	-0.01	0.00	0.00	0.00

Notes:

(i) This table reports the effects of undoing the trade disruption effects of the Iraq War in 2003.

(ii) The first four countries listed in each panel are the Iraq War belligerents. The last two countries listed in each panel are the neutral countries that experienced the biggest welfare change because of General Equilibrium effects.

(iii) Column (1) indicates the percentage change in a country's total exports. Column (2) reports the welfare effects, which can be interpreted as a portion of the opportunity costs of conflict since this measures how much a country's real GDP would increase by undoing the Iraq War. Columns (3) and (4) decompose the incidence of welfare on consumers and producers, respectively.

Third, an interesting aspect of both wars is that the U.S-led coalition countries were not affected perceptively through the trade channel. As explained above, this may due to the fact that the bilateral trade with Afghanistan and Iraq is low relative to their total trade volume for these

countries.

8 Concluding Remarks

This paper studies the economic cost of the Afghanistan and Iraq wars associated with trade disruption. To the best of my knowledge, it is the first paper that estimates the heterogeneous impact of war on trade, both across war cases and country pairs of adversaries, and its welfare implications.

Using a state-of-the-art gravity equation, I estimate the heterogeneous effects of war on trade. I find significant differences in the magnitude of the impact of war on trade across war cases. The Afghanistan War practically eliminates trade among belligerents, while the Iraq War does not seem to affect trade. Moreover, I find evidence of heterogeneity across country pairs fighting the same war. The Iraq War, in particular, illustrates this: the war dampened trade between Iraq and Great Britain and Australia, but not between Iraq and the U.S.

Equipped with the heterogeneous effects, I assess the implications of war for welfare when accounting for heterogeneity using a new quantitative trade model. Specifically, I conduct two counterfactuals: the undoing of the Afghanistan War in 2001 and the undoing of the Iraq War in 2003. I find evidence that the heterogeneous impact of war on trade generates meaningful differences in the welfare effect of the invaded countries. In particular, for Afghanistan: accounting for heterogeneity, both by war case and country-pair, results in a welfare gain nine times larger than the average case (9 percent vs. 1 percent). For Iraq, the no heterogeneity scenario generates about 1 percent welfare gain, while incorporating heterogeneity at the war case does not create any welfare effect. When incorporating heterogeneity across country-pairs, the welfare gain is 0.87, slightly smaller than the average case.

Even though the Afghanistan and Iraq wars have a significant negative impact on trade between U.S.-led coalition countries and invaded countries, the coalition countries are essentially unaffected by the war. This intuitive finding implies that asymmetries in size matter, and therefore for large

countries, the fact that war disrupts trade does not necessarily mean that war is costly in terms of disrupted trade.[24]

Finally, the framework used in this study can be extended to examine the output destruction associated with wars and quantify welfare effects. I'm currently working on adapting the methods developed by Anderson et al. (2021) to estimate in reduced-form the destruction effect of war on income controlling for its impact on trade. These estimates can be employed to compare the welfare effects of both trade disruption and output destruction.

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[24]The present analysis abstracts from the costs associated to arming, which according to a growing literature, might increase with trade disruption.

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A Appendix

A.1 Country Sample 1980-2016

Table 9: Country Sample

Afghanistan, Albania, Algeria, Andorra, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Cyprus, Czechia, Czechia, Democratic Republic of the Congo, Democratic Yemen, Denmark, Djibouti, Dominica, Dominican Republic, East Germany, East Timor, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Eswatini, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Liechtenstein, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Moldova, Monaco, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, North Korea, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of North Macedonia, Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Korea, South Sudan, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syrian Arab Republic, Taiwan, Tajikistan, Tanzania, United Republic of, Thailand, The Bahamas, Timor-Leste, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Yugoslavia, Zambia, Zimbabwe

A.2 Extension to Study the Destruction Effect of War on Income

To demonstrate how the Structural Gravity Model of Trade can be extended to study the destruction effects of war on income, in this subsection, I will derive a relevant equation by employing the methods of Anderson et al. (2021). For expositional purposes, I will retain the endowment structure of the model, but the model can accommodate a more complex production structure.

I begin by introducing the presence of conflict to equation (6), which defines the value of

output, resulting in:

$$Y_{i,t} = \phi_{i,t} p_{i,t} Q_{i,t} \left(\omega_i^{W_{i,t}} \right), \tag{A.1}$$

where the multiplicative term in parenthesis is the new addition. This term consists of a country-specific parameter $\omega_i \in (0,1)$ treated as exogenous that governs the rate of destruction of war, defined as $\eta_i \equiv (1-\omega_i)$, and a binary conflict indicator variable $W_{i,t}$ that captures the presence or absence of war: it takes the value of 1 when there is war and zero otherwise. Notice that when there is peace ($W_{i,t} = 0$), the value of output is the same as equation (6) from the standard structural gravity system.[25]

I then substitute the market clearing condition (5) for prices in (A.1), solve for $Y_{i,t}$, and finally take logs to obtain:

$$\ln Y_{i,t} = \frac{\sigma-1}{\sigma} \ln \phi_{i,t} + \frac{1}{\sigma} \ln Y_t + \frac{\sigma-1}{\sigma} \ln \frac{1}{\alpha_i} + \frac{\sigma-1}{\sigma} \ln Q_{i,t} - \frac{1}{\sigma} \ln \left(\frac{1}{\Pi_{j,t}^{1-\sigma}} \right) + (\ln \omega_i) W_{i,t}, \tag{A.2}$$

where the variable $\ln \left(\frac{1}{\Pi_{j,t}^{1-\sigma}} \right)$ is the inverse of trade openness, and the parameter $(\ln \omega_i)$ captures the destructiveness of war.

A.3 Robustness Check, without Replacing Missing Values with Zeros

This section offers a sensitivity analysis of the results, specifically for replacing missing trade values with zeros. Overall the results are qualitatively identical and quantitatively similar to the results reported in section 6. Table 10 reports results on the impact of war on trade emphasizing the Afghanistan and Iraq wars, while Figure 2 presents estimates on the impact of war on trade for all wars in the sample.

[25] Similar to Martin et al. (2008), I treat the rate of destruction as exogenous.

Table 10: Impact of War on Trade, without Replacing Missing Values with Zeros

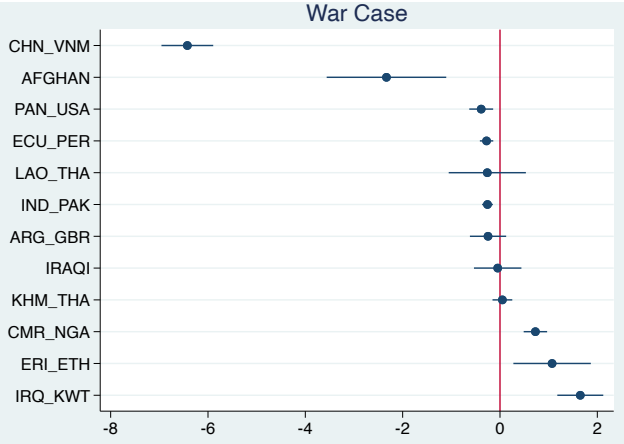
VARIABLES	(1) WAR_AVG	(2) WAR_CASE	(3) SYMM
GATT_WTO	0.276***	0.276***	0.276***
	(0.0512)	(0.0512)	(0.0512)
RTA	0.162***	0.162***	0.162***
	(0.0437)	(0.0437)	(0.0437)
WAR_BIL	-0.156*		
	(0.0904)		
WAR_BIL_ALL_OTHER		-0.160*	-0.160*
		(0.0913)	(0.0913)
WAR_MULTI_BRDR	0.0184	0.0184	0.0184
	(0.0218)	(0.0218)	(0.0218)
AFGHAN_WAR		-2.307***	
		(0.634)	
AFG_GBR			-0.758***
			(0.185)
AFG_USA			-2.938***
			(0.184)
IRAQ_WAR		0.197	
		(0.234)	
IRQ_AUS			-2.218***
			(0.168)
IRQ_GBR			-0.245
			(0.170)
IRQ_USA			0.398**
			(0.169)
Observations	747,100	747,100	747,100
Country-pair FE	✓	✓	✓
Importer-time FE	✓	✓	✓
Exporter-time FE	✓	✓	✓
Border-time FE	✓	✓	✓

Notes:

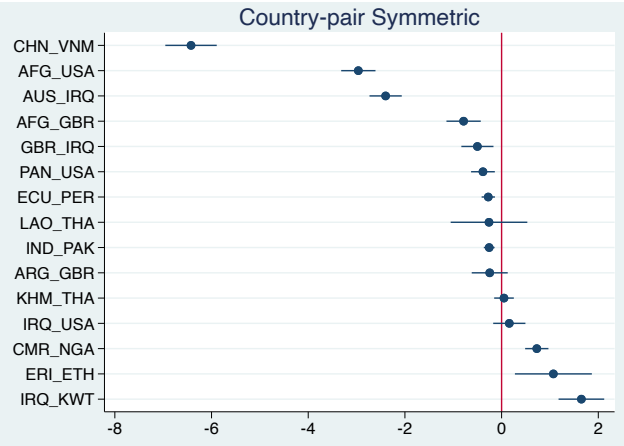
(i) This table presents estimates on the impact of war on trade incorporating heterogeneity indicated in the column headers. These estimates were obtained without replacing missing trade values with zeros. Column 1 highlights the no heterogeneity where all wars have the same average partial effect. Column 2 indicates the presence of heterogeneity across war cases, where the Afghan and Iraq wars have a distinct impact on trade. Column 3 indicates the presence of heterogeneity across country-pairs fighting the Afghan and Iraq Wars.

(ii) Robust standard errors in parentheses are clustered by country-pair. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 2: Heterogeneity of the Impact of War on Trade Without Replacing Missing Trade Values with Zeros



(a) Across war cases



(b) Across country-pairs of adversaries

Notes:

(i) These figures present heterogeneous estimates of the impact of war on trade for all wars in the sample spanning the period from 1980 to 2016. These estimates were obtained without replacing missing trade values with zeros. Panel (a) isolates the impact of war on trade for each war case. Panel (b) isolates the impact of war on trade for each country-pair fighting a war.

(ii) The trade volume effect implied by an estimate $\hat{\beta}$ is as follows: $(\exp(\hat{\beta}) - 1) \times 100$. For example, a coefficient $\hat{\beta} = -2$ translates to a trade volume effect of -86.47 percent $= (\exp(-2) - 1) \times 100$.

(iii) Some countries involved in wars do not appear in the figures because they did not trade for the whole period of the war.